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OF

THE UNITED STATES

GEOLOGICAL AND GEOGRAPHICAL SURVEY

OF

THE TERRITORIES,

EMBRACING

COLORADO AND PARTS OF ADJACENT TERRITORIES:

BEING A

REPORT OF PROGRESS OF THE EXPLORATION FOR THE YEAR

1875.

BY F. V. HAYDEN,
UNITED STATES GEOLOGIST.

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UNITED STATES GEOLOGIST-IN-CHARGE.

LETTER TO THE SECRETARY.

OFFICE U. S. GEOLOGICAL AND
GEOGRAPHICAL SURVEY OF THE TERRITORIES,
Washington, *March* 15, 1877.

SIR: I have the honor to present for your approval, and for publication, the Ninth Annual Report of the United States Geological and Geographical Survey of the Territories, embracing the principal results of the work, both in the field and in the office, during the year 1875, when the Survey continued the work of the two previous seasons in Colorado, completing the southern and southwestern portions of that Territory, and including a belt, fifteen miles in width of Northern New Mexico and Eastern Utah.

The entire force of the Survey was divided into seven parties for special duty, four of which were assigned to specific areas for the performance of topographical and geological work. The fifth party attended to the primary triangulation, the sixth collected photographic views of the most interesting scenery and ancient ruins, while the seventh transported the supplies to the various districts.

The areas for exploration the present season were much farther from the base of supplies than heretofore, rendering the labor greater, and causing great loss of time in traveling to and from these bases. Yet the amount of topographical and geological work accomplished has not been exceeded by that of any previous year.

As heretofore, the starting point was at Denver. The first or southern division operated in Southeastern Colorado. It was composed of A. D. Wilson, chief topographer, directing; Franklin Rhoda, assistant topographer; Dr. F. M. Endlich, geologist; with two packers and a cook. The district surveyed by this party embraced an area of 12,000 square miles. Within these limits, Mr. Wilson made 143 stations on the more commanding peaks.

A system of triangles was extended over the whole area, while at the same time the topographical sketches and angles were taken, barometrical readings were made at all occupied points, at all camps, passes, and other places of note visited during the season. Many of the stations have been carefully connected in height by fore and back angles of elevation and depression, to be used as a check on the barometric heights, while the heights of all located points have been determined by a system of angles of depression and elevation.

The district assigned to this division for the summer of 1875 joined on to the south borders of that surveyed in 1873 and 1874. Longitude 104° 30′ formed the eastern, longitude 108° the western, and 36° 45′ north latitude the southern boundaries.

A plan for the most rapid and successful completion of the work undertaken was prepared by Mr. Wilson, and subsequently carried out as proposed. This district contained the foot-hills sloping eastward from the Front Range, the southern continuation of the Sangre de Cristo Range, the southern end of San Luis Valley, the extension of the La Plata Mountains, and the lower country of the Rio San Juan and its tributaries. A small portion of the sedimentary eastern foot-hills was first surveyed, and the work then carried westward to the mountainous vicinity of the Upper Rio Grande. Instead of forming a well-defined, sharply-limited range, the mountains south of the Rio Grande have the form of a high plateau, with numerous isolated peaks. Both the plateau and the peaks mentioned are volcanic. From the position of volcanic beds composing the higher peaks, it may be inferred that at one time the summit of the plateau extended to a considerably higher altitude than at present. Toward the southwest, it drops off suddenly into the lower country, containing the Rios Piedra and Pinos, presenting a line of steep, rough mountains, formed in part by the abrupt termination of the plateau, in part by the peaks above mentioned, the former contrasts strongly with the rich land in the valleys of the two rivers. Here, as at so many points in the districts surveyed by the southern division, the geological features determine the orographic character. With the plateau end the volcanic beds and the sedimentaries of Cretaceous age set in. But few stratigraphical disturbances have changed the relative position of the beds, and the country therefore shows regular features. Long lines of high ridges, abrupt on the north side, sloping more gently toward the south, extend from east to west, and are cut by the drainage of the San Juan. Eastward, the edge of the plateau recedes, losing at the same time some of its roughness, and a broad expanse of comparatively low bluff country appears. Rich valleys, partly timbered or covered with grass, follow the course of the larger streams, owing their formations to the rapid erosions and ready disintegration of the shales belonging to Cretaceous No. 2. Springs containing an unusual amount of mineral ingredients, some of them hot, occur in these valleys. Owing to the slight southerly dip of the Cretaceous beds, this formation claims a considerable area of the region extending from the Rio Animas eastward to the border of the district. Above the well-determined strata of Nos. 2 and 3, a series of shales and sandstones set in, in which no characteristic fossils whatever were found. They reach a thickness of about 3,000 feet, and contain coal at a number of points. It will not be possible to determine their geological age with any degree of certainty until careful comparisons of the parallel formations observed by Mr. Holmes and Dr. Peale can be made. The absence of fossils is greatly to be regretted, but none were found, although many square miles were traversed containing the series. Speaking with the reserve that imperfect comparison of the notes taken dictates, it would appear that the Trinidad coal-bearing series is parallel to this one.

After having completed the survey of this lower region along the Rio San Juan and its tributaries, the work was continued to the extension of the La Plata Mountains. Here again volcanic rocks were met with, identical in every respect with those farther north and west. Here, as well as previously on the headwaters of the Pinos and Piedra, evidence of former glaciers was found. Considerable areas showed the grooving and striation of rocks *in positu*, produced by the motion of ice and bowlders. Deep cañons were cut into, volcanic conglomerate occurring there, that had not preserved the grooving and striation, however, owing to the rapidity with which it yields to the effect of atmospheric influences. A gentle slope eastward of the volcanic rocks, that there reached to the youngest member of the group, basalt, gradually merged into the San Luis Valley. Affected by local basaltic eruptions, as well as by the easterly dip of the volcanic beds, the drainage on the west side of this valley presents some interesting features, consisting in sudden curves northward. Northward, the unbroken flows of basalt continue on the west side of the valley until Rio Alamosa is reached, where they end and drift begins. A number of volcanic bluffs, trending nearly north and south, separate this portion from the valley through which the Rio Grande runs after making its turn southward west of Fort Garland. This region, geologically, is more interesting than the western one, on account of the evidence furnished demonstrating the existence of two very large lakes at the close of the volcanic activity there. The two were connected by a narrow strip of water south of Fort Garland, and the lower one extended southward nearly to the Rio Colorado. At that time, too, the course of the Rio Grande was different from its present one. By the formation of a narrow cañon in the basaltic beds, the course of the river was deflected, the lakes drained, and the topography left very nearly in the shape we now observe it. The accurate determination of all the points connected with the existence of these lakes offers no material obstacle, but requires by far more time than could be bestowed upon it in the regular course of the survey.

Separating the eastern foot-hills and the great plains from San Luis Valley is the southern continuation of the Sangre de Cristo Range. Several peaks of this range rise to an elevation of nearly 14,000 feet, while many of them reach 13,000 feet above sea-level. Here again metamorphic rocks set in, containing indications of metalliferous veins. Sedimentary beds, belonging to the Carboniferous and Cretaceous ages, the latter only on the eastern slope, however, rest against the metamorphic "core" of the range. Volcanic eruptions of the trachytic series have occurred, and show an arrangement parallel to the general course of the chain. A more or less isolated group of peaks is north of Fort Garland, termed the Sierra Blanca. Passes are both north and south of it,—Mosca Pass and the Sangre de Cristo and Abeyta Passes. While Cretaceous beds, overlying the Carboniferous and subjected to considerable disturbances, slope off from the range toward the eastward, their area is somewhat limited, as the Lignitic group there again makes its appearance in the Raton Hills and north of them. Lithologically, this is identical with the one observed on the Rio San Juan. Comparisons of the succession of strata and relative thickness, etc., will be found in Dr. Endlich's report. The age of this group has for some time occupied the attention of geologists, and given occasion for dissenting views. It is highly probable that the results obtained during the past season will not admit of a definite decision with regard thereto. They will at least be entitled to more consideration than those of explorers having merely traveled over a limited area, as so large a continuous district containing the formation has been examined. It is not possible at present to state positively what these results will be; but, from the observations taken in the field, it can be deduced that the age of the Lignitic group near Trinidad is *not* Cretaceous. A full discussion of this important subject will be found in a subsequent portion of the Report.

Upon the completion of the examination of the just-mentioned group, the work of the season was connected to the north and northeast with that of 1874, and therewith finished. On October 12, the party returned to Denver, having fully accomplished the purpose for which it was sent out. Important and useful information has been obtained regarding mineral and agricultural resources of the district, and data have been obtained for the preparation of a topographical and geological map of the area surveyed.

The southwestern division was conducted by W. H. Holmes as geologist, with G. B. Chittenden as chief topographer and T. S. Brandegee as assistant topographer. Mr. Brandegee also acted as botanist.

The area assigned to this division is bounded on the east by the work done by Mr. Wilson in 1874, or a line about on the meridian of 108° west longitude; on the south by the parallel of 36° 45′; on the west by meridian 109° 30′; and on the north by 37° 30′ north latitude. These boundaries include an area of about six thousand five hundred square miles. An area of about five hundred square miles was surveyed along the eastern base of the mountains on the outward march. Here Mr. Chittenden made about twelve stations, connecting with the former work and completing the sheets to the proposed eastern line of the Survey.

The easternmost line of the district assigned to this division was over four hundred miles from Denver. The party arrived there on the 30th June, and commenced work immediately.

The work was generally done by means of the plane-table, and reënforced by both vertical and drainage sketches from all the stations, and also by time-meanders of all the main streams, and generally by a running sketch of the routes traveled. The main stations averaged *one to every seventy-five square miles of area.*

By meandering, Mr. Chittenden surveyed the San Juan River, the La Plata, the Mancos, and the Dolores, all of them considerable streams, and besides these the McElmo and Montezuma Creeks, which, though well defined stream-beds, contain no running water. These last-named dry rivers are each upward of seventy-five miles long, and for a considerable part of their course are in deep cañons. In the meander, he made a trigonometric location as often as once in ten miles.

The great trouble in working was lack of water. The party were often obliged to ride out ten, fifteen, and even twenty miles from the rivers to make a station and back again for camp, because outside of the rivers themselves there was no water at all.

In regard to the systems of working generally employed now in the different surveys west of the Missouri River, the plane-table system, which was generally used this summer, is admirably adapted to a low, broken country, where good "points" are abundant, and works also extremely well in a simple cañon country, where there are surrounding prominent points at not too great distance. But in a mountain country, it could not be used to any advantage, and was eventually abandoned in all the mountain work. In low, broken, and cañon country, it is probably the best system that can be used; but, in the ordinary rolling and mountainous country of the Northwest, it will not repay the extra weight and time which its use entails.

In any but a very mountainous country, a system of *meander* seems to be almost necessary to make work on a scale of four inches to a mile complete. It is the abuse, and not the use, of the old odometer system that has brought it into so much discredit. If properly checked, the meanders give to the more important portions of the country, as the traveled routes and principal rivers, the greater degree of accuracy which is their due. The third and only remaining system in use in the West is that generally employed on this Survey, and formerly used both in the California Survey and in that of the fortieth parallel. It consists of a system of vertical and horizontal sketches based on a rather elaborate triangulation, and checked by numerous angles, both vertical and horizontal. This system is peculiarly adapted to a rolling or mountainous country, and in such country cannot be equaled by either of the other modes. It works well, too, in country of different character, and is probably, on the whole, the best system on which to base work in the average country of the West. It should, however, be supplemented by good meanders of all the main roads and rivers. In the work of the Survey this summer, the three systems were employed, and the above remarks are the immediate result of the summer's observations.

The party completed about six thousand square miles in the West, being obliged, after the trouble with the Indians, to leave unworked a small corner in the Northwest, requiring about five days to be cômpleted. This piece of ground joins directly on to Mr. Gannett's uncompleted area, and lies entirely west of the Colorado line. In going to and from the work, six full weeks were spent in marching. Mr. Chittenden worked about six thousand five hundred square miles, and made eighty-four main stations.

The geological examination by Mr. Holmes was fruitful of most important results. His investigations were extended from Colorado into portions of Utah, Arizona, and New Mexico.

In 1874, Dr. Endlich examined the district lying to the east, so that Mr. Holmes took up the work where he left off at 108° west longitude, and carried it without difficulty to 109° 30′. In general, the geology is not greatly complicated. The section of stratified rocks exposed extends from the Tertiary to the Carboniferous, including about 2,000 feet of the former and slight exposures merely of the latter. About 9,000 feet of measures passed under examination. Of other rocks, there are—four small areas of trachyte, one limited area of metamorphic rock, and a few unimportant dikes.

Beginning at the east, Dr. Endlich's section on meridian 108° includes the entire series, beginning with the Lower Carboniferous in the north and extending up into the Tertiary at the south. The strike is east and west, the dip south from 5° to 45°. Working to the westward, Mr. Holmes found the whole series flattening out, *i. e.*, approaching a horizontal position. At the same time, a gentle rise toward the northwest brings the Cretaceous rocks to the surface, or at least up to the general level of the country. The Tertiary formations are, therefore, confined to the southeast. From Station I, an outcrop of the light-colored sandstone belonging to the base of this series could be traced along its entire course through the district.

The heaviest seam of coal examined in these beds is 26 feet in thickness. It is rather light and impure on the surface, but probably of moderately good quality. A number of less important seams were also observed.

West of the Rio La Plata, the Upper Cretaceous beds are raised to a higher plane by a slight monoclinal fold, after which they spread out to the west, forming the *Mesa Verde*. This mesa extends nearly to the San Juan on the south, west beyond the Rio Mancos, and north to the middle of the district, an area of more than 700 square miles. On these three sides, the mesa breaks abruptly off in lines of irregular, escarped cliffs, generally from 1,000 to 2,000 feet in height.

The striking features of this series are the exposures of two horizons of massive sandstones. The upper forms the top of the mesa; the lower, 1,000 feet below, produces a subordinate shelf. Shales intervene between the sandstones of the Lignitic and the upper sandstones of the mesa, and between these and the lower sandstones. Around the base of the mesa, the Middle Cretaceous shales outcrop. The belt covered by these is narrow, and is followed by the hard sandstones of the Dakota group, which are very persistent here as elsewhere, and occupy the higher level of the entire mesa country to the west and north. The Jurassic strata and the "red beds" are exposed in the sides and bottoms of the numerous cañons and stream-courses, the latter only in the greater valleys and in patches about the bases of the trachytic areas. The Jurassic section is, in the upper part, almost identical with the corresponding series in other parts of Colorado, but at the base has a larger development of soft sandstones and marls. The identification rests upon the analogy of position and lithology. The "red beds" are massive sandstones and conglomerates, as usual.

The only important mountains are the Sierra La Plata. They lie toward the northwest, and are principally of Carboniferous rocks, so highly metamorphosed as to have lost all apparent structure. A large number of rich lodes of gold and silver have been recently discovered in this group about the sources of the Rio La Plata, and an extensive placer-bar is located near the exit of the river from the mountains.

In the extreme northeast corner of this district is a group of trachytic mountains, including Lone Cone, which belongs to the San Miguel Mountains. West of the Mesa Verde, almost in the center of the district, stands the "Late" group, of which Ute Peak is the culminating summit. It covers an area of some forty square miles, and is simply a mass of trachyte pushed up through and poured out over the floor of the Dakota group.

In the extreme southwest corner, principally in Arizona, is the Sierra Carriso, identical with the Late in nearly every respect, differing only in having carried up portions of the Carboniferous rocks about the base, while a fragment of the same formation is caught up in the center of the group.

Of the 6,000 square miles, 5,700 are of sedimentary rocks: 230 of these in the southeast are of the so-called Lignitic; 800, chiefly included in the Mesa Verde, belong to the Upper Cretaceous; and the remaining 4,900 to the Lower Cretaceous, and such of the earlier periods as are exposed in the crooked and narrow valleys, and about the trachytic groups. In the Cretaceous series, Mr. Holmes examined a number of seams of workable coal, procured fossils in ten distinct horizons, and expects to be able to identify these horizons with such corresponding ones as exist on the Atlantic slope. The section obtained is the most complete and satisfactory made in Colorado up to this time. The trachyte areas include about 250 square miles, and seem to present many remarkable and interesting features.

The prehistoric remains in the cañons and lowlands of the Southwest are of great interest, and the study of them by Mr. Holmes was as complete as possible under the circumstances. Many cliff-houses, built in extraordinary situations, and still in a fine state of preservation, were examined. A good collection of pottery, stone implements, the latter including arrow-heads, axes, and ear-ornaments, etc., some pieces of rope, fragments of matting, water-jars, corn, and beans, and other articles, were exhumed from the *débris* of a house. Many graves were found, and a number of skulls and skeletons that may fairly be attributed to the prehistoric inhabitants were added to the collection.

The western or Grand River division consisted of Henry Gannett, topographer, in charge; W. R. Atkinson, assistant topographer; A. C. Peale, geologist; two packers; and a cook.

The district assigned to this party lies between the parallels of latitude 37° 52′ and 39° 15′; is limited on the west by the meridian 109° 30′, and on the east by the western limit of the work of last year, approximately the Gunnison and Uncompahgre Rivers. This embraces the country drained by the Uncompahgre and Dolores Rivers and their branches.

The party left Denver on June 7, and on July 3 commenced work. They worked uninterruptedly until August 15, when the work was brought to a sudden close by the Indians.

The work was carried to the western line of Colorado, and toward the northern end extended 25 or 30 miles into Utah, and reached the north and south lines throughout, except in the southwestern part. The total area surveyed is about 6,000 square miles. In doing this, seventy-four stations were made.

The country is extremely diversified. The Uncompahgre flows through a broad valley, fifty miles in length by about twenty in width, almost perfectly flat, and very dry. The elevation is 4,500 to 6,000 feet. The soil is poor, and vegetation, except in the river-bottom, very scanty.

Between the Uncompahgre and the Dolores is a high ridge, whose axis is parallel to the course of the rivers—*i. e.*, about N. 30° W. It has a long, gradual slope to the Uncompahgre Valley, while it breaks off sharply and steeply to the Dolores. The average elevation of the crest is 8,000 to 9,000 feet. Most of this country is well timbered with heavy pine, quaking-aspen, and some spruce. There is also considerable open country, which is covered with luxuriant grass.

The Sierra La Sal is a short, isolated range of mountains, just west of the Dolores, separating it from the Grand River. The direction of the range is about north and south, its length about fifteen miles, and the elevation of the summits 12,000, to 13,000 feet.

The Grand River from the mouth of the Gunnison to that of the Dolores is alternately in open valley and low cañons. On the south, the river hugs the edge of the plateau closely, while on the north low, open, desert country extends about fifteen miles back from the river. This desert country extends down the Grand and across to the Green, forming the great plateau in which these streams and the Colorado cut their caño ns.

South of the Sierra La Sal are fine valleys extending nearly to the head of the Dolores. Farther west, the country is a plateau, without water, covered with sage and piñon-pine, and cut by numberless dry cañons.

The geological features of the district surveyed by the Grand River division during the season of 1875 are comparatively simple, there being no great uplifts nor many local disturbances. The sedimentary formations represented are all included under Carboniferous red beds (Triassic?), Jurassic, and Cretaceous. Exposures of metamorphic rocks are seen in several parts of the district, limited mainly to the bottoms of cañons, the streams having cut through the overlying sedimentaries. The eruptive areas are also limited. In the southern part of the district, we had the overlapping edges of various trachytic flows, whose sources of origin were in the Uncompahgre Mountains, still farther south. Besides these, there are three distinct centers of eruption, viz, the Lone Cone group of mountains on the south, the Abajo Mountains in the southwest, and the Sierra La Sal Mountains toward the northwest. These are of porphyritic trachyte, and have been pushed up through the Cretaceous layers, which dip gently from them. The greater part of the district, however, is covered with sedimentary rocks, generally horizontal, or, if dipping, but little inclined. In these beds, the drainage is outlined by cañons, which are from a few hundred to over a thousand feet in depth. During the summer months, the streams are dry.

Leaving the Los Pinos Indian agency, the first work was on the south side of the Gunnison River, in a narrow strip of country lying between Mr. Gannett's district of 1874 and that of Mr. Wilson for the same year. The rocks here are trachytes, interlaminated with tuffs in horizontal layers. They rest partly on metamorphic rocks, and partly on the remnants of Cretaceous sandstones. Previous to the outpouring of these trachytes, the country was evidently subjected to considerable erosion, the sandstones being in many places entirely removed, exposing the gneissic rocks upon which they were deposited. Going westward toward the Uncompahgre River, the volcanic rocks disappear, and rocks of Upper Cretaceous age show in bluffs on the east side. The weathering of these beds has produced a barren alkaline soil, in which there is no vegetation. In the immediate river-bottom, there is some good soil, but it is limited in extent. The course of the Uncompahgre is a few degrees west of north, and between it and the drainage of the San Miguel and Dolores Rivers, which has approximately the same direction, is a plateau-like country, with a gentle slope to the eastward, toward the Uncompahgre, and breaking off in benches on the Dolores side. Seen from the mountains, this plateau appears very regular; nevertheless, it is very much cut up by numerous cañons, which carry water only in wet seasons. The floor of the plateau is composed chiefly of sandstones of the Dakota group (Cretaceous No. 1), underlaid by Jurassic shales and red beds (Triassic?), which rest upon metamorphic rocks, as seen in the cañons. On the western side of the plateau is a monoclinal fold, which in some places becomes a fault of 300 to 500 feet. One of the most curious features of this region is a cañon extending from the Dolores River to the Gunnison River. It is evidently the bed of an old stream, which probably once flowed toward the Dolores. At present, there are in it two creeks, one a tributary of the Gunnison and the other a branch of the Dolores, the latter the larger stream of the two. At the divide between them, the cañon is about 1,200 feet deep, 900 feet of gneissic rock and 300 of sedimentaries on the top. The dip is toward the east, and the creek flowing in that direction gradually gets higher and higher in the schists, and finally cuts through the overlying sandstones, in which it joins the Gunnison. Toward the west, the cañon rapidly increases in depth until it is 3,000 feet below the general surface. The stream on this side cuts across the line of faulting of the west side of the plateau, and enters the red sandstones, which incline westward. In these, it joins the Dolores River. North of the cañon, between it and Grand River, the Dakota group, which prevails to the southward, is almost entirely absent, the red beds forming the greater part of the surface, which is here a maze of dry cañons. The country gradually falls off toward Grand River, the western line of faulting becomes a fold, and the eastern fold, which is also faulted in places, gradually becomes less. North of Grand River, beds of Upper Cretaceous age appear, probably succeeded by Tertiary as we go north. On the San Miguel and Dolores Rivers, and extending westward, the rocks are sandstones. There are broad folds extending across the country whose axes are parallel, the general direction being northwest and southeast. Between the San Miguel and Dolores, the Dakota group forms the floor. Beyond the Dolores, the red beds prevail, capped with isolated patches of Jurassic shales, and underlaid with beds of Carboniferous age. The latter show only in few places. The drainage here has two general courses at right angles to each other. The main streams flow in a general northwestery direction.

In the Sierra la Sal, the prevailing rock is a beautiful porphyritic trachyte, which in some places has included masses of Cretaceous shales. One of the most prominent peaks has a capping of sandstone, which was lifted up by the eruption of the mass, the base of the peak being entirely of trachyte. There are evidences of glacial action here. Northwest and west of the group, the red beds have the *roches moutonnées* form, beautifully seen from the summits of the mountains.

The Abajo Mountains are of porphyritic trachyte, similar to the Sierra la Sal, as are the mountains about Lone Cone, which properly belong to the district assigned to the San Juan division.

The work of the fourth division, directed by G. R. Bechler, extended over several isolated areas, all situated between meridians 104° 30′ and 106° 30′ and parallels 38° 40′ and 40° 30′, or from the foot-hills of the Rocky Mountains to the Upper Arkansas and Eagle Rivers, and from a point six miles south of Pike's Peak to within fifteen miles of Long's Peak.

In this district, the entire Middle and South Parks are located, and three of the large rivers of the West, the Arkansas, Grand, and Platte Rivers, together with several of their large tributaries, have their origin. The principal branches are Blue, Snake Williams, and Frazer Rivers on the west slope, and Tarryall, Fountain qui Bouille, Bear, Clear, Saint Vrain, Boulder, Thompson, and Buckhorn Rivers on the eastern slope.

The main Rocky Mountain Range and its minor ranges are, in this district, peculiarly complicated; for the latter, at times, on account of their height and magnitude, seem to lose their subordinate character, and become independent ranges, while the main range contains groups or clusters of peaks so complicated in their form and connection, that it requires close observation on the part of the topographer to lay down the true drainage.

Among the minor ranges, the Park, Williams or Blue River, Gore's, Tarryall, and Platte River Ranges rank in height among the largest, while for extreme ruggedness the Gore and Tarryall Mountains cannot well be surpassed. In this district, the great mining industries of Colorado are found.

The geographical features of this area are as follows:—Between the Argentine and Georgia Passes, a ridge of mountains diverges from the main chain and follows a course about southeast, connecting with the mountains near the Pike's Peak group on its west side. This is the Tarryall Range, a rugged and abrupt granite wall, with several peaks over 12,500 feet in height, and most of the others rising above timber-line. The greatest depressions in this range are where the Tarryall and South Platte Rivers break through in cañons, and where the Ute Pass and Kenosha Pass afford an entrance to the South Park. To the east of the Kenosha Pass, a few miles, the Tarryall Range separates into two ridges, which run nearly in an eastern direction. The northern ridge borders the south side of the North Platte River, and is called the Kenosha or Platte River Range.

After completing the survey of Platte River, Tarryall, and the South Park districts, Mr. Bechler ascended the Arkansas Valley, crossed the Tennessee Pass, and examined the country that lies between the Eagle and Blue Rivers, of which very little was known. This territory is bounded on the south by the imposing mountain masses of the Mount Lincoln group, and on the east by the cliff-walls of the Blue River Range, and on the northeast by Gore's Range, with its needle-shaped peaks extending for twenty miles like sharp pinnacles.

In completing the survey of this district, Mr. Bechler joined, by his topographical work and triangulation, three separate surveys of previous years.

Crossing Gore's Range and the Blue River, Mr. Bechler passed through the Middle Park and over the Boulder Pass to the sources of the Big Thompson Creek, an important stream rising on the east side of the Long's Peak group. Much excellent work was done in the ridges of hogbacks at the east base of the mountains, thus bringing the season's labors to a most successful termination. One hundred and six stations were made; barometrical elevations were 450; and the number of elevations taken with the gradienter were about 6,000.

The party under Mr. Gardner had made but four stations when it was prevented from further prosecution of that duty by Indians. One of the stations occupied was very important, viz, the Sierra la Sal Mountain, which enabled Mr. Gardner to secure an excellent set of observations, thus extending the triangulation far into Utah, and connecting our eastern work with the great Colorado River of the West.

During the latter part of the season of 1874, Mr. W. H. Jackson, the photographer of the United States Geological Survey, in connection with Mr. Ernest Ingersoll, visited the southwestern portion of Colorado for the purpose of photographing the ruins which rumor had placed in the cañons of the Mesa Verde and about El Late. The season was far advanced, and there was but little time for investigation, yet the eight days that were actually devoted to the subject brought to light a group of ancient habitations so novel in their construction and position that they have excited a very general interest. The results of the trip, as published in Bulletin No. 1, second series, of the Survey, have already been widely distributed. The illustrations secured by photography, and then reproduced by photolithographic processes, have done much to popularize and render familiar the leading features of the subject, and, showing as they do all the phases of the eccentric methods of these ancient builders, has made them an authority, and they have already been reproduced in a number of later publications.

The first trip proving so successful, Mr. Jackson was dispatched again this season to the same region with instructions to ascertain, as far as possible, the extent and distribution of these ruins north of the present Moquis Pueblos. Associated with him in the enterprise was Mr. E. A. Barber, special correspondent of the New York Herald. A guide, two packers, and a cook constituted the whole party, and then, with six weeks' supplies, the party started from Parrott City, on the head of the Rio La Plata, August 27, the general course being down the Rio San Juan to the De Chelly, up that to near Fort Defiance, and then over to the seven Moqui "cities". Returning, they crossed the San Juan at the mouth of the De Chelly, and traveled northward to midway between the Sierra Abajo and La Sal, and then returned to the starting-point across the heads of the cañons, which run southward to the San Juan.

The Upper San Juan, Mesa Verde, and El Late regions came within the area assigned Mr. W. H. Holmes, who, in addition to his geological investigations, made a special examination of the archæology of the region, bringing out with his ready and artistic pencil even more wonderful ruins (of the same general class, however) than were found by Mr. Jackson the season previous.

Traveling westward to the head of the McElmo, a day was spent in the further investigation of that interesting locality. A number of new ruins were discovered, but in no way differing from those already figured. The extreme heat of the atmosphere and the aridity of the country prevented more than a superficial examination of the many side-cañons which debouch into the main one. Enough was seen to determine satisfactorily that ruins were to be found only in the near vicinity of tillable land and in those cañons which had alluvial bottoms. This fact held good in the other regions; for in no case could a single vestige of any habitation be found in the sterile, rocky gorges removed from cultivable ground. The ideas of the ancient inhabitants of these houses as to good farming land would hardly come up to that of an eastern farmer, yet a strip of bottom-land only fifty yards in width at the bottom of their deep cañons would yield maize enough to subsist quite a town. The supposition that they were an agricultural people is strengthened by the fact that in the vicinity of any group of ruins there are also a number of little "cubby-holes", too small for habitation, but very evidently intended for "caches", or granaries, and the large towns contain small apartments that must have been for the same use.

The only known water in the country, short of the San Juan, over forty miles distant, was on the Hovenweep, near the town which was discovered last year, thus necessitating the retraversing of so much of the country. A day spent in some of the tributary cañons developed no remains of any importance, although every little side-cañon contains traces of former occupation by the town-builders. To the west of the Hovenweep is a high, level plateau, separating it from the cañons of the Montezuma, and running north and south, from the waters of the San Juan to those of the Dolores. Upon this were found the remains of many circular towers, all of about the same size, twelve to fifteen feet in diameter. They are generally almost entirely obliterated, but in two or three cases portions of the wall, twelve to fifteen feet high, of well-built masonry, were found. This being a sandstone mesa, a thousand feet above the surrounding valleys, does not contain a spring or any water except such as collects in the water-pockets after a shower. The soil upon its surface is thin, and in places blown off clean to the bed-rock. Grass, cedar, and artemisia flourish; in fact, it is most excellent grazing-land, and, as cultivation was out of the question, these people must have had herds of sheep or goats, which they brought up here to graze during the winter, just as the Utes and Navajoes do at the present time, and these towers were built as places of refuge or residence for their herders.

Eight and ten miles below the Hovenweep town, are two groups of ruins worthy of note. The first is built upon an almost perfectly rectangular block of sandstone, which occupies a prominent position on a spur of the mesa. It is thirty-eight by thirty-two feet, and twenty feet in height, as true and as level as though set by masons. The summit is entirely covered with the work that was built upon it, very evidently for merely defensive purposes, for directly at the foot of the rock, at its south side, was the habitation of the family. A line of wall forty feet square incloses a space, within which was another building resting against the rock itself, the roof of which served as a means of access to the rock above. Two miles below, where the McElmo comes in, and upon the point of the mesa, are other similar ruins, but built much less regularly. Upon one of the faces of the rock is an inscription chipped in with some sharp-pointed instrument, and covering some sixty square feet of surface. Figures of goats, lizards, and human figures abound, with many hieroglyphical signs. The top of the mesa afforded much food for speculation in the interesting remains there discovered. The extreme point was a perfectly flat, level table, fifty by one hundred yards in diameter, with perpendicular walls of from fifty to one hundred feet on all sides, excepting the narrow neck which connected it with the main plateau. Across this neck, a wall had been built to keep off either human or beast, and rendered the place perfectly isolated. Inside, nearly the entire space was subdivided into small squares and double-walled circles formed by slabs of stone set on edge, each square, about three by five feet. The supposition has always been that these were burial-places. They were dug down upon to a considerable depth without discovering anything. Here the soil was thin and light, so that the labor of excavating was easy. A number of the squares were cleaned out to the bed-rock beneath, which in some cases was not more than a foot below the surface, but without discovering anything more except that in every case the earth had been burned, and a thin layer of charcoal remained. The question arises as to whether these people might not have been cremationists.

The Rio San Juan at the mouth of the McElmo is a stream averaging one hundred feet in width and three to five in depth, flowing in great curves that almost touch upon themselves again, and bordered with dense groves of cottonwood. The bottoms are from one to three miles in width, and run back over sage-covered benches to the sandstone bluffs, picturesque in outline and color, which rise from five hundred to one thousand feet above the river. They gradually close in upon the stream until it is finally lost in the great cañon below the mouth of the De Chelly.

Twelve or fifteen miles down the river brought the party to the first important ruins, although the older, almost unrecognized "indications" were abundant everywhere. At that point, the bench-land juts up over the river, and almost upon the brink is a quadrangular structure one hundred and sixty by one hundred and twenty feet square, with a small open court facing the river. A singular feature in its construction was a semicircular apartment in the center of the building, and the rear of the court, about the outer circle of which was ranged a series of seven other apartments averaging thirty-five by fifty feet. Under the bluffs, and almost overhanging the stream, were a row of little cave-houses. Other cave-houses were niched in the cave-like recesses of the bluffs for some distance above and below.

Some ten miles farther the bordering bluffs came down quite near the stream, in some places overhanging it. Cave and cliff ruins occurred frequently in them. Upon the south side of the river, an important cave ruin was discovered, which was quite remarkable in its way. Imagine a perpendicular bluff nearly three hundred feet in height, the upper half of which is a firm, white sandstone, and the lower half a dull red, soft, and friable variety. Time has excavated an almost perfectly hemispherical cave from this bluff, equally divided between the two kinds of rock. It is two hundred and fifty feet wide, two hundred feet deep, and the same from top to bottom at its outer face. Midway from top to bottom, and running completely around the half-circle which formed the back of the cave, are two benches, upon the upper of which is built the town, or series of rooms, two hundred feet in length in the aggregate, the lower serving as a walk, or promenade, from which access could only be had by ladders. A little to the left of the center is the principal building, consisting of three rooms, each two stories in height, and now standing twelve feet high. Adjoining it on the right is a long row of twelve apartments, built as a solid block, and on the left an open space of sixteen feet, and then another small building. In the open space were four holes, four inches in diameter and twelve deep, drilled into the rock, serving evidently as post-holes for a loom.

All the rooms have been burned out clean, so that not a vestige of woodwork remains. The walls are remarkably well preserved, the adobe mortar on the inside still retaining the impression of the delicate lines on the thumbs and fingers of the hands of the builders. Impressions of the whole hand were frequent, showing them to have had small and finely formed hands. Corn-cobs and pieces of pottery were found imbedded in the mortar. In the center of the larger rooms, beneath the *debris*, were found the fire-places, circular excavations, which still retained the charred wood and ashes of aboriginal fires. Perched up in one of the houses, under a great dome of overhanging rock that distinctly echoed every word uttered, with a steep descent of over one hundred feet to the broad, fertile bottoms, handsome groves, and meandering course of the river, these old, old people, whom even the imagination can hardly clothe with reality, must have felt a sense of security that even the inroads of the barbarian northern tribes could hardly have ruffled.

Omitting mention of large numbers of ruins which are clustered along the San Juan, the next important group discovered, for this is the first time any of these have been brought before the world, were those of the Rio De Chelly. The party reached this point August 7, the very hottest portion of the year, in a region noted for the intensity of the scorching rays which radiate from its bare plateau of white sandstone. The average temperature throughout the day in the sun was 140°. The temperature of the water in the river, in the midst of the rapid current, was 88°, and that was the coldest water to be had.

The Rio De Chelly, for a distance of about thirty-five miles above its mouth, is so cañoned, and the wash (for the bed of the stream is perfectly dry the greater portion of the year) cuts from wall-rock to wall-rock so frequently that it is impossible to travel up it except in the bed, and that is so tortuous and rocky in places that it would be difficult, if not impossible. Making a detour to the right, the first opening into the cañon was reached ten miles above. Here, an interesting and extensive ruin was found, which was so well preserved that it seemed to have been vacated less than a score of years, and so near like the workmanship and manner of building of the present Moquis that it would not be difficult to imagine them lurking among the deserted rooms. Thi ruin was situated in a long cave-like bench, or mesa, running along the face of a perpendicular bluff some fifty feet above its base, and a total length of nearly three hundred yards. The town was irregularly, but compactly built, conforming to the rock upon which it was placed, the rooms arranged in a single row most of the way, but at either end bunching up to two and three deep. A ground-plan shows seventy-five rooms, with many little irregular "cubby-holes", with a total length of 548 feet. A few yards farther to the right, a half-dozen detached buildings, cisterns, and reservoirs yet remain perfect enough to show their purpose. In the center of the mass was a well-preserved circular apartment, a little below the general level of the others, that was probably an *estufa*. The goat-corrals were inside between the houses and the bluff. Digging beneath the *débris*, several pieces of finely-preserved pottery were found, the same finely ornamented and glazed ware of which the fragments are universally scattered over the whole country. Beneath the center of the town, there was found in one group some whole jars of about two gallons capacity each, of the gray indented ware, but they were too fragile to transport upon pack-mules. Besides the pottery, many stone implements and arrow-points were unearthed. Another detour to the right, this time over an elevated plateau of white sandstone, across which were drifted great dunes of white sand, brought the party to the famous, so-called, diamond-fields of Arizona, about which there was such an excitement in 1872. Lingering on its bare red plain, upon which the sun beat with redoubled intensity, only long enough to gather about a pint of garnets, which were of excellent quality and very abundant, camp was made at the foot of a side-cañon, which came in from the west, and was known as the Cañon Bonito Chiquito. Another group of ruins occurred here, not in a large town, but in scattered houses, both up and down the De Chelly and the Bonito. A marked feature was great reservoirs, in which there was, even now, abundant and excellent water. Two or three miles below, in the cañon of the main stream, was a well-preserved two-story house, standing upon a bench elevated fifty feet above the valley, and overhung by a great roof of rock that effectually shielded it from the storms. Near by was a great natural reservoir filled with good water. Another five or six miles, and the cañon of the De Chelly opened out into a great valley, from one to three miles in width, and extending up to the foot of the great cañon near Fort Defiance. Twenty-five to thirty-five miles above the Bonito are some peculiar table-rocks and monuments that form notable landmarks. The ruins are now scarce, only a few being met with in the caves at the side of the valley. The bottom-lands bear the impress of very numerous ruins, adobe, very likely, that are now almost entirely obliterated, and would hardly be noticed were it not for the broken pottery.

At the head of the valley of the De Chelly, the trail turned off to the southwest, just above the upper edge of the great white mesa. Taking only two others, Mr. Barber, and Lee, the guide, and sending the remainder of the train back some fifty miles, where there was suitable grazing, Mr Jackson continued over to the Moquis Pueblo, seventy-five miles distant, with only the photographic apparatus and supplies for five days. Tequa was reached by noon of the following day. As these pueblos have been so frequently described and illustrated, the party spent only two days and a half among the six most easterly towns, viz, Tequa, Se-chum-e-way, Moqui, Moo-she-neh, Shong-a-pah-wee, and She-paul-a-wee. Photographs of each of these were made, and numerous sketches illustrating their habits, dress, and occupations, collections of recent and ancient pottery, and tools, and other objects of interest, were made. The comparison between the workmanship of the northern town-builders and these Moquis was very much in favor of the former. The highest perfection was reached in the cliff-houses of the Rio Mancos, where some of the houses were marvels of finish and durability; and, then traveling toward the Moquis, there is à gradual merging of one style into the other, from the neatly-cut rock and correct angles to the comparatively crude buildings now inhabited.

Retracing their steps to the San Juan at the mouth of the De Chelly, the party now traveled northward toward the Sierra Abajo, up a stream known as Epsom Creek, from the water which is found near its head tasting and operating like that salt. The usual indefinite ruins which occur on the lowlands continued up this valley over thirty miles. To the west was a great labyrinth of cañons running off into those of the great Colorado, an examination of some of which discovered many cave- and cliff-houses and towns, all of the same general type as the others. The ruins gradually diminished as they approached the Sierra Abajo, and several days spent in the examination of the cañons and plateaus about it and the Sierra La Sal failed to bring to light any more evidences of their occupation.

Nearly opposite the Sierra Abajo, or Blue Mountains, as they are locally known, head the great cañon and valley of the Montezuma, which empties into the San Juan. Here the bottoms of the cañons have once supported a very thickly settled community. There is almost a continuous series of ruins for a distance of twenty-five miles; this in one cañon only, and all the others contain numerous remains, chiefly in cliff-houses and towns. In the main cañon first spoken of are two ruins notable for the size of the stones employed in their construction. In one, built upon a small isolated tableland in the middle of the valley, are stones set upon end, six feet in length by eighteen inches square, and ranged along the walls a distance of twenty-five or thirty yards. Another case is where stones seven feet in height (above ground) and twenty inches square are standing perpendicularly about five feet apart, and form one side of a wall inclosing the ruins of a large, important building. Throughout the cañons, every available defensive point has been utilized, and is now covered with the remains of heavy walls and large blocks of houses. Another singular feature was the number of holes cut into the perpendicular lower wall of the cañon for the purpose of ascending the rocks, holes just large enough to give hand- and foot-hold, and leading either to some walled-up cave or to a building erected above. Some of these steps ascend the nearly perpendicular face of the rock for 150 or 200 feet. On exposed surfaces, disintegration has almost entirely weathered away the holes, while on more protected surfaces they are deep enough to still answer their original purpose. The main western branch of the Montezuma contains the greater number and more important ruins of all northern tributaries of the San Juan west of the Rio Mancos. Water was found in a few pools near its head, and lower down running along in a small stream a distance of two or three miles, where it sank again. The bottoms are rich, and the present Indians, Utes, who occupy the country, raise good crops of corn without irrigation.

The result of this trip was the collection of a large number of utensils, both modern and ancient, stone arrow- and spear-points, knives and axes, photographs, especially illustrative of the most important ruins, and numerous sketches of everything of note. These results are fully elaborated in the several following portions of the present Report.

During the season of 1875 Mr. J. T. Gardner, then in charge of the primary triangulation, made four important stations in Southern Colorado, viz: West Elk Mountain, Leon Peak, North Mam, and Sierra la Sal. The last station is located beyond the extreme western boundary of Colorado, in Utah, and the observations were very complete and valuable. From this point the party under Mr. Gardner proceeded toward the Abajo Mountain, but were attacked by a lawless band of Ute Indians, and thus their season's work was closed. In the autumn of that year Mr. Gardner resigned his position on the survey to accept the very important one of director of the trigonometrical survey of the State of New York.

In order that every branch of scientific study and investigation might have proper attention, a competent mineralogist was attached to each division of the Geological Survey, as mines and mining features of the country were regarded of the highest scientific and economic importance.

During the prosecution of the work of the Survey, attention has always been paid to the development of the natural resources of the country traversed. Mineral and agricultural wealth has been the subject of especial study, furnishing, as it does, an indication of the future prospects, commercially and financially, of the territory that at the time may be explored. With a view to increase the scientific knowledge with reference to horizontal and vertical distribution of minerals, all occurrences have been carefully noted, and summarized in published catalogues. Since 1873, Colorado, one of the richest mining States of the United States, has been the subject of exploration. In accordance with the predominating industrial features of the country, particular attention was given to the investigation of its mineral riches. The mines of all the principal mining districts were examined by experts, and reports thereupon were published. Although the character of these reports was necessarily such that no direct benefit could therefrom accrue to any individual mine, it is certain that the discussion of such districts has furnished general data, the correctness and impartiality of which will go far toward assuring mine-owners and workmen of eventual success and remuneration in the work they have undertaken. It has been a prominent feature of this Survey to explore (immediately after discovery) any new district that may have been announced, and to give, as speedily as possible, to the public the benefit of such explorations. Thus, the first authentic reports relative to the famous San Juan mines are to be found in the publications of the Survey. Owing to the organization of the parties in the field, examinations of such nature can readily be made without the loss of too much time, and at the same time with the coöperation of civil engineers, which may at times be desired by the geologist or mining expert. In consequence of this arrangement, it is possible for each party to obtain, in a by far shorter period of time than would otherwise be required, information that ranks high in accuracy and completeness.

In connection partly with the examination of mines, special attention was given to the occurrence of minerals at various localities throughout the State. The result derived has been embodied in a catalogue of Colorado minerals. As was expected, it has been gratifying, and the publications of the Survey are thus able to present a list of minerals from Colorado, exceeding in number 200 species. Attention has been directed more particularly—for obvious reasons—to those that there rank as "ores", and their horizontal distribution affords important information as to the character and location of the mining districts. At the same time, their chemical constitution furnishes a hint as to the relative value of the mines in which they occur as ores. Apart from this more practical consideration, the data collected are an addition to mineralogical science. Comparatively little is known thus far regarding the distribution of minerals throughout the earth, and every additional catalogue, if conscientiously prepared, giving sufficient details, is a contribution to science,—a contribution which, from its character, may, when the collection of facts is complete enough, lead to important and valuable generalizations.

Every attentive reader must have noticed that there is, and has been of late years, considerable difference of opinion among geologists and palæontologists, each eminent in his own department, as to the true geological age of several of the formations hitherto studied in the Western Territories. This difference of opinion does not arise from any failure of each to understand his own facts correctly, but because American scientists have heretofore been content to use a foreign standard, believing that it was inflexibly applicable to the whole world. Accumulated experience has shown that the various evolutional tides of organic life have not advanced at the same *rate* in all parts of the world. Thus, while we find that a certain grade of vertebrates, invertebrates, and plants are associated together in the strata of, and collectively characterize, a certain geological period in Europe, in America we find that the same grade of plant life was evidently reached much earlier, and the same grade of vertebrate life was continued much later, etc. In short, using the European standard, we find in America an actual mingling in the same strata of Cretaceous and Tertiary types of organic remains. From the fact that all fossiliferous strata are sedimentary accumulations in seas or other bodies of water, the remains of invertebrate animals are far more abundant than any other, because they lived in and upon the sediment while it was accumulating, while the remains of land animals and plants could have reached the places of their entombment only from the shores. Thus, invertebrate fossils have always been regarded as more reliable and valuable than any other in determining the geological age of the strata containing them. Indeed, they have generally been regarded, as they often are, the only available evidence, and entirely sufficient. It was with this generally accepted invertebrate standard in mind, that all the early explorers of the geology of the Western Territories referred the various groups of strata they found to the different geological periods, and the differences of opinion have arisen through subsequent investigations of the fossil plants and vertebrates of the same groups. The result of all this is not confusion, but beautiful harmony. It shows that we have in Western North America an unbroken series of strata, ranging from early and unmistakable Cretaceous to late and equally unmistakable Tertiary. There are consequently several groups of strata, transitional in their character, that different specialists, viewing their fossil contents from different standpoints, are disposed to place a little higher or lower in the geological scale, as the case may be. This is a perfectly natural condition of things; for where the geological series is complete, no man can say where one formation ends and another begins.

In 1870, a photographer was attached to the Survey, and the results arising therefrom have fully proven the wisdom of thus adding a most useful art to the organization. An unthinking public might imagine that the employment of photography in connection with the work of the Survey is more ornamental than useful, and that the sole business of the photographer is to secure in the field a number of pictures merely to please the eye, and not for practical and scientific use. This idea is so at variance with those believed to be popularly entertained as to practical economy, that it seems worth while to enumerate some of the many useful applications photography may be put to. Although in its infancy, it has been so successfully applied to many branches of Government work that it is now considered a necessity of any well organized expedition, or in any office where there is any considerable amount of illustrating or designing, notably so with the English and continental governments, where large schools of instruction are supported for the sole purpose of turning out skilled employés.

In our own country, photography was first used to any extent by the Government during the war in securing series of illustrations for the Surgeon-General and Engineer bureaus, and since then for the reproduction of the drawings of the Supervising Architect, and other work of like nature for the United States Treasurer's office. This establishment is the nearest approach to those maintained at Woolwich, Berlin, Paris, and Vienna, but is insignificant in comparison with them.

After the close of the war, the previous good services of photography in the field recommended it to the exploring and surveying expeditions, and it was extensively employed by them. A photographic corps was attached to the Survey in 1870, and it has continued its use ever since. Besides the constant and important use made of these illustrations in the preparation of the geological and topographical reports, copies of them are now used by professors in all the principal colleges of the land to illustrate their geological teachings.

The photographic work has been under the direction of Mr. W. H. Jackson, an experienced landscape-photographer, who has made an average of 400 negatives each year, ranging in size from the stereoscopic up to plates 20 by 24 inches square. The first year the work lay entirely within Wyoming and Utah Territories. In 1871 and 1872, the expeditions to the Yellowstone regions afforded opportunities that were not lost, and the splendid series of photographs then secured have retained their popularity to this day. In 1873, 1874, and 1875, the work was transferred to Colorado, and the operations of the first season were confined to the mountain-ranges bordering the Middle and South Parks and the Elk Mountains beyond. It was on the trip of 1873 that Mr. Jackson made one of his greatest successes, in securing a fine view of the Mountain of the Holy Cross. In 1874, the views covered a much greater range of subjects, taking in the Parks, the San Juan Mountains, and the remarkable ancient ruins south of the La Plata Mountains. These ruins were first brought to the notice of the world through the photographs made of them by Mr. Jackson. The interesting results secured the previous year justified the sending of Mr. Jackson to the same region again in 1875, but extending his journey down the hitherto unexplored San Juan to the mouth of the Rio de Chelly, and then to the Moquis Pueblos in Arizona, many interesting ruins were discovered, which were fully described and illustrated in the Bulletin and also the Annual Report for that year. Returning from Moqui via the De Chelly, the plateau country between the Sierra Abajo and La Plata was found to contain many interesting ruins, and was thoroughly photographed. An interesting feature in connection with this season's work was the success attending the production of a series of 24 by 20 inch negatives of the most prominent points in the San Juan Mountains, the very first plate of this size ever made among the Rocky Mountains.

From the two thousand or more negatives made during these preceding six years, we must ascertain what return they have made for the time and money expended upon their production, and entirely aside, too, from their æsthetic qualities, and the pleasure which lovers of the beautiful and picturesque may derive from them. They have done very much, in the first place, to secure truthfulness in the representation of mountain and other scenery. Twenty years ago, hardly more than caricatures existed, as a general rule, of the leading features of overland exploration. Mountains were represented with angles of sixty degrees inclination, covered with great glaciers, and modeled upon the type of any other than the Rocky Mountains; the angular lines of a sandstone mesa, represented with all the peculiarities of volcanic upheaval, or of massive granite, or an ancient ruin with clean-cut, perfectly squared and jointed masonry, that would be creditable to modern times. The truthful representations of photography render such careless work so apparent that it would not be tolerated at the present day.

One of their most evident practical uses is in securing faithful views of the many unique and remarkable features of newly explored territory, that are subsequently to be reproduced, by engraving, in the Reports. Especially to be noted in this line are the views of the remarkable hot-spring deposits of the Yellowstone National Park, where the exceedingly intricate and delicate tracery of the incrustations, that would defy the most expert pencil, is readily secured in all its varied forms. So it is also with the great cañons, grand waterfalls, impressive mountain masses, the craters of old volcanoes, and beds of ancient lakes, the faulting and folding of the strata, and many other features, of which the geologist finds it necessary to have accurate representations for the illustration of his subjects. To the topographer, also, it is of great assistance in enabling him to represent correctly the surface of the country upon his map; panoramic views for that purpose being made from the summits of the highest peaks.

In ethnography, it gives us faithful portraits of the varied families of our great Indian population, representing with unquestioned accuracy the peculiar types of each; their manners of living, dressing, occupations, and mythical inscriptions. In archæology, how important it is that the uncompromising lens portrays the at present almost inaccessible ancient ruins of the Southwestern Territories! These photographs can be sent all over the world, and practically answer the purpose of a personal inspection. The photographs of the ancient ruins have been of great assistance in the construction of the models of the remarkable cliff-houses that have been prepared by some of the members of the Survey. In the office, the uses of photography are manifold: copying the maps of the topographers to a given scale for the engraver or photolithographer, and also rare documents or pictures; the production of views for the stereopticon for lectures; and for enlarged transparent photographs on glass from small originals, whereby the minutest feature of rock structure, the varied details of an old ruin, or the grand and imposing mountain mass, are brought so vividly before the eye that they can be studied to much better advantage than in nature, the mind being in rest, and far from the perplexities of the surroundings.

The total number of negatives in the possession of the Survey are now nearly four thousand. Of these, upward of twelve hundred are of Indians photographed from life, representing the most prominent individuals from seventy-four different tribes. The great Sioux family is in this manner well represented, and among them are Red Cloud, Spotted Tail, and Sitting Bull. The Apaches, Comanches, Cheyennes, Utes, Navajoes, etc., are also well represented by excellent negatives, showing not only their *personnel*, but many of their customs.

The occasion of the display at the International Exhibition at Philadelphia led to a desire to represent as forcibly as possible some of the recent discoveries of the Survey of remarkable ancient ruins in Southwestern Colorado, and the success of Mr. Holmes with the Elk Mountain models suggested the same means for effecting this purpose. There are six now completed of archæological subjects, as follows:—

The Mancos Cliff House, by Mr. Holmes, represents a ruin in an exceedingly well preserved condition, perched upon a little shelf, or niche, in the face of a bluff, 800 feet vertically above the valley below. The model is 30 by 40 inches in dimensions, and the scale four feet to one inch.

An ancient Cave Town in the lower cañon of the De Chelly, near the San Juan River, represents a very interesting and extensive ruin, built along a narrow shelf, or bench, seventy-five feet above the valley, and overhung by the bluff. The whole ruin is nearly six hundred feet in length, with originally about one hundred or more apartments. The model as constructed by Mr. W. H. Jackson is forty inches in length, and shows one-third of the ruin; the scale is six feet to one inch.

A restoration of the above, also by Mr. Jackson, is the subject of the third of the series. In this, the buildings are built up to the condition in which they were originally supposed to have been before their desertion. They show many points of resemblance to the present Moquis in Northwestern Arizona, noticeably so in the use of the ladder to reach their houses. Groups of miniature people have been arranged about the model, representing them engaged in various occupations, with their pottery and other domestic utensils.

The Great Triple Walled Tower, on the McElmo, by Mr. Holmes, is a horizontal model thirty inches square, representing, on a scale of four feet to one inch, the ruins of an exceedingly interesting circular stone tower in Southwestern Colorado.

The fifth of the series is a model of a Cliff House, in the bluff of the lower cañon of the Rio De Chelly in Arizona, on a scale of three feet to one inch, and of the same size as the Mancos model. This is especially intended to show the manner in which its former occupants passed up and down the steep face of the bluff in which it is built, by steps hewn in the rock.

A model of the Pueblo of Tequa in Northeastern Arizona, represents, upon a scale of eight feet to one inch, one of the most picturesque and interesting of the villages of the Moqui Indians. It is perched upon the summit of a narrow plateau of bare rock, 600 feet in height (only the upper 100 feet of which are included in the model), showing the pathways cut in the solid rock, affording the only means of access, and up which are carried all of the wood, water, and provisions of the inhabitants. This last forms a fitting accompaniment to the preceding, as the Moquis are supposed to be the descendants, or a remnant, of the same people who built the houses and towers represented by the models of the foregoing series.

The last two have been completed since the closing of the International Exhibition. The production of model representations for distribution among colleges and institutions of learning will be continued as new subjects are obtained.

It will be seen also by the publications of the Survey that the ethnography and philology of the Indian tribes of our Western Territories are receiving a fair share of attention. Several papers on this subject have been printed in the Bulletin; and one of the most important volumes on the subject ever published is about to be issued, entitled "The Ethnography and Philology of the Hidatsa Indians", by Dr. Washington Matthews, U. S. A. They are one of the three stationary tribes that have lived on the Upper Missouri, near Forts Berthold and Clarke, from time immemorial, are very closely allied to the Crow Nation, which dwell in the Yellowstone Valley, and belong remotely to the great Dakota stock.

This volume may be regarded as a most carefully prepared analytical monograph, and cannot be otherwise than an acceptable and timely contribution to Indian philology to scholars all over the world. Other contributions will follow from time to time as they can be prepared. A biographical and historical catalogue of some of the prominent Indians of about seventy-five different tribes, prepared by W. H. Jackson, will be published during the present year.

Zoölogy has always been recognized by the Survey as not only a legitimate and proper, but also very important and practically valuable collateral department of scientific research, the relations of which to geology and geography are natural and intimate. In conducting the Survey, from the very beginning, the services of zoölogists have been engaged both in the practical work of the field and in the technical researches of the museum and the library. Among the collaborators in this department are included not a few of the most eminent zoölogists of America, the constant object being to secure the services of the most accomplished specialists in each particular branch of zoölogy. The results of this policy are witnessed, not only in the yearly accessions of fresh material in the way of specimens, but in the numerous zoölogical publications of the Survey.

The Annual Reports contain various papers on zoölogy, by gentlemen officially connected with the Survey. The Bulletins are still richer in this department, containing numerous papers by such distinguished naturalists as Packard, Coues, Ridgway, Allen, Scudder, Osten Sacken, Uhler, Hagen, and others no less eminent in their specialties. One of the miscellaneous publications by Dr. Elliott Coues, U. S. A., on the Ornithology of the Missouri Region, is a closely printed octavo of 800 pages, which is based primarily on the collections of the Survey, and constitutes a formal and authoritative treatise on a majority of the birds of North America. In the magnificent series of quarto publications, or "Monographs", in which the results of original and exhaustive researches are published, zoölogy again receives due attention. One of the volumes contains Thomas's revision of the *Acrididæ*, or Grasshoppers, a most important and timely contribution. And here it may be remarked that if the "grasshopper problem" be solvable, we are likely to have the matter settled by the United States Entomological Commission, and all available scientific knowledge is to be brought to bear upon this question of vital national importance. Another volume of the series consists of Packard's splendid monograph of the Geometrid Moths, which has received the highest possible commendation from all quarters. A third will consist of Coues's and Allen's Monographs of the North American *Rodentia*, the largest order of mammals, and one sustaining the most important economic relations with the agricultural interests of the nation.

In thus glancing at the zoölogical work accomplished by the Survey, we do not include work done in fossil zoölogy, or palæontology, since this comes more distinctively within the field of geology itself. But to the study of the extinct faunas and floras of the West have been applied the labors of such preëminent palæontologists as Joseph Leidy, E. D. Cope, F. B. Meek, Leo Lesquereux, and others, whose results are beyond praise.

During the progress of the survey of Colorado, several preliminary maps, on small scales, have been published in the Reports. Of these it is necessary to specify but a few.

In the report of the field-work of 1873, there is a drainage-map of the area surveyed—18,000 square miles—on a scale of eight miles to one inch.

The Report for 1874 contains a preliminary map in hachures, on a scale of ten miles to one inch, of all the work done in the State up to that time; a map of the Elk Mountains, topographical and geological, on a scale of two miles to one inch; and a preliminary map of the eastern front of the Rocky Mountains, on a scale of four miles to one inch.

Owing to the need of the settlers, a drainage-map of the San Juan country, on a scale of four miles to the inch, was also issued, and afterward incorporated in the Report. Besides these, there are many small geological maps of special areas.

The atlas of Colorado, now nearly ready, will contain :—

First. Title-page, legend-sheet, and map of the primary triangulation.

Second. A general drainage-map of the State, on a scale of twelve miles to one inch.

Third. An economic map, colored to represent areas of arable, pasture, timber land, etc.

Fourth. The final map of the State (including small parts of New Mexico, Arizona, and Utah), in six sheets, on a scale of four miles to one inch, in contours 200 feet apart in vertical distance. The area embraced in these maps is about 70,000 square miles.

Fifth. The final geological map of Colorado, in six sheets.

Sixth. A general geological map of the State on a scale of twelve miles to an inch.

Seventh. Two sheets containing the general sections across the State, illustrating the geological map.

Eighth. Two sheets of panoramic views.

When finished, Colorado will have a better map than any other State in the Union, and the work will be of such a character that it will never need to be done again. Colorado will never support so dense a population that a more detailed survey will be required. Accurately located points on which the local surveyors can base their work are abundant in all parts of the State. The work of the geological survey should always precede that of the land survey, as the former indicates what portions of the country are suited for settlement and should be sectionized.

It is the intention of the Survey to continue the collection of all geographical data concerning the relief of the country west of the Mississippi River. These collections of heights have been published from time to time, in a succession of editions, under the title of "Lists of

Elevations", the first edition being by Professor Cyrus Thomas, the three succeeding ones by Mr. Henry Gannett. The fourth edition, to be published in 1877, embodies the results of this collection up to date. It contains, among a variety of other matter, profiles of nearly all the railroads in the part of the United States above mentioned. The results given by these profiles have been made to accord, and the heights of several thousands of points on them have been determined with an approach to accuracy. This edition contains also the heights of many thousands of points determined approximately by means of the barometer. Heights of many thousands of mountain-peaks are given, from which very correct ideas of the ruling heights of the principal ranges may be derived.

The mean heights of the States and Territories and of the United States have been determined with an approach, at least, to correctness.

It contains also tables of the slopes of the principal streams of the West, which are of value in studying the important question of irrigation.

Besides the tables of heights, it contains a map of the United States, in approximate contours of 1,000 feet of vertical intervals, which, in a measure, embodies all the results of this department. Toward the improvement and ultimate perfection of this map, this work is to be mainly directed in future.

This map indicates not only, in a rough way, the height of any part of the country, and the areas above certain heights, but the magnitude, height, and general slopes of the great plateau underlying the mountain ranges of the West, the true *Sierra Madre;* the trends, mean heights, and geographical character of the ranges; and the areas covered by plains, plateaus, and mountains.

To express still more clearly the facts brought out by the map, it is the intention of the Survey to make shortly a relief model of the United States, on the basis of this map.

The Survey for the past two years has been accumulating the materials for a general geological map of all the States and Territories west of the 94th meridian, on a scale best adopted to the purpose of correlating, as far as possible, the different formations known over that area. Great confusion is liable to ensue by ignoring well established names and giving new and very restricted local names. Most of these names must eventually yield to the law of priority, and disappear in the light of a more general and systematic classification. The Cretaceous divisions can undoubtedly be extended all over the West, and the numerous Tertiary lake-basins may be correlated in time. In this way we may be able to understand more clearly the remarkable simplicity and unity of the structure of the entire Rocky Mountain region. It is true that the geology of very much of our country is as yet practically unknown, but some method can be adopted which shall distinguish such portions from those on which the work has reached a certain grade of excellence.

The delay in the publication of the Annual Report of the Survey for 1875 has been produced by causes beyond the control of the geologist-in-charge. The great increase of labor incident to the International Exposition at Philadelphia drew away much of the force that would otherwise have been expended in the preparation of reports. The Annual Report for the year 1876 will follow the present one in a few months.

The article on Economical Entomology, by Dr. A. S. Packard, it is claimed, will form a timely contribution, and will very properly precede the more exhaustive reports of the United States Entomological Commission. Professor J. A. Allen's valuable Memoir on the Bison is republished from the Geological Survey of Prof. N. S. Shaler, and by his permission, with numerous additions. The Annual Report will thus not only give a wider circulation to a most interesting and an exhaustive memoir, but serve also to call the attention of Congress to the wanton and useless destruction of our larger mammals all over the West.

The Survey is under obligations for important aid in the reduction of rates on the Union Pacific, Denver Pacific, Kansas Pacific, and Denver and Rio Grande Railways.

With the hope that the present Report will prove an acceptable contribution to our knowledge of the Western Territories, I have the honor to remain, very respectfully, your obedient servant,

F. V. HAYDEN,
United States Geologist.

HON. CARL SCHURZ,
Secretary of the Interior.

PART I.

GEOLOGY.

REPORT OF A. C. PEALE, M. D., GEOLOGIST OF THE GRAND RIVER DIVISION, 1875.

LETTER TO DR. F. V. HAYDEN.

WASHINGTON, D. C., *July* 1, 1876.

SIR: I have the honor herewith to hand you my report as geologist of the Grand River division for the season of 1875. As usual I refer to the report of Mr. Henry Gannett for topographical details, elevations, &c. We did not commence work until the 4th of July, and were stopped by trouble with the Indians on the 15th of August. We had therefore barely six weeks in which we were able to do any work. This will account for the brevity and somewhat incomplete state of the accompanying report. All specimens had to be abandoned.

My plan of working in the field was substantially the same as that followed in 1873 and 1874.

I have followed also my usual plan in the report, considering first the general features of the district, and taking up afterwards the special and detailed geological facts of each formation represented. I have also colored a provisional geological map.

Necessary absence during publication and rapidity of preparation must be my excuse for any errors that may appear in this report.

In conclusion, let me express my thanks to all the members of the party for their hearty co-operation.

With great respect, I remain, your obedient servant,

A. C. PEALE

Dr. F. V. HAYDEN,
United States Geologist-in-charge.

GEOLOGICAL REPORT ON THE GRAND RIVER DISTRICT.

CHAPTER I.

GENERAL INTRODUCTION.

The district assigned the northern or Grand River division for the season of 1875, lies between the parallels of latitude 37° 52′ and 39° 15′. On the west it is limited by the meridian 109° 30′ and on the east by the western limit of the work of 1874, which is approximately the Gunnison and Uncompahgre Rivers. In addition to this there is a narrow strip of country south of the Gunnison River, from 10 to 20 miles in width, extending from meridian 107° to 107° 30′. This lies between our work of 1874 and Mr. Wilson's for the same season. The entire area includes about 7,900 square miles, of which, owing to interruption of work by the Indians, the survey of only 6,000 square miles was completed. Of this, about 1,500 square miles are in the southwestern corner, and 500 north of Grand River.

The drainage of the district has two general directions, viz, northwest and southwest. All the streams are tributary to the Grand River, which is one of the forks of the Colorado River of the West. The greater part of the district is plateau in character; the Sierra la Sal being the only mountain group. The Lone Cone group lies in the district to the south, and will be fully described in Mr. Holmes's report for 1876.

The La Sal Mountains consist of three groups of isolated peaks, about thirty in number, forming a range about fifteen miles long and five miles in width; its general direction is about north and south. The drainage radiates from the mountains, the streams on the south and east flowing into the Dolores, while those on the north and west flow directly into the Grand.

The Abajo Mountains are partly in and partly outside of the district, lying in the extreme southwest corner. On account of the interruption of our work by the Indians, they were not visited. Excluding the mountain masses, which will probably not exceed 100 square miles in extent, the range in elevation is from 4,000 to over 9,000 feet. A comparatively small proportion of the country is fitted for agricultural purposes, farming land being confined to portions of the valleys of the Uncompahgre and Gunnison Rivers, and to some small valleys on the upper part of the Dolores, and a few of the streams draining the Sierra la Sal.

As already stated, a great part of the district is plateau-like. The levels are, however, above that of the streams; the latter cutting deep and, in some places, impassable cañons, which, with the exception of those occupied by the main streams, are dry the greater part of the year. They cut the plateaus into mesas. In another part of this report they will be referred to in more detail. The higher plateaus are timbered with pines and quaking-aspens; the lower ones are generally destitute of timber. Along the courses of the streams are groves of cottonwoods, which, however, are not numerous.

The geological features of the district are comparatively simple, there being no great uplifts nor many local disturbances. The sedimentary formations represented are all included under Carboniferous Triassic? (red-beds), Jurassic?, and Cretaceous. Exposures of metamorphic rocks are seen in several parts of the district, limited mainly to the bottoms of cañons where the streams have cut through the overlying sedimentaries. The areas covered with eruptive rocks are also limited.

In the southern and southeastern portions of the district are the overlying edges of the various trachorheite flows, whose sources of origin are the hign peaks of the Uncompahgre Mountains, still farther south, in Mr. Wilson's district for 1874. The rocks are trachytes interlaminated with tufas in horizontal layers. South of the Gunnison, between our district of 1874 and Mr. Wilson's district for the same year, they are underlaid by breccia deposits which rest partly on metamorphic rocks and partly on remnants of sandstone which are in all probability of Cretaceous age. Previous to the outpouring of these trachytic flows the country had evidently been subjected to considerable erosion, the sandstones in many places having been completely eroded, exposing the gneissic rocks upon which they were deposited. Besides this lava-covered region there are three distinct centres of eruption, viz, the Sierra la Sal, Abajo Mountains, and the Lone Cone group. The Sierra la Sal is typical of them all, and is composed of porphyritic trachyte which has been pushed up through the sedimentary layers which now dip away from the mountains. The greater part of the district is covered with sedimentary rocks, of which the Cretaceous formation is most largely represented on the surface.

South of the Gunnison River, as far west as the Uncompahgre River, the prevailing rocks, as we have already noted, are volcanic. The Cretaceous sandstones beneath show only occasionally in some of the cañons, and are rather of Lower Cretaceous than of Upper Cretaceous age.

In the Uncompahgre Valley, however, especially on the eastern side, Upper Cretaceous rocks prevail, outcropping in bluffs between the river and the cañon of the Gunnison, forming *mauvaises terres*. In the valley of the Gunnison, opposite the mouth of the Uncompahgre, in the district of 1874, they are well marked and were described in the report for 1874. The erosion of these beds has produced a barren, alkaline soil, in which, partly from want of water, vegetation does not flourish. In the immediate river-bottom, especially at the upper part of the stream, there is some good soil, but it is limited in extent. The Uncompahgre, San Miguel, and Dolores Rivers are approximately parallel, the general direction being a few degrees west of north. Between the San Miguel and Uncompahgre Rivers the country is a plateau which slopes gently toward the Uncompahgre from a point about 25 miles west of the river. At this distance is a crest parallel to the San Miguel. It is the edge of a monoclinal fold which, as we go toward the north, becomes faulted in places. Between the Uncompahgre plateau and the San Miguel is another plateau, (the San Miguel,) very nearly level, and from eight to ten miles wide. The floor of both these plateaus is the sandstone of the Dakota group, (Cretaceous No. 1.) Farther north, between the Gunnison and Dolores, the Uncompahgre plateau has the same width as it has farther south, but on the Dolores side there is oftener a fault than a fold, while on the Gunnison side there is a monoclinal fold. The red beds also frequently appear as the floor, the Cretaceous sandstones capping butte-like prominences.

One of the most curious features of the region is the Unaweep Cañon, extending from the Gunnison to the Dolores River. It is evidently the bed of an old stream which flowed either towards the Gunnison or towards the Dolores. At present there are in it two creeks, one a tributary of the Gunnison, and the other a branch of the Dolores. The latter is the principal stream. At the divide between the two creeks the cañon is about 1,200 feet deep, 900 feet of gneissic rock and 300 of red sandstones resting on the metamorphic rock. The dip of the sedimentaries is towards the east, and as they gradually become lower the creek is geologically higher. The granite wall, therefore, becomes lower and lower until the stream joins the Gunnison in the sandstones of the Dakota group, above the red sandstones and shales, (Triassic and Jurassic). Towards the west the cañon deepens rapidly until it is 3,000 feet below the general surface. The stream cuts across the line of folding and faulting on the west side of the plateau, and enters the red sandstones, in which it joins the Dolores. These sandstones did towards the west until we cross the Dolores and approach the Sierra la Sal, when the dip changes to the east.

North of the Unaweep Cañon, between it and Grand River, the Dakota group, which prevails to the southward, is almost entirely absent, the red beds forming the greater part of the surface. There is a series of cañons, and the general slope is toward the north. The western line of faulting continues for some distance, and then becomes a fold, and the eastern fold becomes at first a fault, and again a fold toward the north.

North of Grand River is a wide valley, in which are Cretaceous rocks, the bluffs bordering it being of Upper Cretaceous age, beyond which are Tertiary strata, forming the "Book" or "Roan" Mountains, which are in reality a series of plateaus, one above the other, with cliff-like edges, forming, in other words, a series of terraces. These we did not have any opportunity to examine, and only noticed them from a distance. Grand River, below the mouth of the Gunnison, is alternately in valley and cañon, most often in the latter. From the mouth of the Dolores it is in deep cañon, in red sandstone.

The San Miguel River and its branches cut deep and narrow cañons through the Dakota sandstones, leaving mesas between the different streams, all having the same general level. As we approach the Dolores, the Jurassic shales form the cappings of the mesas, the Cretaceous sandstones being completely eroded away. Still farther north the cañons increase in depth, and are cut through massive red sandstones, with here and there isolated patches of Jurassic beds on top, like huge monuments, while in the bottoms of the cañons beds of Upper Carboniferous age sometimes appear.

Between the San Miguel and the Dolores the Dakota group forms the floor. West of this are several broad folds whose axes are parallel, having a direction about northwest and southeast. Sometimes the Dolores River cuts across these folds, and again it follows the axes, generally occupying anticlinal valleys. The rocks here are Triassic? red sandstones, capped with remnants of Jurassic shales. All this country is extremely dry, only the larger streams carrying water. West of the Sierra la Sal we could see *roches moutonnées* forms cut in the red sandstones which prevail there. These are northeast of the Cañon Colorado, which was named from the red rocks through which it is cut.

In this chapter I have endeavored to give simply the general features, topographical and geological, and in the succeeding chapters will take them up more in detail, and then consider separately the various formations represented in the district.

The region, we might say, was entirely unexplored. Gunnison, in 1853, passed just north of it, and although he puts a portion on his map, it was outside of his line of march, and it is therefore necessarily incorrect. Along his line of travel his map is very correct. Captain Macomb in 1859 traveled across the extreme southwestern corner of the district just beyond the point we reached in our work.

The district, as laid out before we took the field, extended 15 miles into Utah. From the Sierra la Sal we worked 23 miles to the westward, that is, about 36 miles over the boundary-line between Colorado and Utah. About 1,200 square miles of our work were in Utah.

CHAPTER II.

SURFACE GEOLOGY—LOS PINOS AGENCY TO UNCOMPAHGRE VALLEY—GUNNISON RIVER AND UNCOMPAHGRE PLATEAU.

The country lying on the south side of the Gunnison River, extending from Cochetopa Creek westward to the Uncompahgre River, was partially described in the report for 1874, when speaking of the Gunnison River. The principal streams here, as we go westward, are the following: White Earth River, Lake Fork, and the Cimmaron and Cebolla Creeks, which unite to form one stream before they join the river. All these streams head far up in the San Juan Mountains, and the geological features of the country about their sources will be found detailed in Dr. Endlich's report for 1874. Their courses are approximately parallel, being a few degrees west of north. There seems to be a slight slope in the country toward the north, although the various volcanic strata appear to be horizontal. On the north side of the Gunnison the dip is toward the south, the cause being found in the eruptive peaks of the West Elk Mountains, as has been fully explained in the report for 1874. To the southward, in Dr. Endlich's district, the dip although very gentle, is toward the north and northeast.

Almost all this region is covered with volcanic rocks, which are cut by the streams into mesas extending in long narrow tongues toward the north. Along the Gunnison they are for the most part underlaid by breccia. As far as observed, this breccia does not underly the trachytic flows everywhere, but only along the principal streams and near the Gunnison, especially on the north. In several places between the main creeks I noticed the trachyte resting immediately on the same gneissic rocks which are so well exposed along the Gunnison in its cañon.

Leaving the Los Pinos Indian agency, we followed the wagon-road which leads to Lake City, (a new mining town on the Lake Fork of the Gunnison,) as far as the Lake Fork. Our first station was made on the west side of White Earth River, on a granitic hill. This was about two miles north of Wilson's Station 7 of 1874.

WHITE EARTH RIVER.

We entered the valley of the White Earth at the mouth of Beaver Creek, one of its eastern tributaries. Here the White Earth has a valley extending four miles down the river, in which the stream winds so much that its length is about twice that of the valley. The valley will probably average about half a mile in width, and is partly settled. Above this valley, the creek is in Dr. Endlich's district, and has been described by him. Below, it is in cañon until it reaches the Gunnison. It here flows through granitic rocks, which are capped with trachyte, a coarse breccia being interposed as we approach the river. About halfway down the valley, on the west side, is a group of springs, or, more correctly, two groups, one of cold and the other of warm springs.

First group.—This group has two springs, the waters from which unite and flow into a turbid triangular pool, which is about fifteen feet from them. They are situated on a mound, which is about 50 feet above the general level of the valley. This mound is composed of a calcareous deposit, slightly rust-colored from the oxidation of iron, which, however, does not appear to be very abundant.

Spring No. 1 is about 4 feet in diameter and 2 feet deep. There is considerable evolution of carbonic-acid gas, which gives the water a rather agreeable taste. It has also a slight taste of iron.

Spring No. 2 is 6 inches in diameter. It probably has the same origin as No. 1, with which also its waters join.

Spring No. 3 (pool) is 12 or 15 feet from the two springs, with which it is connected by a ditch-like channel, iron-stained and filled with *confervoideæ.* It is triangular in shape and ab ut 20 feet across at its widest part. Its water is turbid, due perhaps to the presence of sulphur.

The following temperatures were taken about 10 a. m., the temperature of the air being 66° F.: spring No. 1, temperature 84° F.; spring No. 2, temperature 84° F.; spring No. 3, (pool,) temperature 80° F. Extending for some distance above the springs, old spring deposits can be seen in the valley, showing that once the springs were probably much more extensive.

Group No. 2.—The springs of this group are nearly all cold. There are a number of pools from which no water escapes, and which do not deserve the name of springs. Around them the mound on which they are situated is turfed over, while nearer the creek the calcareous deposit is distinctly seen. There are but two springs here deserving of notice.

No. 1 is about 5 feet in diameter, and tastes and smells strongly of sulphur. Its temperature was 71° F., that of the air being 66°, about a quarter after ten oclock a. m.

No. 2 is the best spring of the group. It bubbles up quite close to the road, and is distinguished by the abundant deposit of iron oxide lining its basin. The evolution of carbonic-acid gas is abundant, and the taste of the water is exceedingly agreeable. Its temperature was 48° F.; air, 66° F. All the temperatures given above were taken July 4, 1875.

The branches of White Earth River are unimportant. The largest, just west of station 1, flows near the line separating the trachyte from the gneissic rock. Station No 1 is gneissic and seems to have been an island in the lava-sea, while the first flows were taking place. It was, however, probably covered by some of the later flows, for station No. 2 has very nearly the same level, and is basalt-capped, the volcanic layers (trachyte and breccia) extending 1,500 feet beneath it. The trachyte beneath the capping of station No. 2 is by no means the upper layer, as we find on going southward. This subject will be referred to again when I come to the consideration of the volcanic rocks of the district.

LAKE FORK.

Lake Fork is one of the largest southern tributaries of the Gunnison River. It rises in the region adjacent to Handie's Peak, in the San Juan Mountains. It flows toward the east, but soon changes its course to the northeast, and again, to a few degrees west of north. We crossed it at the mouth of Indian Creek, a small tributary from the east, about 14 miles above its mouth. It is here in cañon-valley. The cañon walls are between 700 and 800 feet high to the first distinct terrace. At about 300 feet above the level of the valley there is an indistinct terrace. This seems to mark the summit of the breccia. Some distance

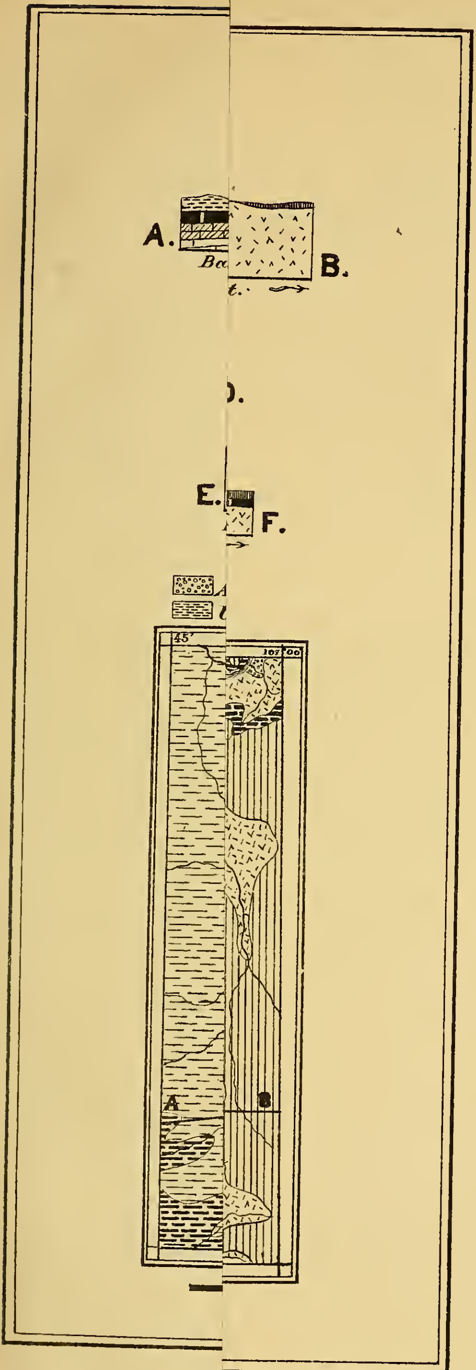

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Plate I.

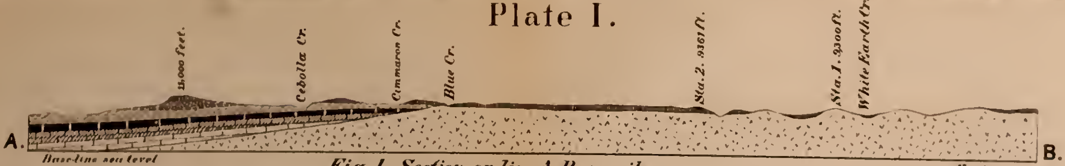


Fig. 1. Section on line A.B. 40 miles.

Fig. 2. Section on line C.D. 17 miles.

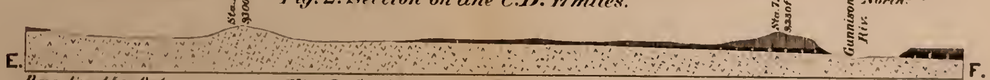


Fig. 3. Section on line E.F. 19 miles.

Alluvium. *Upper Cretaceous* *Middle Cretaceous.* *Dakota "* *Jura Trias* *Paleozoic.* *Archæan.* *Trachorheites* *Basalt.*

Fig. 4. Map of south side of Gunnison River.

Scale of miles.

back, on the second terrace, is another on which station No. 2 was located. It is about 1,000 feet above the level of the stream. These terraces seem to mark the levels of different flows of lava. Between the walls of the cañon opposite Indian Creek, Lake Fork has a valley half a mile in width, which gradually narrows as we go up the creek, when it begins to be in the mountains, or when we go down, the stream in this direction, gradually cutting into the archæan rocks which underlie the trachytes. This cañon is a true box cañon, particularly near the mouth of the stream, and can be crossed only in a few places. The archæan rocks are dark micaceous schists.

Station No. 2 is situated on a basalt-capped point, which marks the northern edge of a plateau which once extended farther to the north. To the southward are higher levels. Stations 3 and 4 are on a butte-like eminence five miles farther west and five miles north. It is about 300 feet lower, but once, probably, represented the same lithological level, the rocks in both places being similar—a dark vesicular basalt. Just east of station 4 is a branch of Lake Fork, which rises in the hills bordering the plateau on the south. On the west is Mountain Creek, a branch of the Gunnison, joining it half a mile below the mouth of Lake Fork. Between these streams is a plateau which, as I have already said, is bordered on the south by a line of mesa-like hills, well wooded. The ends of these mesas are between the branches of Mountain Creek and the west fork of Lake Fork, and mark the present limit of a volcanic flow above the one which covers the plateau of the south side of the Gunnison. North of stations 3 and 4 is a small branch of Mountain Creek which heads in a level space marked by outcrops of reddish gneiss. This is devoid of soil in many places, and the area seems to connect the strips of archæan rocks of Lake Fork and those of Mountain Creek. Where the trachyte is present in this region, it seems to rest immediately on the archæan rocks, showing that the surface must have been very irregular precedent to the lava-flows.

Between the White Earth and Mountain Creeks the country is very open and grassy, the timber being confined to the banks of the stream, which are below the level of the plateau. There are few prominences—that of stations 3 and 4 and two on the Gunnison being all that rise much above the general level. The stream next west of Mountain Creek is called Blue Creek by the Indians. It is formed by three creeks which are not more than about a mile apart. The two eastern streams unite on the south side of a high mesa, and flow at right angles to their former course until they join the most western branch, which is the main stream. The main stream then keeps on in its original direction, parallel to the original courses of the other two branches. (See map, Fig. 4, Plate I.) Although this creek carries considerable water, it is short, when compared with Lake Fork. The main stream is about 30 miles long, rising in the Uncompahgre Mountains, while the eastern branch is only five miles in length, and the middle one, which is formed by two forks, is 8 or 10 miles long. Altogether they drain about 108 square miles. They cut deep cañons, the water in the streams being from 500 to 600 feet below the summits of the ridges, which are covered with a growth of quaking-aspens. As we go up-stream, the cañons are much deeper, which is the case also when we go down the main stream. The wagon-road of Gunnison crosses the ridges in a sort of gap that separates the tongue-like plateaus extending from the Uncompahgre Mountains, from the mesas bordering the Gunnison River. In these cañons, where the road crosses, the rocks are gneissic, and upon them rest breccias, which seem to increase in thickness toward the south.

After the branches of Blue Creek unite, the stream produced by their union flows in a straight course to the Gunnison. On both sides are plateaus, or rather mesas, with flat tops, (the Twin Mesas,) which have approximately the same level. Under this capping, along the Gunnison, there appear to be both breccia and sandstones, as seen from the opposite side of the river.

On the northern sides I was unable to detect their presence. In many places, however, if not in all, I am inclined to think the trachyte rests immediately on the archæan rocks, without any interposed layers.

CEBOLLA AND CIMMARON CREEKS.

The Cebolla is the main stream of the two whose consideration we now take up. Together they drain about 216 square miles of country. Cimmaron Creek, the eastern branch, is the creek next west of Blue Creek. Both branches rise in the Uncompahgre Mountains, draining the north faces of Uncompahgre Peak and the peaks west and north in the immediate vicinity. About five miles from the Gunnison the two creeks unite in an open valley. This valley is a depression in Cretaceous shales. Both rivers are terraced. On the north the shales seem to abut directly against the archæan rocks. It is altogether probable that farther south the older formations come in gradually beneath the shales, but the country in that direction soon rises into high hills and mountains, in which the sedimentary formations are covered with the volcanic rocks. Bowlders of red sandstone are seen in the beds of the creeks. The Cretaceous shales continue uninterruptedly across to the Uncompahgre Valley. Between the Cimmaron and Cebolla is a high plateau which seems to have a very uniform level. It is covered with a dense growth of timber. Between the Cebolla and the Gunnison are high granitic hills. There are three summits. The two most eastern have a capping of trachyte, a remnant of a former plateau-level which was doubtless a continuation of the mesa on the west side of Blue Creek. There appears to be no breccia between the schists and trachyte, although on the south breccia deposits rest on the Cretaceous rocks and underlie the volcanic mesas that stand between the two creeks as well as in Tongue Mesa on the west side of Cebolla Creek. The strata in the divide between Cebolla Creek and the Uncompahgre belong to the Upper Cretaceous, and contain layers of lignite.

UNCOMPAHGRE VALLEY.

The Uncompahgre River rises in the Uncompahgre Mountains, its total length from the mountains to the mouth in the Gunnison being about 65 miles. It is formed by the union of two streams, one rising in the heart of the San Juan Mountains and the other between Uncompahgre Peak and Wilson's station 10 of 1874. On the east side of the latter, (Rio de las Vacas,) which is the most eastern branch, is a long narrow mesa about 14 miles in length. It preserves the same general level for that distance, breaking off to the south into a ridge of curiously-shaped peaks. The mesa marks the portion of the ridge that is capped, while the peaks are probably composed of breccias, with perhaps, in some places, remnants of the trachytic flow capping them. This accounts for the square tops that are noticed on some of them. The trachytic capping on the plateau must be exceedingly narrow in some places. It is underlaid with breccia, which in turn rests on Cretaceous strata, below which, if we could penetrate, we would doubtless find strata as far down in the geological scale as the Triassic. The peaks south of the narrow mesa (Tongue Mesa) just described show beautifully the influence of the character of rocks upon erosion. The valleys were once probably the seat of glaciers, although the rocks, being comparatively soft, post-glacial erosive influences have removed the traces to a great extent. The peaks range in elevation from 11,000 to 14,000 feet, and during the melting of the snows in the spring great changes must be made owing to the increased force of the streams, fed from the accumulated snows of the preceding winter.

Between the Eastern branch (Rio de las Vacas) and the main Uncompahgre is a broad strip of rolling country, gradually becoming steeper as we approach the mountains. Near the forks it assumes a mesa-like character, the sand-stones of the Dakota group (Cretaceous No. 1) forming the tops of the tables, which are about 500 feet above the level of the streams. Before reaching the hills, however, higher beds are seen, and their soft and shaly nature causes them to weather into rounded hills, which are characteristic of the Middle and Upper Cretaceous strata in this region The main Uncompahgre rises in the Uncompahgre Mountains, between the head of the San Miguel River and the Lake Fork of the Gunnison, opposite the sources of the Animas, a branch of the San Juan. This portion of the river is described by Dr. Endlich in his report of 1874. In a little valley, where two branches join before the river leaves the mountains, is the site of the new mining town Ouray. Here also are a number of hot springs. The rocks are mainly Carboniferous, intersected by volcanic dykes and lodes, with mineral matter. Emerging from the mountains, the river enters what is called Uncompahgre Park. This is a small, grassy valley, just outside of the mountains. Before reaching this park, the Carboniferous beds have sunk and the red beds appear, dipping to the north. Above them, in the park, is the Dakota sandstone. Next, at the lower end, we notice the Cretaceous shales abutting against the Jurassic, and above the latter the Dakota group. There is, therefore, at this point a fault. From the park the stream plunges into a cañon cut through Cretaceous Dakota sandstones. Before entering this cañon, a branch comes in from the west at right angles to the main stream. This creek, Dallas Fork, and its branches have several park-like openings. The mountains just south here present a steep front toward the north, rising in many places in sheer precipices, below which are the heads of the creeks which unite to form the western branch of the Uncompahgre. The principal one of these creeks rises on the northern face of Mount Sneffles. The course of the Dallas Fork, which receives the waters of these creeks, is due east. It follows the line of the fault which has been referred to, and which will be more fully described in another portion of the report. The rocks on the north side dip to the northeast. Between the branches are black shales (No. 4 Cretaceous) and yellow sandstones. The stream heads in a beautiful, grassy plateau, opposite the San Miguel River, and joins the main stream at the foot of Uncompahgre Park. A short distance above the mouth of Dallas Fork are the springs which give the name of Uncompahgre—red-water spring—to the river and park. They are warm, and surrounded by a red deposit, consisting mainly of iron oxide.

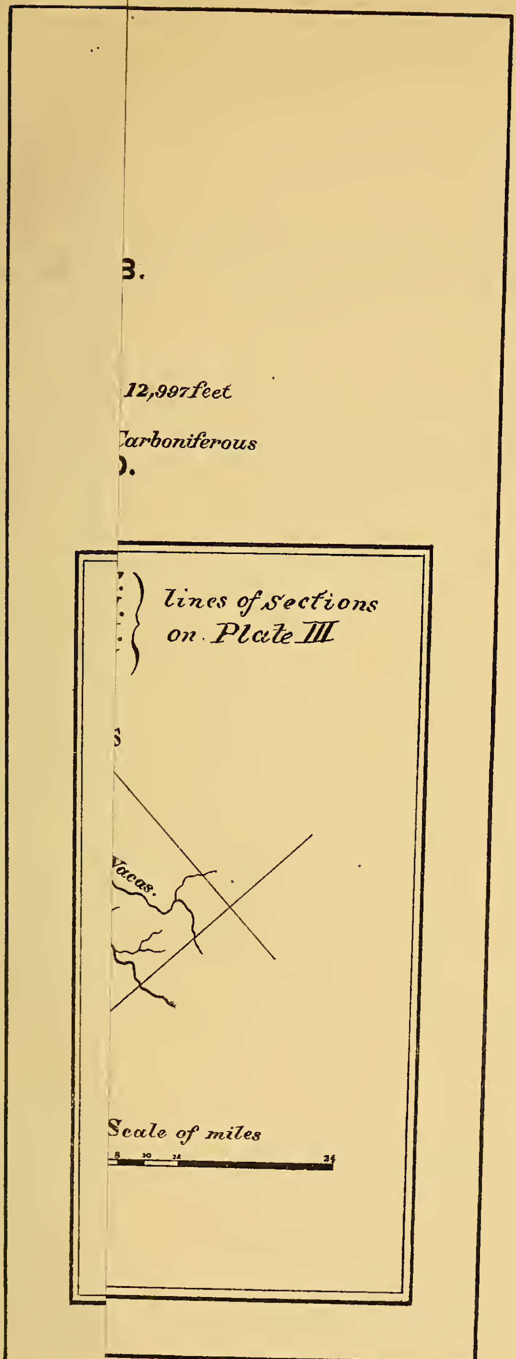
The Uncompahgre enters a cañon immediately after the Dallas Fork unites with it. The walls of the cañon here are from 700 to 800 feet above the level of the stream. The cañon is eight miles long, and is for the most part a narrow valley. There are a few open spaces, the largest, where the eastern branch, Rio de las Vacas, comes in, about five miles below the head of the cañon. The rocks are mainly Dakota sandstones, dipping about 5° to the northeast.

Just below the mouth of the Rio de las Vacas there is a bed of trachyte. On the eastern side the river has cut into this rock, which rises in bluffs about 150 feet above the river. These bluffs are very regular. On the western side the mass of trachyte does not seem to be interlaminated, but intruded irregularly, sometimes showing at the top of the cañon. The band of lignite usually found in the Dakota sandstones is here changed to anthracite, probably from the effect of heat during the intrusion of this igneous rock. At station 11 the cañon is about 500 feet deep, and at station 10 very little lower. A mile back of station 11 there are some higher points, which mark in all probability the presence of remnants of higher beds with trachytic intrusions. (See Fig. 4, Plate III.) East of station 15 there is a depression, in which the creek, flowing into the Uncompahgre above station 11, rises. The dip of the rock at station 10 is more to the eastward than it is at the head of the cañon, where there is an inclination northward.

The east side of the Uncompahgre, from the mouth of the cañon to Cedar Creek, rises to the hills about station 6. The strata are of Middle and Upper Cretaceous age, and the soil derived from their erosion is alkaline, almost destitute of vegetation, sage-brush and grease-wood excepted. Near the river terraces occur. These, however, are more marked on the western side, farther north, where they extend to the Gunnison. The dip of the rocks underlying is to the east. Near the river there are Middle Cretaceous beds, which gradually disappear as we go westward toward the crest which marks the western edge of this sloping Uncompahgre plateau. The crest is from 8,500 to 10,000 feet high. Its direction is more west of north than is the course of the Uncompahgre. (See Fig. 3, Plate II.) The Gunnison, below the mouth of the Uncompahgre, however, gradually takes a course which is in line with the course of the upper part of the Uncompahgre, so that the widest part of the plateau is opposite the angle included between the Gunnison and Uncompahgre Rivers. The width here is about 30 miles.

From a point five miles up the Uncompahgre from its mouth, to station 23, is a distance of 27½ miles. Station 23 has an elevation of 9,228 feet, which is 3,872 feet above the Uncompahgre at the point just mentioned. This is an average rise of a little over 140 feet per mile. For 10 or 12 miles from the Uncompahgre, however, the surface is very nearly uniform, and then we have a comparatively gentle monoclinal fold, which gradually becomes a plateau-top as we approach station 23. The level portion near the Uncompahgre is beautifully terraced, and composed of cretaceous shales underlaid with sandstones of the Dakota group. The shales gradually disappear as we recede from the river. (See sections in Plate III.)

From station 18 to camp No. 20, on the Uncompahgre, is a distance of 18 miles. The elevation of station 18 is 9,557 feet, 3,745 above the level of the Uncompahgre, where the wagon-road crosses it, (near camp 20.) Here the rise toward the crest begins much sooner. There are three branches of the Uncompahgre flowing across this slope toward the northeast. During the summer they are dry, and their direction is marked only by the cañons they have cut in the sandstone. They have but few lateral cañons. Rising near the crest, they keep (with the exception of the southern) a nearly uniform course to within about 7 miles of the Uncompahgre, when they turn abruptly toward the north, flowing more nearly parallel with the Uncompahgre, until finally they flow into it. Near the sources of these creeks the



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

Plate II

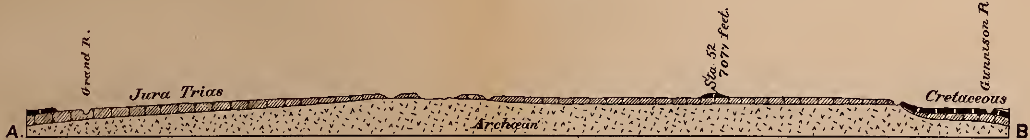


Fig. 1. Section on line A. B.

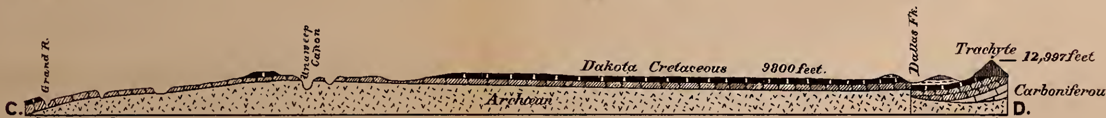


Fig. 2. Section on line C. D.

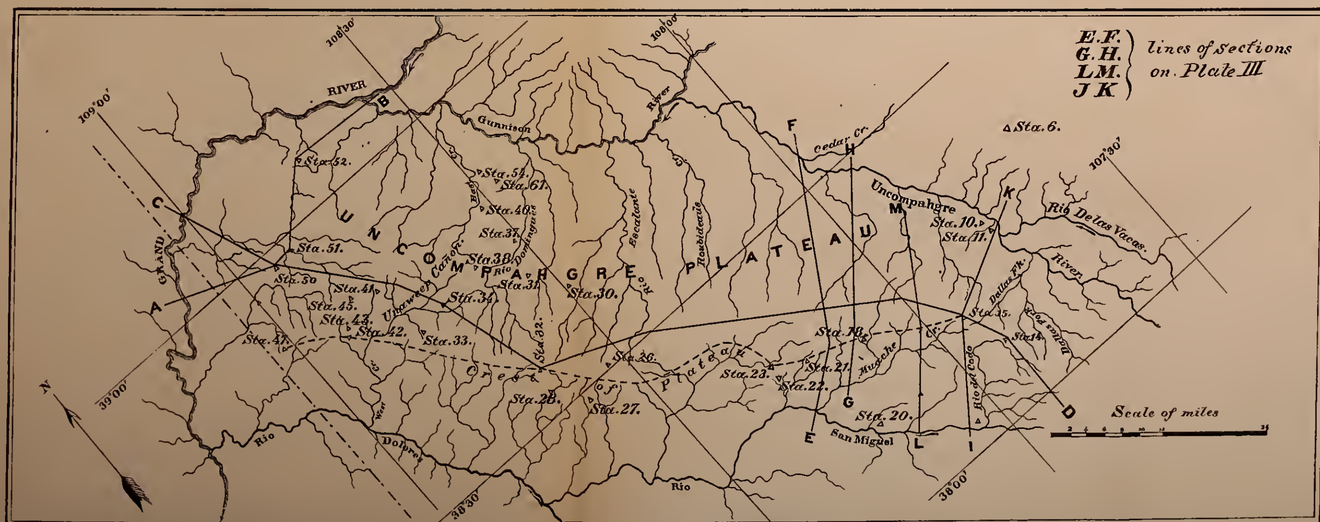


Fig. 3. Map of Uncompahgre Plateau.

cañons may possibly show in some few places the red sandstones that lie beneath the Jurassic shales. Of this, however, I cannot speak positively, not having followed the gullies or cañons to their heads. On the opposite side a number of the streams cut through not only to the red beds, but also to the archæan rocks upon which the Triassic strata rest. The summit of the plateau is well timbered with pines and groves of quaking-aspens.

The geological features of the crest will be referred to in another portion of the report. The terraces on the west side of the Uncompahgre are from 50 to 70 feet high opposite Cedar Creek. As we go down stream they increase. On most of them there is no vegetation, the summit being strewn with pebbles. In some places, where there is an abundant growth of sage, irrigation would doubtless cause the now almost useless soil to sustain farms. A short distance below the cañon some Ute Indians are farming in a rude way. Frosts in June (1875), however, had killed their first crops, and the facilities for irrigating the land were insufficient. When the Ute Indian agency is moved here from the old site on Los Pinos Creek, the capability of the land for agricultural purposes will perhaps be more fully demonstrated. Along the course of the river are occasional grassy bottoms which would make rich farming land. They are limited, and liable to inundation during the early spring.

The western side of the lower Uncompahgre Valley is an alkali desert, a sparce growth of stunted sage-brush being the only vegetation. In many places even this is absent. The soil is light-colored and clayey, with gypsum and alkali. There are numerous little gullies cut into it by the drainage from the line of buttes that lie between the Uncompahgre and the western wall of the Grand Cañon of the Gunnison. There are two lines of these buttes of Middle Cretaceous shales. The soil is derived from the breaking down of the soft strata. During dry weather it is soft and pulverulent, making traveling across it exceedingly difficult. The sun reflected from it is glaring, and its creek-beds are totally devoid of water all summer. This Uncompahgre Valley has been called the paradise of the Utes. They usually winter in it; its comparatively low elevation, ranging from 5,000 to 6,500 feet, rendering it particularly suitable for that purpose. The Uncompahgre Park has an elevation of from 7,000 to 7,500 feet. At Ouray, and near the head of the river in the mountains, mining is carried on to a limited extent. The greater part of the river is inside of the limits of the reservation for the Ute Indians.

GUNNISON RIVER.

The portion of the Gunnison River to be considered here is that between the mouth of the Uncompahgre and Grand Rivers, with the country on the west side. The eastern side and all above the Uncompahgre was fully described in the report for 1874. The first stream joining the Gunnison below the Uncompahgre is Roubideau's Creek. This is an unimportant stream marking the entrance of the Gunnison into its lower cañon. It rises on the plateau north of station 23, and is similar to the branches of the Uncompahgre southeast of it. It is cut through Dakota and underlying sandstones, and is bordered with terraces.

With the next creek, to which we have given the name Rio Escalante,* we enter a region much more cut up by the water-courses tributary to it. The plateau here has a width of about twenty-five miles from station 26 to the Gunnison River. The creek is formed by four branches flowing

*Escalante was a Roman Catholic priest, who traveled across the country in 1777.

with approximately parallel courses towards the northeast, and having their sources near the crest of the ridge overlooking the plateau of the San Miguel and Dolores. The first branch rises south of station 29, east of station 26, and the next northeast of 26; while the remaining two rise between stations 26 and 32. Station 26 has an elevation of 9,789 feet; and 32 is 9,518 feet above sea-level. After eighteen miles these creeks all unite, at an elevation of about 5,600 feet. The ridges between them are timbered, and the valleys are beautifully grassed. Near the heads of the creeks are beautiful little parks, which, in August, were perfect flower-gardens. The rocks here are sandstones and shales of the Dakota group, with Jurassic shales showing along the creeks at the bottom of the cañons. Farther down the red beds show beneath them, especially as we approach the cañon of the Gunnison, which was called the Unaweep cañon by Gunnison, from the red color of the rocks.

From the forks, the stream flows eight or nine miles to the Gunnison, falling about 4,000 feet from the head to its mouth, the greater part of the fall being in the last 9 miles. The Gunnison here lies on a monoclinal fold. This fold was noticed in speaking of the Uncompahgre River. Along the Gunnison, however, it is much more marked. The creeks cut rapidly through the Dakota group and the soft Jurassic shales to the red sandstones. All the gullies are deep, so that there is a maze of cañons and cross-cañons, in which the bright red of the sandstones and purples, greens, and yellows of the shales give a variegated appearance to the scenery. Although water is abundant at the sources of the stream, it generally sinks before reaching the Gunnison, at least during the summer.

Before the snows leave the plateau these streams are probably subject to floods, which have had much to do with the eroding of their channels. The cañons, however, are not the result of sudden causes, and may have existed in embryo long before the plateau attained its present elevation.

Game appears to be abundant on the plateau, especially near the crest overlooking the country to the west.

Between Roubideau's Creek and Escalante Creek just described, is a small and unimportant creek, rising in the timbered portion of the plateau north of station 23. Pine forests appear to be more numerous here than on the north side of the creek. On the crest we find quaking-aspens, somewhat dwarfed, on the extreme summit of the plateau, and very crooked, attesting the prevalence of heavy snows during the winter months. Even as late as the latter part of July we found remnants of snow-banks on the hills between stations 26 ond 32.

The next branch of the Gunnison is probably what was called Unaweep River on Captain Gunnison's map. It is by no means as important a stream as laid down there. We have called it Rio Dominguez, after one of Escalante's comrades. Between it and the Escalante Creek last described are several small branches, some of which are mere gullies. The largest is about ten miles long, and is probably dry during the greater part of the year.

The monoclinal fold is more marked here, and crossing its axis a few miles west from the Gunnison we soon reach a level-topped surface covered with piñon pines. But few points rise above this general level. Along the axis of the fold we find the country very different. The sandstones are here cut through by cañons and cross-cañons so that without trails one cannot travel far in any direction.

The Dominguez has two branches, one rising on the east, and the other on the west side of station 31. Almost its entire course is in Triassic sandstones.

Near the Gunnison, when the dip of the strata increases, Jurassic shales capped with Dakota sandstones appear above the white, soft sandstone that marks the upper limit of the Triassic beds. It is possible that a narrow strip of gneissic rock may show near the bed of the stream before it reaches the river. At the Gunnison it is in the red-beds. We did not have time to follow its whole course, which must be done before all the details of the region through which it flows can be stated. It seems to carry considerable water, although much of it sinks when it gets into the sandy soil before reaching the Gunnison. It is very irregular in its course near the head, differing in this respect from the creek next south of it.

The next creek we take up is East Creek in the Unaweep cañon. It is much shorter than the Dominguez and at a much lower level, not being on the plateau, although some of its branches rise there. Its level is shown by the base-line of the cañon in Plate IV, Fig. 2. It rises about 1,200 feet below the level of the plateau in a broad prairie-like divide, on the western side of which rises the stream flowing to the Dolores River. Its course at first is about northeast for about ten miles. In this part of its course it has one branch from the plateau on the south and two from the north. These branches flow with a comparatively gentle descent until they reach the edge of the cañon when they plunge over the granite wall. When we passed through the cañon in August these streams were all dry. The rate of fall of the valley for this part of its course, is 105 feet per mile. The upper part of the creek is entirely in gneissic rocks which rise in perpendicular walls, and are probably half a mile apart. On top of the archæan rocks are red sandstones dipping to the east at an angle of 4° to 5°, gradually decreasing to the west and increasing as we go east. The granite exposure becomes less and less as we go down stream. The red sandstones having a greater inclination than the fall of the stream, the bed of the creek passes into the red sandstones, the granitic rock ending as a narrow tongue a short distance below station 54.

Immediately under station 54 the course of the creek changes to due north, which it keeps for four miles, when it gradually turns eastward, until it flows into the Gunnison, with its original course. Its fall now is at the rate of about 150 feet to the mile. It is in cañon for 9 miles, cutting at first through soft, variegated Jurassic shales. Two miles above the mouth a large branch comes in from the plateau rising east of station 41, at an elevation of 8,600 feet. The elevation at the Gunnison is 4,635 feet, a fall of 3,965 feet in a distance of about 20 miles. The greater part of the fall is in the last 10 miles, where the creek descends rapidly in a narrow cañon. In the upper portion of its course the rocks are red sandstones, in which it soon cuts a deep cañon. Emerging from this, it joins the southern branch, and, keeping on in its original direction, cuts across the lower part of the Dakota group to the Gunnison, which it joins in a valley, marking a break in the cañon of the Gunnison. Bordering this stream are the variegated Jurassic shales. Although the creek descends at the average rate of nearly 200 feet per mile, which rate is largely increased as its crosses the monoclinal fold, it in reality ascends geologically, the red beds first sinking out of sight, and next the Jurassic shales, until the Dakota sandstones are at last the bordering rocks. We have already seen this to be the case in other streams to the south. Looking up these creeks from a point on the opposite side of the Gunnison, we see before us a broad surface, sloping in a gradual and gentle curve toward the river, gashed by the outcoming streams flowing at right angles to the axis of the fold. This necessarily leaves between the creeks broad masses of rock with square-cut edges, curved only in one direction, viz, from the top of the fold to the river.

The creek just described carries water at the heads of both branches, but it disappears before the Gunnison is reached. Proceeding north, we find three more tributaries of the Gunnison. The first is a small creek, heading only five miles from the river. The next is longer, and spreads into three branches, all of which cut profound chasms, which, when we saw them in the latter part of July, were perfectly dry. We found it impossible to get down into these cañons. Commencing at the heads of the creeks and following them for a short distance, we find them plunging abruptly over precipitous edges to a level from 100 to 200 feet lower, and then descending through rapidly deepening cañons, from which they flow abruptly into a comparatively open country to the Gunnison. Following the edges of these cañons, we come to the edge of precipices 800 to 1,000 feet high, overlooking the valley in which the Gunnison and Grand Rivers unite. These tongue-like points are of the bare light-colored sandstone which marks the top of the red beds. In the cañons and along the front of the bluff-like prominence we could see granite-rocks below the red beds, and beyond, at a much lower level, were the upturned edges of the Dakota sandstones. Instead of the uninterrupted monoclinal fold, we have here a fault, with the ends of the beds on the downthrow dragged up. It is impossible to tell the amount of the fault, for we were unable to get down to the edges of the Dakota sandstones, but they must have been at least 800 feet below us. The fault continues some distance to the north, where we could see the Dakota sandstones standing in vertical position; and still further beyond the fold again showed, the continuity of the red beds being unbroken, the outcrop of both the Jurassic shales and the Dakota group ending before the summit of the fold is reached. This fault a short distance farther north is shown in Plate II, Fig. 1, which represents a section across the plateau. In speaking of the monoclinal fold in the report for 1874, I referred to the probability of its degenerating into a fault as we followed it toward the north.

The last branch of the Gunnison from the west joins it about a mile and a half above its mouth. It drains the country south of station 52, rising in the upper part of the red beds. Here it flows toward the north for six miles along the western edge of a mass of Jurassic shales, which rest on the red beds, and are capped with Dakota sandstones. The strata here dip to the northeast. After flowing to the northeast for six miles the creek turns abruptly to the northeast, cutting at first through the shales. It soon reaches the massive red sandstones, through which it cuts a profound cañon to the gneiss, and cutting across the fault comes out into the Dakota sandstones in the valley of the Grand and Gunnison Rivers. This stream repeats the history of nearly all the creeks in this region in being dry. The hills are covered with a growth of piñon pines.

GRAND RIVER.

Below the mouth of the Gunnison, Grand River at first flows in open valley, from which it gradually cuts a cañon at first in the Cretaceous strata and then in Jurassic and Triassic. Its course is a few degrees north of west. This it keeps for a distance of about twenty-six miles in an air line, when it turns abruptly to a few degrees west of south for four miles, and then goes southwest for twenty miles, as we follow the course of the river, when it again turns toward the south, flowing ten miles to the mouth of the Dolores, having curved around the northern end of the Uncompahgre plateau, which we have just been describing. In almost its entire course the river is in cañon, going from the Cretaceous into Triassic rocks and out again into Jurassic and again into Triassic near the mouth of the Dolores. That portion of the Grand below this point will be treated of in the next chapter.

Although the Grand is in cañon, the cañon is for most of the distance comparatively low. There is a wide valley stretching from its northern edge to a line of bluffs on the north, eight to fifteen miles distant. These bluffs present steep cliff-like faces from 2,000 to 3,000 feet high. Farther back, rising in terraces, are other cliffs. These are what, on the maps, are laid down as the Roan or Book Mountains. This name was given on account of the red, gray, and bluish colors of the strata, the edges of which show in these cliffs in horizontal layers, the strata dipping to the northeast. They are called Book cliffs by Powell* where they occur on Green River. The bluffs on the north side of the Grand are the direct prolongation of the cliffs at the foot of Gray Cañon of Green River. Ascending the cliffs we would find ourselves on the middle terrace described by Powell† in which the Gray Cañon of Green River is cut. At this point the lower terrace does not appear. On Green River the dip appears to be more to the north than on the Grand.

Opposite the mouth of the Gunnison the valley is about eight miles wide, from the Grand to the foot of the cliffs. There is a gradual slope toward the river. The rocks in the cliffs are Cretaceous clays and the soil in the valley is made from the *débris* of these clay cliffs; it is alkaline and destitute of all except the most sparse vegetation. At the river we find the Dakota sandstones near the mouth of the Gunnison. The Grand does not commence to cañon for twelve to thirteen miles below the mouth of the Gunnison.

On the lower side, between these two points, are three creeks flowing into the Grand; the two largest of these rise north of station 52. Between the last branch of the Gunnison and these the Uncompahgre plateau ends abruptly on the line of a fault. Between the two principal creeks, however, the fold is uninterrupted, the red beds having the complete fold. No. 1, cretaceous, does not continue over nor does the Jurassic, although the latter comes in again beyond the gap which marks the line of the fault farther south. Station 52 is on Jurassic or Lower Dakota rocks. These rocks extend but a short distance to the westward. Isolated patches, capping massive buttes of red sandstone, mark their termination in that direction. The cañon of Grand River commences a short distance west of the mouth of the principal creek flowing north from station 52. Above the cañon are groves of cottonwoods, but in the cañon, which is cut deeply into the brick-red sandstones, there are only occasionally sand-banks with few trees. The cañon is not very regular, its height in some places being 500 feet and in others only 200. In a few places the walls are absent, and the river's edge can be readily reached. There are a number of deep, dry, lateral cañons on the south side of the river.

From station 49 we attempted to follow the south side of the river to the mouth of the Gunnison, but found it impossible. These deep gullies in the red sandstone we could not cross, and we were finally

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* Exploration of the Colorado River of the West, pp. 167, 168, &c. † *Ibid*, page 167.

obliged to go back to the trail by which we reached the river and retrace our steps to Unaweep Cañon. On the north side of the Grand there are Jurassic shales capped with Dakota sandstones forming hogbacks. There are numbers of small isolated buttes between the hogbacks and the river. There is a break in the cañon of the Grand immediately east of station 49. The river here has an open valley, with beautiful cottonwood groves. The valley is overgrown with sage-brush, and the cottonwoods grow in otherwise barren sandbanks. From this valley the river enters a cañon of much greater depth. Its length we were unable to determine. At the entrance the water fills the space from wall to wall, massive red sandstones towering high on either side. On the north they seem to dip abruptly, and the overlying shales are beautifully exposed. The average rate of fall per mile of Grand River from the mouth of the Gunnison to the valley below station 49 is 4.7 feet. North or a little east of north from the station is the bend of the Grand where it turns to the south. The great bend is farther east and north. At that point its course changes from northwest to southwest. The river is in open valley on the south, with bluffs a short distance back on the north side. The latter bend is the point at which on most maps the Dolores is made to enter. The river at station 49 is here about fifteen miles from the base of Book Cliffs. The valley is more broken up than farther above, especially near the river. It is still a dreary desert; the streams are alkaline and the soil soft and clayey. Although the creeks are dry during the summer, they cut deep gullies, the floods in rainy seasons washing away great quantities of the loosely aggregated soil. According to Gunnison's report, coal exists at various points in the country between the Grand and Green Rivers. It is probably in the Dakota group, which at the mouth of the Gunnison contains a very inferior lignite.

The desert country continues across to the Green River, bordering the foot of the Book Cliffs.

Returning to the south side of the river we see two tributaries, the Little Dolores and Granite Creek, joining it below station 49. Both rise in the plateau close together, at an elevation of from 8,600 to 9,000 feet. We take up the Little Dolores first. Glancing at the map the first thing attracting our attention is the difference in the directions of the drainage at different points. Near the source the streams come in at acute angles. Farther down they join at right angles. At the heads of the creeks there is but a slight slope, what little there is being to the east or northeast; farther down the inclination is greater and to the north. The Little Dolores drains the largest area. Its general course is northwest, although it has several bends to the southwest, from which, after short courses, it always returns to northwest.

The plateau in which it rises, north and northeast of stations 41 and 44, is well timbered, and abounds in open, grassy parks. Between the forks the country falls off in terraces, the surface rocks being Triassic. The upper beds of the formation, as usual, are lighter colored than those below. Near the heads of the creeks they are orange-yellow, becoming pink as we go north. Immediately beneath them we have blood-red sandstones, which rest on gneissic rocks. The latter show in narrow strips along some of the creeks, after we descend the first terrace. The terraces are most marked on the western branch of the creek. Below the first terrace we have more open valleys than above. These are bordered with walls of red sandstones, with white or light pink layers at the top. Still farther down the dip of the red beds to the north increases, and we do not at first notice the white capping, which, however, shows again as we approach the Grand. The creek approaches the river in a deep, cañon-like valley, with walls 500 or 600 feet high, presenting bluff faces of massive blood-red sandstones. This is a country of piñon-pine and sage-brush. Willows are found along the water-courses, and cottonwoods on the large streams. Although water appears to be present at the sources of the creeks, it sinks before the mouths are reached. We found water, generally, only in holes, where it was shaded by overhanging willows.

The western or southern of the two creeks, Granite Creek, joins the Grand immediately above the Dolores, and rises between stations 45 and 47, in country precisely similar to that at the head of the Little Dolores just described. Instead of keeping its course to the northwest, it turns to the southwest after receiving its principal tributaries.

In traveling through the region just described, it is not safe to attempt to travel away from the Indian trails. Water is scarce, and to be found only in holes near the trails. The cañons are, many of them, impassable, and the traveling is often extremely difficult even on the trails. The crest of the plateau overlooking the San Miguel and Dolores Rivers will be reserved for the next chapter.

UNCOMPAHGRE PLATEAU.

In the preceding portions of this chapter the Uncompahgre plateau has been partially described, and other parts will be treated of in detail in the succeeding chapter. Still I have thought it best to give at this point a general description.

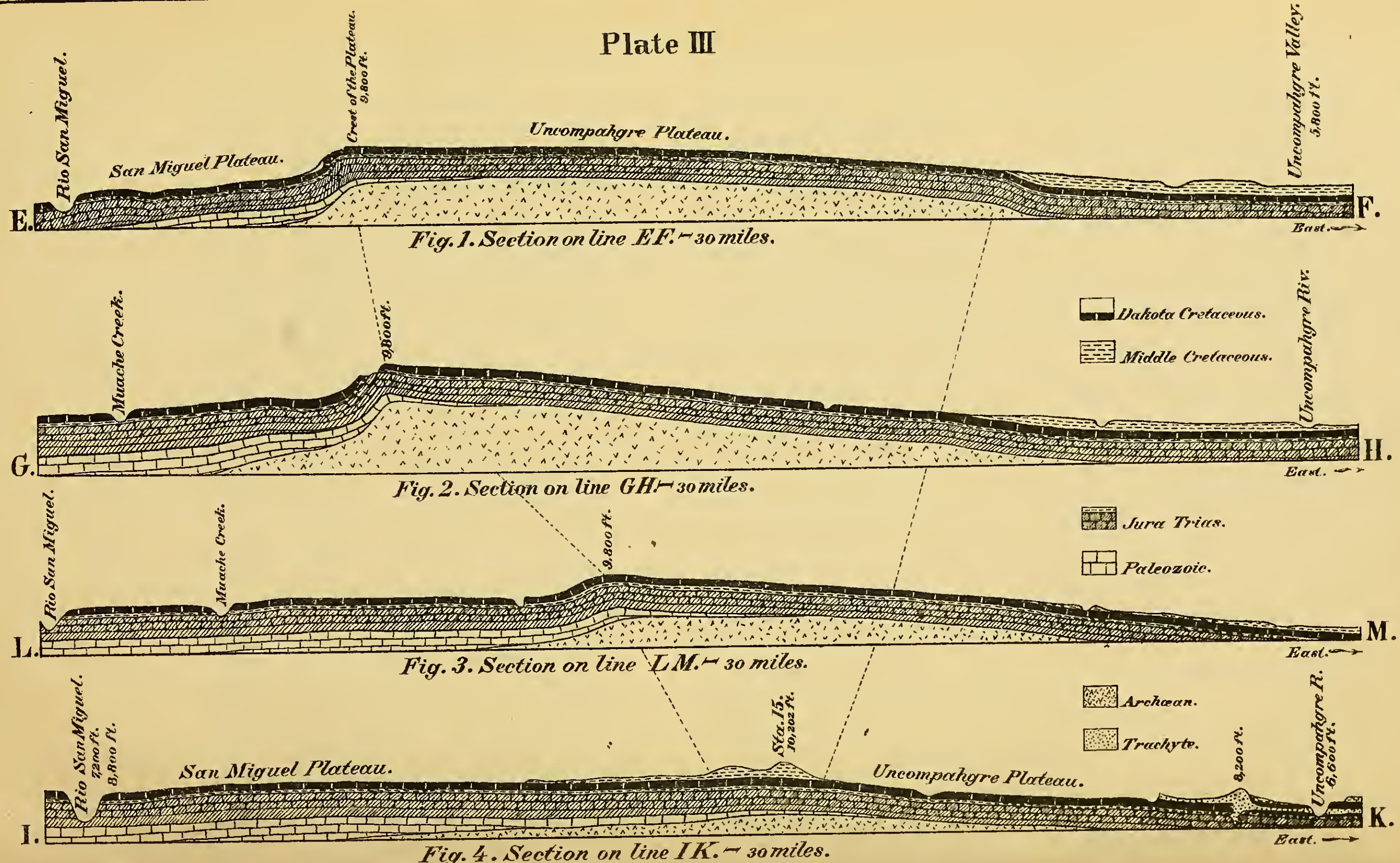
The plateau extends from the foot of the Uncompahgre Mountains northwestward to the bend of Grand River, a distance of about 90 miles. Its width is from 15 to 25 miles. At the south the Cretaceous shales are the surface rocks, and dip gently from the mountains toward the northwest, abutting against the Jurassic shales and Dakota sandstones along a line of faulting marked by the course of the Dallas Fork of the Uncompahgre River. From this point to the Unaweep Cañon the prevailing dip is to the eastward. The Unaweep Cañon divides the plateau into two portions. On the south the prevailing formation is the Dakota group, except northwest of the Rio Escalante, where it has been almost entirely eroded away. North of Unaweep Cañon a tongue of the Dakota sandstone extends westward from the Gunnison, but beyond this the red beds of the Trias form the greater part of the surface, dipping toward the north.

Leaving the Uncompahgre River, in the valley, where the wagon-road crosses it, and going westward, we rise gently to the plateau without knowing where the valley ends and the plateau begins, until we reach the crest, some 4,000 feet above the Uncompahgre Valley. At one point along this rise there are indications of a slight fold, and at the crest we are on the axis of one that is much more abrupt.

There are, therefore, two monoclinal folds diverging from a point at the foot of the Uncompahgre Mountains, one having its axis in the direction north 38° west and the other north 52° west, approximately. Of these the most marked is the western, the crest of the plateau. (See dotted lines, Plate III.) The eastern is scarcely noticeable at first, and we seem to have a simple anticlinal with an abrupt flexure on the west and the eastern side sloping gently, causing an inclined plateau. The eastern fold, however, soon becomes more marked, and we have still a sloping plateau, but with a monoclinal fold on the east and a fault on the west, with the ends of the beds thrown down, dragged up. This is the structure from station 32 eastward to the Gunnison.

North of Unaweep Cañon the east and west sides of the plateau appear to be more nearly alike, and we have a dragged fault on both sides. Going north from the canon, however, we find a monoclinal fold with an east and west axis, and the Grand River is in a canon cut in the red beds, while hogbacks of No. 1 Cretaceous, dipping northward, are seen on the north side of the river. (Fig. 1, plate II.) We see, therefore, that the monoclinal folds are modified at various points. From the exposures noted in the numerous cañons it is evident that the red beds (Trias?) are superimposed to the granitein the Uncompahgre plateau. West of the crest Carboniferous strata are seen, and overlapping similar to that along the eastern edge of the Front range is noticed, and the similarity of the fold is apparent, although along the Front range we have no faulting. The abrupt fold in both cases is noted near the line of overlapping of the Carboniferous by the Trias, the greatest elevation occurring where the least thickness of strata occurs. The mode of action in both cases is probably the same, although the amount of elevation in the Uncompahgre plateau is far less than that in the Front range. As to the age of the elevation of the Uncompahgre plateau we have no clew, but the probability is that it was synchronous with the Front range and Park range.

Plate III



Sections across the Uncompahgre Plateau.
for lines see map Pate II.

CHAPTER III.

SURFACE GEOLOGY—SAN MIGUEL AND DOLORES RIVERS—UNAWEEP CAÑON—SIERRA LA SAL AND GRAND RIVER.

Under the heading San Miguel River I shall take up the plateau that borders the river, to which the name San Miguel plateau has been given, and also the western crest of the Uncompahgre plateau where it overlooks the San Miguel plateau.

Under the second heading, "Dolores River," I shall consider the region lying between the Dolores River and the crest of the Uncompahgre plateau. The country between the San Miguel and the Dolores was uncompleted, owing to the interruption of our work by the Indians, and we were able to obtain only a general idea of it from glimpses of it obtained from the crest of the Uncompahgre plateau, the Sierra la Sal, and from Lone Cone. The third heading will be "Unaweep Cañon."

The fourth division of the chapter, "Sierra la Sal and Grand River," will be devoted to the country drained by the streams radiating from the Sierra la Sal.

SAN MIGUEL RIVER.

The San Miguel is a branch of the Dolores, to which, above the junction, it is equal in size and in the amount of water carried. It rises in the extreme northwestern part of the San Juan Mountains, opposite the sources of the Dolores, Animas, and Uncompahgre Rivers. In this region it is formed by two streams, one flowing north and the other west. Both rise in the midst of volcanic rocks, which they soon leave, flowing out into the sedimentary formations, mainly Cretaceous shales. After the union of the two streams the river flows toward the northwest, gradually emerging from the mountains and cutting through the Middle Cretaceous, the Dakota group, the Jurassic shales, and the upper part of the red beds. The river is in a cañon 1,600 to 2,000 feet in depth. In this upper portion of the river there are placer bars which are being worked to considerable extent.

Emerging from the mountains, the San Miguel flows out into the San Miguel Plateau, keeping in a narrow cañon averaging about 1,000 feet in depth. The course of the river for about twenty-five miles from the mountains is about northwest. It then turns to the westward for about eight miles; then flows to the southwest for about eight miles more, and finally for about twenty-two miles has a course northwest to its mouth in the Dolores. The prevailing formation on both sides of the river is the massive sandstone, forming the upper part of the Dakota group, (Cretaceous No. 1.) In the cañon, toward the upper part of the river, the red beds show, but as we follow down the stream the outcrop sinks and we have only a narrow belt of the Jurassic shales below the Dakota group bordering the river. There is but little river-bottom, and the stream winds but little in its course. On the southwest side of the river the principal drainage is from Lone Cone and the San Miguel Mountains. These creeks flow almost due north, rising in the Middle Cretaceous shales, but soon cutting through them, and finally joining the river in the Jurassic or Upper Triassic? strata.

The plateau on the northeast side of the river is comparatively level and covered with groves of pines. The surface rock is the Dakota sandstone. All the creeks cut cañons through it on their way to the river, and the plateau is cut into mesas, especially noticeable near the San Miguel. Between station 20 and the crest of the Uncompahgre plateau there is a broad anticlinal fold, so slight that in looking down upon it from the Uncompahgre plateau it is not noticed.

The first creek joining the San Miguel from the northeast after it fairly emerges from the mountains has been named "Del Codo," on account of the curious elbow in its course. Rising in the group of volcanic peaks forming the western part of the Uncompahgre Mountains, it flows northward across the Middle Cretaceous shales, approximately parallel to the branches of the Uncompahgre, which rise in the northern face of the Uncompahgre Mountains. From them it is separated by a spur-like ridge capped with Middle Cretaceous. The creek soon cuts into the Dakota sandstones, and seven miles from its head deviates from its northward course and flows northwest for about three miles, when it makes a sharp turn or elbow and flows a little west of south in deep cañon to the San Miguel, joining the river in the red sandstones of the Trias ?. In this latter course it is joined by three short streams in cañon, that rise in the same group of mountains with the main stream. In these cañons, as in all those cut in the plateau, there is a belt of the Lower Dakota group and of the Jurassic shales bordering the streams.

The western crest of the Uncompahgre Plateau begins on the spur separating the Rio del Codo from the Dallas Fork of the Uncompahgre. It is from seven to ten miles from the San Miguel, and is about 2,000 feet above the general level of the San Miguel plateau. From station 18 to station 26, a distance of 30 miles, the direction of the crest is north 60° west. The drainage as far as station 21 is by creeks that cut across the crest at right angles to its direction. These creeks all unite in one stream, Muache Creek, which joins the San Miguel before it bends to the westward. The gashes in the crest afford an excellent opportunity to study its structure. The primary condition is a monoclinal fold, the sandstones of the Upper Dakota group being in general the surface formation. At station 15 the fold is very slight, and although the strata are to a great extent concealed, there is but little doubt that shales of Middle Cretaceous age underlie the drift scattered on the hills. Station 15 may have a capping of breccia, although the beds are concealed. As we go northwest from station 15, which has a capping of shales, the fold becomes more marked, the shales disappear, and the Dakota sandstone is folded over the crest, its continuity being unbroken. (Section, Fig. 3 Plate III.) From the crest it slopes gently to the Uncompahgre River.

In the third creek, northwest from station 15, the fold has become greater, (Fig. 2, Plate III,) and in the cañon cut by the stream there is the following section:

1. Upper Dakota, sandstone.
2. Lower Dakota, shales.
3. Jurassic variegated beds.
4. Massive red sandstone, light colored.

Five or six miles farther northwest is another creek which cuts deeper and heads farther back in the crest, and the following additional beds appear beneath:

5. Blood-red sandstones, with shales.

6. Purplish shales.

Between the two creeks just referred to, the continuity of the Dakota sandstone (No. 1 in the section just given) is broken, and on the west side of the fold it dips steeply to the west.

On the north side of the last-mentioned creek it is tipped 5° past the vertical, (Fig. 1, Plate III,) but soon regains its original inclination, and flattens out on the San Miguel plateau, which in this region consists of mesas between the different streams tributary to the San Miguel. The upturned edge of the Dakota sandstone continues for some distance to the northwest, the strike being parallel to the direction of the crest. In many places there appears to be faulting, with the edges of the beds thrown down, dragged up, so that it is difficult at first sight to say whether there is simply a fault or an abrupt fold. Farther to the north, however, there is not room for the fold, and the fault is more plainly seen. The ends of the strata that are dragged up dip steeply to the westward and in places are tipped past the vertical.

Near stations 27 and 28 the line of outcrop of the upturned Dakota sandstones has receded to the westward, and the upper portion of the group forms the capping of mesas between the branches of the San Miguel.

Both stations 27 and 28 are just below the crest of the Uncompahgre plateau, on the upper part of the red beds, (Triassic ?.) These red beds rest directly on the granite. West of the stations, and at a lower level, the edges of Jurassic strata are exposed, dipping at a sharp angle to the westward, and also resting on the granite. Here we will leave the crest of the Uncompahgre plateau, and reserve further description of it for description under the head of the Dolores River, as it overlooks that stream.

The description of the country west of the San Miguel, extending to the Dolores, will have to be reserved until it is more thoroughly investigated. Enough was seen to demonstrate the presence of several folds whose axes are approximately northwest and southeast. Immediately west of the San Miguel the plateau appears to rise toward the west, to the western side of an anticlinal fold that is low and broad. There is also a slope from the mountains toward the north. Near the mountains there are remnants of the Cretaceous shales resting on the Dakota sandstones.

DOLORES RIVER.

The Rio Dolores has its origin in two large streams that rise in the northwestern part of the San Juan Mountains. The North Fork rises in the southern face of the group named San Miguel Mountains, and the South Fork or Bear River drains the Bear River group of mountains and the country between it and the La Plata Mountains. The course of the Dolores after the junction of the two forks is south. It then turns abruptly west, and next flows north a short distance, and then to the northwest as far as it has been definitely located in latitude 37° 45′, and longitude 108° 45′. Beyond this is a gap in the work of 30 miles in an air-line. In this, however, its general course is probably northwest, for where we leave it and where we take it up again that is the direction in which it is flowing.

The geology of the Upper Dolores and its tributaries will be fully detailed in Mr. Holmes's report. Suffice it to state here that the rocks through which it flows, mostly belong to the Dakota group of the Cretaceous, Jurassic shales and even the top of the red beds sometimes showing beneath them in the cañon.

At the point we take up the Dolores again, it is flowing toward the northwest. It, however, soon turns and flows northeast, at right angles to the axes of two anticlinal folds, cutting directly across them. The anticlinal axes are occupied by creeks on both sides of the river. There are smaller streams in the synclinal valleys, but, as seen from Lone Cone and the Sierra la Sal, they are not of much importance, and their direction was not definitely determined.

The valley of the Dolores was probably outlined before the formation of the anticlinal folds, and therefore the anticlinal and synclinal valleys, whose drainage is tributary to the Dolores, are of later origin than the valley of the Dolores. The underlying rocks of these folds are the red beds, with, perhaps, Upper Carboniferous beneath. Of the latter, however, we cannot be certain until the river has been examined in detail. Above the red beds, Jurassic shales occur.

After passing through the most eastern of the folds, the Dolores is joined by the San Miguel, and flows north for a short distance, and then turns to the northwest, holding that course to its mouth in the Grand. All this distance it is in cañon, from 1,500 feet to 3,000 feet deep. At the mouth of West Creek, flowing from the Unaweep Cañon, the walls are about 2,500 feet high. This increases as we go down stream to a certain point, and again decreases. The cañon walls are of sandstones and shales. The top of the cañon is a bluff face of blood-red massive sandstone, surmounted by pink sandstones more massive in appearance but softer. These belong to the red beds. Below them are alternations of blood-red sandstones and shales. Below these are pink sandstones and red shales, with gypsum. As we descend the sandstones become conglomeritic. The dip is about 5° toward the east, or, perhaps, a little north of east as we go north. The drainage on the west side of the Dolores will be considered under another head.

Between the San Miguel and West Creek, coming from Unaweep Cañon, are two large creeks heading in the crest of Uncompahgre Plateau, and flowing into the Dolores.

Standing on the crest and looking down upon this country we see a great number of mesas, separated by deep cañons. Although along the Dolores there is an eastern dip, still there appears to be also an inclination to south of east. Between the crest and the Dolores there is a slight synclinal, which is also indicated by the drainage.

Starting from the San Miguel River, a short distance above its mouth, and going north and northwest, we find the mesas between the creeks at first with a capping of No. 1 Cretaceous. This gradually disappears as we approach the Unaweep Cañon, and north of it the red sandstones are on the surface, even the Jurassic not coming in again until we approach Grand River.

The first creek flowing into the Dolores from the east, north of the San Miguel, rises on the western edge of the crest of the Uncompahgre plateau south of stations 28 and 32. Between the head of this creek and station 26 is the head of a stream flowing into the San Miguel just above its mouth. These streams cut through the sedimentary beds to the archæan rocks. Cretaceous No. 1, caps the crest dipping towards the northeast. As we go from station 26 to station 27, which is nearly 700 feet lower, we pass over the edges of Lower Dakota and Jurassic shales until at station 27 we are on the red-beds, the upper layers of which are light-colored.

They rest on granitoid rocks which show beneath the station, and in narrow strips extending up the creeks. Crossing the narrow strip of granite we find the Jurassic shales in immediate superposition to the gneiss. We have then here a faulted fold. A very short distance north, the red-beds show beneath the Jurassic on both sides of the strip of granite, and still farther along the granite is concealed, the red-beds continuing across.

At station 28, there is a break again, but it is impossible to say whether there is any faulting or simply a fold with the layers partially removed. Granite appears along the creek and branches draining the country immediately about station 28. The most northern or western branch of the creek we have been discussing, rises in an amphitheatre a little north of west from station 28. The floor of this amphitheatre is gneissic, and its walls red sandstone. Beyond it, between it and the creek, flowing from station 32, the fold of the red beds is continuous and unbroken. The upper portion of the Triassic beds in this region are light-colored, in fact in many places they are almost white, and it is only by noticing their structure, which remains the same whatever the color, and watching the change in color, with their position in relation to the remaining strata, that we can identify them. Another point to be noted here is that they are directly superimposed on the archæan rocks. Between stations 32 and 35, the drainage flows to the west and southwest to a creek, whose valley is parallel to that of the Dolores, although the stream flows in exactly the opposite direction until joined by the creek from station 32, when it turns and flows due west to the Dolores. Between this creek and the Dolores are three small streams which cut deep cañons in the red beds, leaving mesas between capped with No. 1 Cretacious toward the south. Farther north only Jurassic forms the capping. The Dakota sandstones have been eroded and removed.

We now return to the crest. The rocks on station 32 are a portion of the Dakota group, an isolated remnant of sandstones that once must have covered this entire country. North and northwest of the station they appear to be entirely absent, while to the east and northeast there are similar fragments capping the higher levels. The creek rising west of station 32 flows, at first west, then southwest, and finally west again to the Dolores. We have already seen that south of this creek the red beds are continuous, the monoclinal fold being perfect. In this short interval, then, there is no crest to the plateau. North, however, it again shows, its direction being about north 40° west, instead of north 60° west, as it is farther south. The red-beds are the surface-rocks on the edge, a strip of granitic rock showing below. This is very irregular, the lower portion of the red beds, or perhaps some older strata, extending over it in many places. The latter probably represent the upper beds of the Carboniferous, better shown on the Dolores River.

The crest near station 33 and the plateau just below the station are drained by a branch of West Creek of Unaweep Cañon. There are several branches flowing southwest to the main stream, which flows to the northwest until it receives all its tributaries, when it flows west into West Creek. Between Unaweep Cañon and this Creek is an almost square piece of country, including about 16 square miles. There are three high points in it, the highest of which is about 3,000 to 4,000 feet above the level of the West Creek. The capping is of stratified rocks, probably Triassic. Beneath them the archæan rocks appear on the east, north, and west. On the south a tongue of stratified rocks appears to connect with the strata on the south side of the creek from station

33. Just below this station is a narrow belt of gneissic rocks, and beyond are stratified beds dipping towards the southwest, at an angle of about 20°, while those on the station have a very gentle slope toward the east. The strata that are tipped may be a portion of the Lower Triassic or the upper portion of the Upper Carboniferous. I incline to the latter view. Those on station 33 are higher topographically and geologically. The narrow belt of granite continues across to the edge of the cañon, and we can follow the outcrop of red beds from station 33 around to stations 39 and 34. Between the latter stations a creek of considerable size flows into Unaweep Cañon, and here the granitic tongue extends some distance up the stream on the plateau. Beyond station 34 we can follow the line of outcrop of red beds across to the Gunnison on both sides of the cañon, the dip of the rocks being to the eastward.

East of station 36 the drainage is toward the east, following the slope of the rocks, in which the creeks sink rapidly, forming cañons of some depth. They gradually turn to the northward to empty into the main stream which flows westward, finally turning to the northwest to flow into the Unaweep Cañon. The other streams between stations 33 and 39 show the same tendency, although not so decidedly, as they are much shorter. When they reach the edge of the cañon they are obliged to descend precipitously to the level of the stream at its bottom. West Creek, in Unaweep Cañon, rises in the broad prairie-like divide opposite the head of the stream flowing toward the Gunnison. The average fall per mile is only 46 feet, for a distance of 8 miles on the Dolores side, while in East Creek, on the Gunnison side, the fall is 105 feet per mile for about the same distance. The stream flowing into the Dolores is the largest of the two. Its valley is at first wide and park-like and the scenery fine, the granite walls rising like buttresses on both sides of the valley. As we go down the cañon, the stream begins to descend more rapidly, at one place for two miles descending 212 feet to the mile and then decreasing again to an average of 94 feet per mile. The valley is very narrow where the creek falls most, and is underlaid by granitoid rocks, from which it emerges into conglomerates of Upper Carboniferous age, dipping to the westward at first with a steep dip, gradually changing to an eastward dip of 5° at the Dolores River. The strata next the granite are conglomeritic and light pink in color. There are included masses of granitic rock, proving that during their deposition there was adjacent land of which the rocks were granitic. Their character proves the water to have been shallow along the western edge of what is now the plateau. On the Dolores beds of lower age are seen, proving that there was a gradual subsidence. This is also proved by the fact that as we go eastward the red beds are directly superimposed on the granitic rocks, and decrease in thickness. It is probable that there is a line of faulting along the plateau here, although it is not simple, the remnants of a fold being still preserved in the upturned edges of the conglomeritic sandstones. The softness of the strata has caused them to be eroded, and where the creek emerges from the granite there is an open place with low rounded hillocks. Through this space the creek flows southwest. Just above this its course is south, with a western turn immediately before leaving the granite.

On the south side of this valley bluffs rise nearly 2,000 feet above the creek level. They are capped with shaly beds, beneath which is a massive bed of pink sandstone, and below the latter is an equally massive bed, of dark red sandstone, beneath which are shaly layers, becoming lighter, colored as we descend. On the north the removal of beds has been most marked.

In the angle between the Dolores and the creek, from the Unaweep Cañon, there is a butte-like mass, with a capping of shales. This butte has but little width, and the connection between it and the mass to the north appears to be partially broken.

North of West Creek we can say but little about the valley of the Dolores, save that the river is for the most part in cañon, with Triassic and Upper Carboniferous rocks showing. The depth of the cañon is from 2,000 to 3,000 feet, judging from the data we have above this point

North and northeast of the mouth of the Dolores there appears to be a dip in the strata toward the north and northwest, which causes the red beds to pass beneath the Jurassic formation, a portion of which shows between the Dolores and Grand River. The lower plateau, extending from the Dolores River to the crest on which stations 42, 47, and 48 are located, is about eight miles in width. The floor is mostly red sandstone, with a few isolated cappings of Jurassic shales. There is a narrow strip of granitic rock showing below station 47, on the opposite side of which there is a bend in the beds, the dip being toward the southwest. The appears to be a slight slope in that direction until we cross the Dolores. The true dip is probably a little south of west, gradually turning to the west and north of west as we go northwest of station 47.

We will now return to the north side of the Unaweep Cañon. As we have already seen, the length of the creek on the western side is about twenty-three miles. For about fifteen miles its course is nearly due west. We have already considered its southern branches. On the north, in this part of its course, it is joined by six creeks, rising in the plateau in a park-like country. The first three have a southerly course, cutting through the almost horizontal sedimentary beds, and touching the underlying archæan before reaching the edge of the cañon, over which they flow precipitously to join the main stream. The fourth branch rises about station 41, in the same park-like country, and flows to the southwest. It does not break over the edge of the cañon so abruptly as the two upper branches. The fifth branch is small. It rises on the south sides of stations 42 and 43. Its course, which is somewhat irregular, is probably almost entirely in the gneissic rocks, although the red beds cap them on either side. Stations 42 and 43 are, I think, on rocks of Jurassic age (or Lower Dakota), although no fossils could be obtained for proof.

The next creek is by far the largest branch on the north. It has its origin in a beautiful park-like country north of stations 42 and 43, between them and station 45. It does not plunge abruptly over the edge of the precipice, but cuts its way gradually through the rocks to the level of the main stream, which it joins where the latter turns to the south. On the west side of the creek is a ridge, which, commencing at station 45, sweeps semicircularly around the western sources of the creek and follows approximately its course, sloping from a point west of station 42 to the edge of the Unaweep Cañon. After this stream comes in, the creek in the cañon (West Creek) flows to the southward for about four miles, at right angles to its former course. It then receives the branch from station 23, and again turns abruptly, this time to the west, flowing in that direction for nearly a mile, when it flows southwest to the Dolores.

Station 47 is located on the upper part of the red beds, on the edge of the plateau. Here, again, is a break in the continuity of the strata, a line of granite appearing on the plateau below, against which the strata, probably a portion of the Lower Triassic, are tipped up. Beyond, there is a slight slope to the Dolores, *i. e.*, toward the southwest. Beyond the Dolores the dip is reversed. On the north side of the creek, rising south of station 47, the dip is west and northwest. When we cross the Dolores, opposite the mouth of this creek, as we shall see in another part of this chapter, there is a marked dip to the north.

From station 47 we could trace the crest about six miles to the northwest. Beyond this point we were unable to work. It is probable that the granitic rock extends but little farther in that direction, but instead turns to the eastward. There is a gap in the work here between the crest and Grand River, the crest being too far from the river to get details, and our trouble with the Indians preventing our going there later in the season, as we had intended when working in this part of the district. From Sierra la Sal we could see a line of what we took to be an outcrop of Jurassic strata, but the distance was too great to be absolutely certain.

UNAWEEP CAÑON.

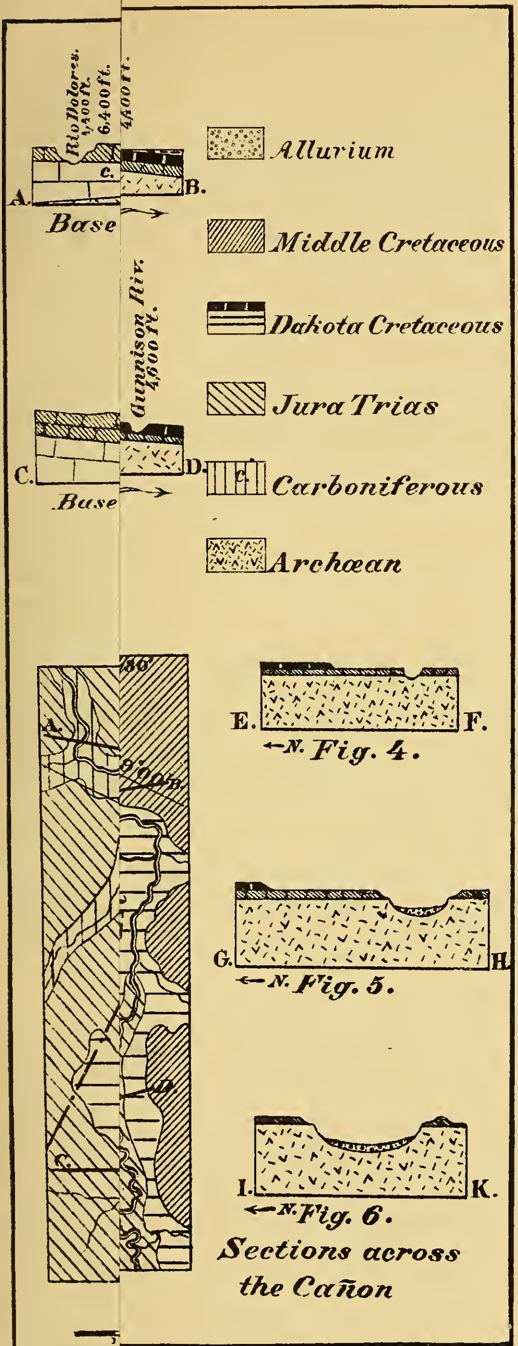
As has been already noted, the Unaweep Cañon has two streams, one flowing to the Gunnison and the other to the Dolores. The divide between them is 1,200 feet below the general level of the country and 2,400 feet above their mouths, and the width of the cañon from half a mile to a mile. It is a cañon of erosion. There is no displacement of the rocks. Gneiss or granite underlies the valley, as is seen at both ends, although in the center it is concealed by the local drift. Resting on the Archæan rocks are the Triassic red sandstones, preserving the same level on both sides of the cañon. The two creeks that at present occupy the cañon are obviously insufficient to account for the erosion implied by the width and depth of the gorge. Some large stream must once have occupied it. Several interesting questions at once arise, viz: What direction did it flow? Was it the Gunnison, Grand, or the Dolores? Why was it turned aside? It is impossible, with the limited data at command, to answer these queries. I shall simply content myself with suggesting certain, points that present themselves to my mind in regard to it.

In the first place, let me regard the cañon as the old bed of the Dolores, through which it flowed to join the Gunnison.

Of the two creeks draining the cañon, the one flowing into the Gunnison is the most inconsiderable. Its fall per mile for the first eight miles of its course is 105 feet. On the other side, for the same distance, the rate of fall is about 46 feet per mile, although a greater quantity of water is carried by West Creek.

The first few miles on either side of the divide present the most striking difference. On the east it is 80 feet per mile, while on the west there is little, if any, difference—11 feet being the entire amount of fall two and a half miles west of the divide. For three and a half miles beyond this the rate is about 65 feet. Beyond, however, where the cañon is narrow, the fall is very much greater. The figures just given would seem to imply that the original bed of the cañon sloped to the eastward. We must remember, however, that the elevation of the plateau probably continued after the cañon was drained. If the Dolores did flow through the cañon, we have to presume that its present course was caused partly by the rising of the Uncompahgre plateau and partly by the elevation of the Sierra la Sal, the former cutting it off from the Unaweep Cañon, and the latter providing a depression in which it has cut its present cañon. Against the theory are the following points:

1st. The great rate of fall in the cañon as it crosses the crest of the



Sections across the Cañon

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

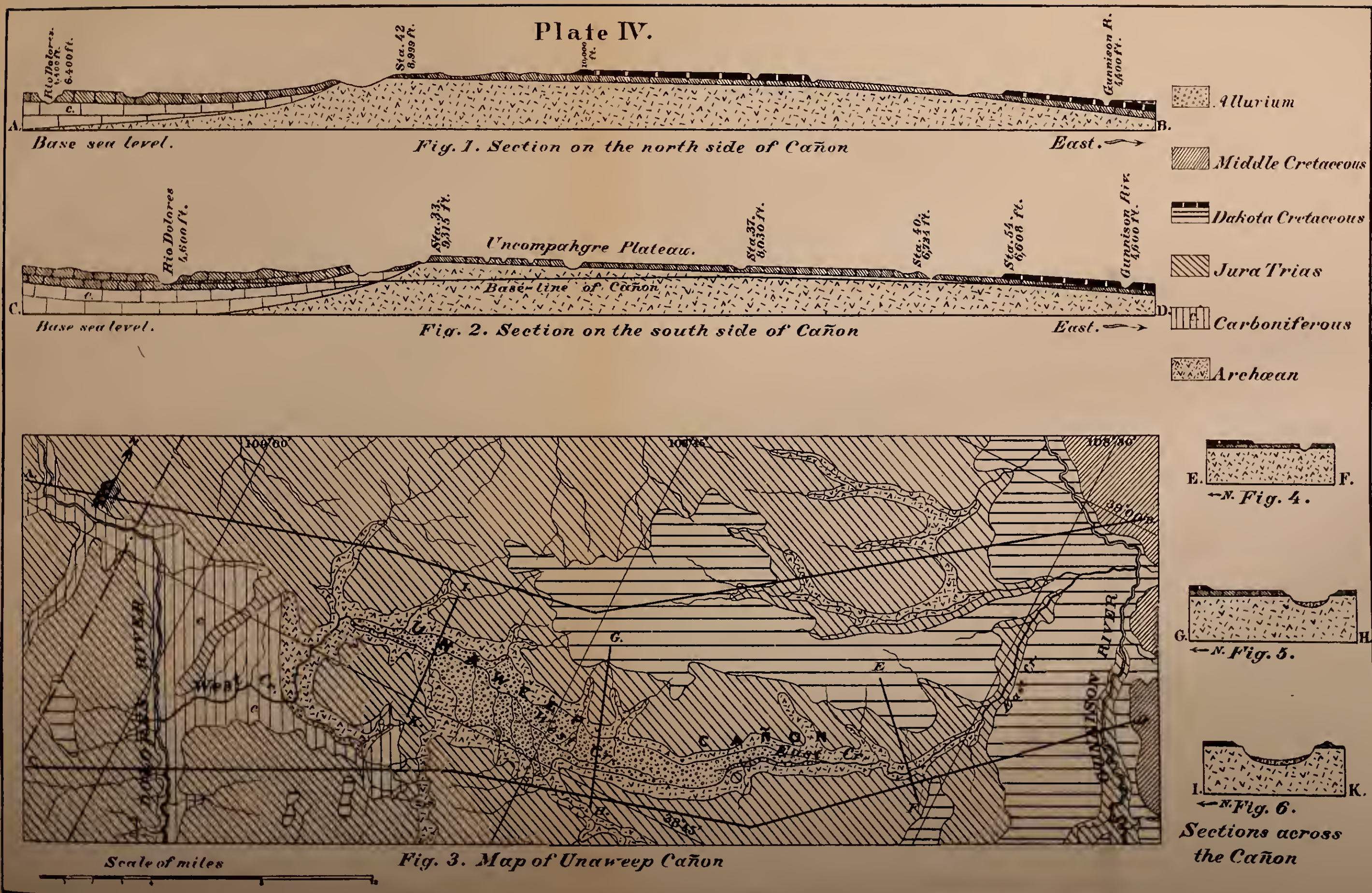


Fig. 1. Section on the north side of Cañon

Fig. 2. Section on the south side of Cañon

Fig. 3. Map of Unaweep Cañon

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

Uncompahgre plateau. The present stream flowing through it is inadequate to explain the erosion of this part of the cañon.

2d. The general slope of the country, as determined by the direction of the Grand and Gunnison Rivers, was to the westward. We would, therefore, naturally expect the stream to flow to the westward.

3d. The probability that the cañon was cut slowly as the Uncompahgre plateau rose.

Now, let us consider the probability that the Grand or Gunnison flowed through Unaweep Cañon. Of the two streams, the Gunnison is the one that seems to have the preference. Where East Creek turns to the northward there is a broad valley extending southward and eastward, which seems to mark the continuation of the cañon, it being much wider and extending to the Gunnison. The valley, however, as well as the cañon of East Creek, is in soft sedimentaries, and very little can be argued as to past conditions from what we see now.

Just east of the crest of the Uncompahgre plateau the cañon is broadest and deepest. The map suggests to us the idea that it once was occupied by a lake. If the Gunnison flowed to the west through the cañon, we may suppose that the plateau rose faster than the cutting of the cañon progressed. This would cause a lake to be formed, with the crest as its barrier on the west. Next, we have to suppose this barrier cut away gradually and the lake drained. Following this, also, we must suppose the elevation of the plateau continued with an accelerated movement to allow the river to take a new course—the present course. If not, we must suppose the present course to have been determined by a new outlet to the lake, and the latter drained in that direction rather than toward the Dolores, in the ancient course of the stream. The lake, if it ever existed, must have spread over a wide extent of country; and we are still left in doubt as to the formation of the gorge, as the lake would evidently not be limited by the walls of the cañon. It is hard to imagine the lake cutting the cañon. If the lake were confined within the present walls of the cañon, we ought to find at least traces of its sediments, which we do not. All that can be said at present is that there is presumptive evidence that the stream flowed to the westward, and was deflected from its course by the continued upheaval of the Uncompahgre plateau. Future close study of the cañon and the surrounding country will doubtless give more facts from which details can be determined, but the view stated above will probably be the general idea which they will confirm.

SIERRA LA SAL AND GRAND RIVER.

The first thing we notice in looking at the map of the Salt Mountains is the radiation in the drainage of which the mountain mass is the center. The entire area includes about 1,300 square miles. On the southeast and northeast the creeks are tributary to the Dolores River, while on the north and west they flow to the Grand.

The Salt Mountains consist of about thirty peaks, forming a range about 15 miles in length and about 5 miles wide. The axis of the range is about north and south. The peaks range in elevation from 11,800 feet to 12,980 feet, rising 8,000 to 8,500 feet above the level of the Dolores and Grand Rivers. The mountains are of porphyritic trachyte, and they are eruptive, although their present form is largely the result of subsequent erosion. Powell* refers to the fact that many of the isolated eruptive mountains in the Colorado River region west of the region

* Exploration of the Colorado River of the West, p. 200–203.

of the Sierra la Sal are formed by erosion of the surrounding strata, and that the summits of these mountains mark in reality the level of former valleys down which the volcanic material flowed. These mountains will be found to consist in part of stratified rocks on which the volcanic material rests. Such a group, he says,* are the Henry Mountains, whose summits we could see from the Sierra la Sal.

From the distant view obtained, I am inclined to class the Henry Mountains with the Sierra la Sal and Abajo, as their outline is similar, and they appear to be isolated as the former are.†

In the Sierra la Sal, on the highest peak, there is a capping of sedimentary beds. In others there are included fragments of shales of No. 2 or No. 3 Cretaceous, highly metamorphosed. The strata surrounding the mountains dip from the central mass of trachyte. The proofs of the eruptive character of the mountains will be treated of more in detail when we speak more fully of the trachyte in a succeeding chapter.

Southwest of the Salt Mountains the country appears to be cut up by the drainage into innumerable cañons. The rocks, as seen from the mountains, are the Triassic red sandstones with mesa tops. Through these rocks the Grand cuts its cañon northwest of the mountains. As we approach the mountains we ascend to a higher level by steps. Far to the northwest of the Grand there are indications of folding which appears to be comparatively gentle. It is improbable that the axes of these folds radiate from the mountains. West and southwest of station 69 the sedimentary beds (whether Cretaceous or older I was unable to determine definitely) dip steeply from the mountains, the line of outcrop curving around the ridge south of the station, and extending toward the north between stations 68 and 69.

Ten or twelve miles south of station 69 is an anticlinal valley, the western side of which has a wall inclining at a high angle dipping to the southwest. Beyond it is the Cañon Colorado, so named from the bright-red color of the rocks. There are a number of gashes in the wall referred to, cut at right angles to its axis, marking the course of streams which, in rainy seasons, flow to the southwest, in the direction of the dip, to the Cañon Colorado. The cañon leads toward the northwest to Grand River. About its sources are narrow valleys, bordered by bluffs of red sandstone, which becomes white near the top, and is in places surmounted by Jurassic strata. The beds appear to be horizontal, and in many places have cave-like holes worn by rain and wind. As we approach the Sierra Abajo, there seems to be a dip in the sedimentaries away from that group of mountains.

The Abajo Mountains, or, as they are often called, Blue Mountains, are wooded from base to summit. Mr. Jackson, photographer of the survey, traveled around the southern end of them, and is of the opinion that they are trachyte.‡ On the south and west the stratified rocks (red beds) appear to jut against the mountains, reaching away from them in a series of steps or terraces. The line of junction cannot be seen on account of the timber. Some distance to the northeast of the mountains I noticed Cretaceous strata. The divide between the Dolores and the branches of the San Juan is a broad plateau-like country with a gentle slope toward the southwest. The branches of the San Juan

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* Exploration of the Colorado River of the West, page 178.

† Since writing the above, I see that the Henry Mountains are exactly similar to the Sierra la Sal. (See report on Uinta Mountains, p. 20.)

‡ Since writing above I learn that Newberry visited the eastern border of the range and determined them to be eruptive. (See Macomb's report, p. 100.) In Mr. Holmes's report a full description of the Sierra Abajo will be found.

Plate V.
Map of Sierra La Sal.
A.B.
C.D.
lines of Sections on Plate VI.
E.F.
G.H
I.K.
lines of Sections on Plate VIII.
Contours 200 feet apart vertically.
Scale of miles.
N.
Valle Colorado
Grand
Cañon Colorado
Tukuhnikavats Creek
Sinbad Valley
Paradox
Dolores
Valley
Rio
West Cr.
A.
B.
C.
D.
E.
F.
G.
H.
I.
K.
Sta. 12.
Sta. 65.
Sta. 66.

rise close to Dolores and flow toward the south and northwest, cutting deeper and deeper into the rocks as they proceed.

The southern portion of the Salt Mountains is drained by a number of branches flowing approximately parallel to each other toward the southeast, uniting to form a stream flowing east and southeast into the Dolores.

Station 68 is on the highest peak of the Salt Mountains. It rises abruptly from its base a distance of 3,277 feet. From the base toward the Dolores there is a more gradual slope over stratified beds. The peak is composed of a porphyritic trachyte, from the base to a point near the top, which is flat and table-like, and composed of a layer of yellow and reddish sandstones and metamorphosed argillaceous shales. These are probably of Cretaceous age, and are doubtless the remnant of strata that once extended over the mountains previous to the action of any erosive influences. The trachyte probably forced its way through the underlying layers, and carried this layer up with it. In some of the peaks immediately north, between stations 68 and 67, black shales (probably No. 2 and No. 3 Cretaceous) appear on the sides, imbedded in the mass of trachyte. Groves of quaking-aspens grow about the base of station, extending some distance down the ridges between the creeks. Where the creeks unite there is open valley, but from this valley the main stream (Tukuhnikavatz Creek) plunges into a cañon, which is a lateral cañon of the cañon of the Rio Dolores. Nearly two miles farther down the Dolores, the next creek comes in, flowing down the broad anticlinal valley, (Paradox Valley,) across which the Dolores cuts before the mouth of the San Miguel is reached. This creek does not head in the mountains, but drains the country east of station 68. Opposite its mouth another creek joins, coming from the southeast in an equally broad valley. On either side the rocks beneath the red beds are exposed. This valley is probably of later origin than the valley of the Dolores.

The next creek (Roc Creek) is of considerable size, draining the eastern portion of the range. The main stream has an easterly course, and rises in the heart of the range between stations 67 and 68. The other branches are north of station 67. They flow out from the mountains directly east for about three miles to a creek flowing to the southeast. This marks the axis of a synclinal fold. The beds are Triassic, dipping from the mountains, and forming the summits of the lower peaks on the eastern edge of the range. Dark-red shales show beneath the red sandstones. There are parks on these creeks, although they cut deeply into the strata. The main creek, after the junction of this branch, cuts into the red beds. For a very short distance it follows the synclinal. Where it joins the Dolores it is in a profound cañon. The synclinal we have referred to is caused by an elevation in the strata about the head of Salt Creek. There seems to have been a center of elevation on the line of a fold, which may have been caused by an eruption of trachyte which did not reach the surface. The strata were probably fractured, and now we have at this point a basin (Sindbad's Valley) around which the rocks dip away from the valley in all directions. The rocks in the center of this quaquaversal are Carboniferous. On the western side there is a line of faulting near which I obtained Carboniferous fossils, *Productus*, *Corals*, &c., I shall refer to this valley again under the head of Sindbad's Valley. Salt Creek is named from its being largely impregnated with salt, which it seems to acquire just before it leaves the basin. The rocks from which it gets the salt are probably of Upper Carboniferous age, containing, beside ssalt, gypsum, alkalies, and sulphur. The southern branch, rising in the basin, flows past a bluff just before it enters the cañon. From this bluff the greater part of its salt is taken. Above this point the water is clear and fresh. On either side of the exit the rocks dip to the northeast, the angle at the base of the wall being 25°. This decreases as we go up, and also as we go toward the Dolores. Massive deep-red sandstones form the capping of the bluffs. Between the basin and the Dolores there are remnants of Jurassic strata. Salt Creek is in cañon from Sindbad's Valley to the Dolores. Crossing to the west side of the basin, we find light-yellowish sand, shales, and limestones, the latter fossiliferous, beneath the red shales and pink conglomeritic beds. They dip to the northeast at an angle of 60°, seeming to jut up against the red beds which here form the bluffs, and dip south of west at an angle of 10°, decreasing as we go toward the mountain, until we reach the axis of a fold, beyond which the strata again rise, dipping from the mountains.

The northeastern portion of the Sierra la Sal is drained by a creek flowing east and north to the Dolores. It rises among the peaks about stations 65 and 66, and receives a branch from the park-like country at the base of the mountains. It soon begins to cut deeply into the rocks, joining the Dolores in deep cañon. Between this stream and Salt Creek there are a number of minor gulches whose streams flow into the Dolores. The largest of these rises on the plateau opposite one of the heads of Salt Creek and goes into the Dolores nearly opposite the mouth of the stream from the Unaweep Cañon. It separates two areas of Jurassic rocks which cap the summits of the mesas between Salt Creek and the creek rising about stations 65 and 66. They are remnants of strata that once, in all probability, extended over the Salt Mountains.

Between Grand River, the Dolores, and the creek flowing northeast from station 65 the rocks are Triassic on the surface, with Upper Carboniferous and in a few places Middle Carboniferous showing in the cañons. A line of hogbacks dipping toward the north extends from Grand River, 8 miles below the Dolores, to a point on the latter 12 miles above its mouth. The Grand cuts through this ridge at right angles to its trend. The cañon of Grand River here is cut almost entirely in red rocks, and as we follow its course with the eye from the summits of the Salt Mountains we can see huge buttes and monument-like masses of these red rocks capped with remnants of the layer of massive red sandstone. A view to the northwest from the mountains showed us an area that seemed to be entirely destitute of vegetation. The rocks were red and presented rounded forms as though carved into *roches moutonnées* by glacial action. It is probable that the Sierra la Sal was once the seat of local glaciers, although the proof of their former existence is not easily demonstrated. I noticed no striæ, nor could I be positive in regard to the existence of morainal matter. The form of the valleys at the sources of the streams in the mountains leads us to suspect their former existence. The great elevation of the mountains above the country surrounding them has subjected them to so much erosion that evidences of glacial action would be naturally much obscured. As to the age of the mountains all that can be said is that their elevation took place in Post-Cretaceous time, and was probably contemporaneous with that of the isolated groups of the Elk Mountains and those of the Southwest, Abajo, &c. The Sierra la Sal will be referred to again under the "Eruptive Rocks."

SINDBAD'S VALLEY.

Sindbad's Valley is the curious, kidney-shaped basin in which the branches of Salt Creek rise. Its axis has a direction northwest and southeast. It has but one outlet, viz, the cañon through which Salt Creek

Plate VI.

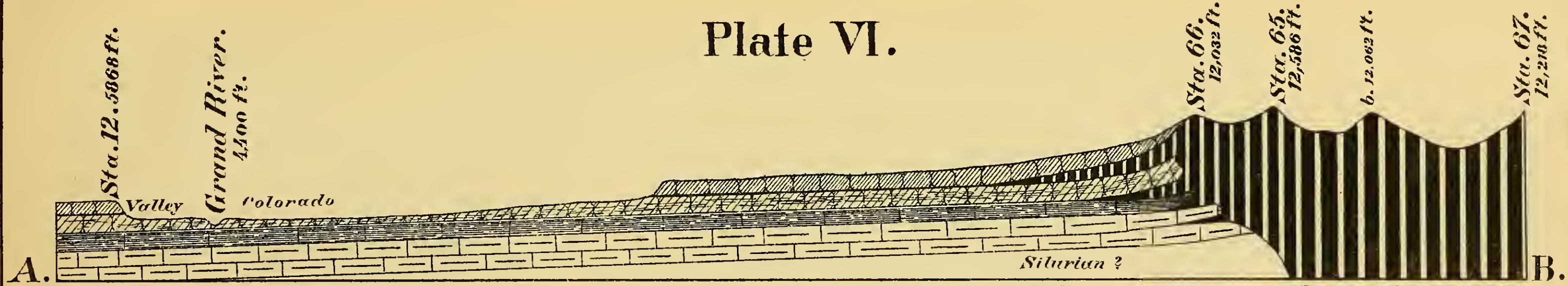

Fig. 1. Section on line AB of map on Plate V.

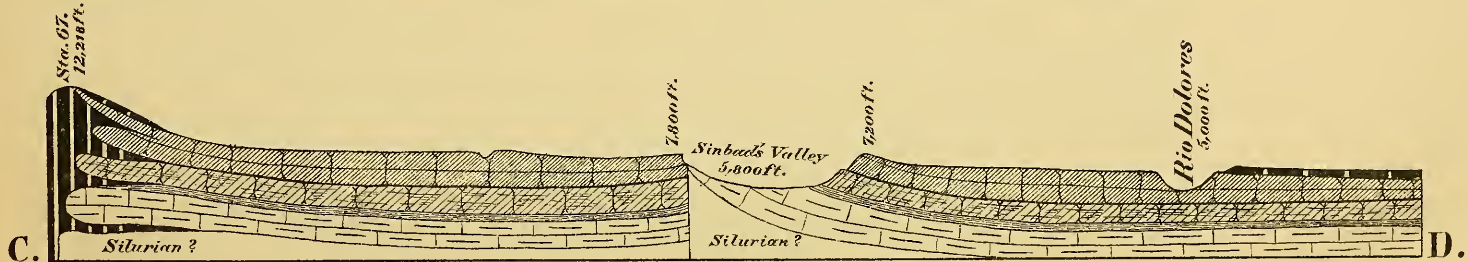

Fig. 2. Section on line CD of map on Plate V.

flows to the Dolores. The basin is nine miles in length and from a mile and a half to three miles in width. It is widest at the north. On the east the dip of the rocks forming the wall is to the eastward. The wall is at this side about 1,400 feet high. On the north it is higher, reaching 1,600 feet on the northwest. The inclination of the beds is to the northward, changing to the westward as we get around to the west side. The western wall decreases in height as we follow it to the southward, and on the south side it is only about 1,000 feet high. The dip here is to the southward. The formation forming the top of the wall is the massive sandstone of the Trias. Against these sandstones on the west where the trail ascends the bluff, Carboniferous limestones abut, dipping 60° eastward, while the Triassic? sandstones are gently inclined to the westward. There is, therefore, a fault. This fault is directly in line with the anticlinal fold noted both south of the Dolores, and north of the valley. This fold is at right angles to the course of the Dolores before it is joined by the San Miguel, and its axis on both sides of the river is marked by a broad valley (Paradox Valley). One the north, also, the Grand cuts across the fold at right angles to its axis. It would seem, therefore, that the fold must have been formed gradually, the rate of elevation not exceeding the cutting power of the streams. This fold may have taken the form of a fault on the west side of what is now Sindbad's Valley, with the downthrow on the west. This, however, does not account for the tipping up of the ends of the Carboniferous strata. It is probable that this occurred later. The quaquaversal structure of the valley suggests the idea that it marks an eruptive center similar to those of the Sierra la Sal, in which, however, the igneous material did not reach the surface, causing only a bulging of the strata. Whether the fault is the result of this bulging or of the folding, as explained above, we cannot say. That faulting did occur is evident. It left the ends of the soft and shaly beds abutting against the hard sandstones, and subsequently they were bent upward. A force acting from the Sierra la Sal eastward would accomplish this. It remains a question to be determined whether the eruption of the mountains had anything to do with it. If the fault occurred previous to the upheaval denoted by the dips of the strata, there doubtless followed a period in which erosive influences were actively at work, and which would assist in rendering the site of the valley a point of weak resistance. The breaking of the strata attending the upheaval would afford a good beginning for subsequent erosive agents, and as they worked deeper and deeper into the soft shaly beds the present form of the valley was doubtless gradually attained.

In the succeeding chapters, I propose to consider the various geological features separately, taking up each formation in order. As already mentioned, the greater part of the district is covered with sedimentary formations; those represented are Carboniferous, Triassic? and Jurassic? and Cretaceous. There are limited areas of archæan rocks and also of volcanic rocks.

CHAPTER IV.

ARCHÆAN ROCKS.

The areas in which archæan rocks are shown throughout our district are limited to those places where the overlying sedimentary beds have been removed. This is generally along the courses of streams flowing in cañons. The rocks are metamorphic, and their characters will be treated of as we refer to the particular localities in which they occur. In many places the schistose character is very distinct and the bedding very clearly seen, but in most cases we were unable to see any traces of bedding, the rocks being granitoid. From the number of exposures noticed it is evident that the rocks underlie the entire district. From the limited and isolated exposures, it was not possible to trace connections from one place to another.

The limited amount of time, and loss of all specimens collected, preclude the possibility of giving many lithological details.

The strata have all undergone such changes since their deposition as sediments, that the only way in which we can approximate their age is by position in reference to the overlying sedimentaries. In our district the oldest recognized sedimentary rocks resting upon the metamorphic series were of Carboniferous or Permo-Carboniferous age this indicates that they are at least of Pre-Carboniferous age. Farther east, and north in Colorado, we find them covered with the representative of the Potsdam sandstone, so there they are Pre-Silurian, or of archæan age. So, also, far to the north, primordial rocks rest upon them, proving them again of Pre-Silurian age.

Although, in these different localities the lithological peculiarities may differ slightly, they belong to the same metamorphic series. As Mr. Marvine says in the report for 1873,* "The conclusion as to their archæan age is also rendered almost necessary on the independent ground of the extent, uniformity, and completeness of the metamorphism which has affected the mass. For it is no case of local metamorphism, nor one of supposed dependence upon adjacent masses of eruptive rocks, nor of the accidental presence of mineral waters. The metamorphism is regular, or normal, affecting a great system of bedded rocks of unknown thickness and indefinite extent."

Sufficient data have not yet been obtained to determine the exact age of the metamorphic series, although, as Marvine remarks of those farther east, "the prevalence of siliceous and granitic types recalls the descriptions of Laurentian areas." In one place the schists are very distinctly stratified, consisting of dark micaceous schists, with seams of quartz and feldspar. These may be of Huronian age, although we cannot trace their relations to those of the other Archaean rocks, as they are exposed in an isolated area at the bottom of cañons distant from the other outcrops. In the cañon of the Colorado, according to Newberry

* Page 138

and Powell, the metamorphic rocks occur beneath the sedimentary, their original structure greatly obscured or entirely destroyed.

I will now take up the different localities of the district in which rocks of Archæan age were observed.

The granitic and gneissic rocks in the valley of the Gunnison from Cochetopa Creek to the Lake Fork were described in the report for 1874. Along the courses of the creeks flowing to the Gunnison from the south we have tongues of metamorphic rocks extending southward from the narrow strip exposed along the main river. (See Fig. 4, Plate I.)

As we have noted in a preceding chapter the prevailing rocks from the Gunnison southward to the San Juan Mountains are volcanic. Near the Gunnison they rest on Cretaceous strata, but farther back Archæan rocks underlie them. On White Earth River there are several hills of granitic rocks rising above the volcanics. Station No. 1 is located on such a hill. Although the outcrops were very indistinct, enough was seen to note the fact that some of the layers were quartzitic and others softer, with red and gray gneissic layers. The slopes of the hill were covered with reddish *débris*. South of stations 3 and 4 is a small area in which the trachyte had been removed from the coarse, red, feldspathic granite rock which here evidently underlies it. No trace of stratification was observed. On the Gunnison the rocks vary from coarse-grained with silvery mica (*muscovite*) to dark schistose and hornblendic gneisses. From Lake Fork to Blue Creek the streams joining the Gunnison from the south come in through deep cañons cut through Archæan rocks which are capped with volcanic layers.

Between Cebolla Creek and the Gunnison River is a granitic hill with three summits, two of which are covered with a horizontal layer of trachyte. This hill is intersected with quartzitic veins. There appears to be an indistinct stratification, which indicates the dip to be toward the southeast. This area is continuous with the plateau on the southwest side of the Gunnison, between that river and the Uncompahgre. Here again the rocks are coarse-grained and reddish in color. In the cañon of the Gunnison, the bottom of which is nearly 3,000 feet below the top or plateau level, veins, probably quartzitic, can be seen crossing in all directions, some reaching from the level of the river to the tops of the walls, which are perfectly bare. Against these rocks, from the valley in which the Cimmaron and Cebolla unite to a point in the Uncompahgre Valley, shales of Upper Cretaceous age abut. There appear to be no older beds until we recede some distance toward the southwest and also the north. There must have been an area here, which in Pre-Cretaceous times was above water. It is probably also of Pre-Silurian age, as we have already noted. A gradual subsidence took place, and we find the sedimentary layers gradually overlapping each other until the Upper Cretaceous beds rest immediately on the granite. Some points may have been above water also during Cretaceous times. After the deposition of the shales there followed an elevation (probably in Tertiary time.) I do not mean to say that all over the Rocky Mountain region there was but one period of elevation from the time of the first appearance of this granitic area above water to the time when the Cretaceous beds made their appearance above water, but merely that at this point we have evidence of but this one, and evidence also of the gradual subsidence of the land from Pre-Silurian times to at least the end of the Cretaceous period. Facts observed in other portions of Colorado point to the Tertiary as the period of this elevation. I shall refer to these points again in another portion of the report.

I will next take up the Archæan areas of the Uncompahgre Plateau between the Gunnison and San Miguel and Dolores Rivers, commencing on the eastern side, and following it around south of the Grand toward the Dolores.

The Gunnison River, from its Grand Cañon to the mouth, is in sedimentary rocks. Going west from the lower cañon and ascending to the plateau, we find on one of the branches of Unaweep Cañon, a strip of gneissic rock. I leave the consideration of the Unaweep Cañon gneissic rocks for the present, and go north. Here we find on nearly all the streams flowing to the Gunnison, narrow belts of Archæan rocks. A little farther north, on high bluffs southwest of the mouth of the Gunnison, we find these narrow belts connected with a line extending along the edge of the bluffs, and marking a point where, instead of the monoclinal fold, usual along this side of the plateau, we have a fault. On the west side resting on the granitic or gneissic rocks, are red sandstones (Triassic?) with a gentle inclination eastward. On the eastern side, the sandstones of the Dakota group (Cretaceous No. 1) rest on the gneissic rocks, dipping to the eastward also, but with a much greater inclination, sometimes being almost vertical. The dip, however, as we go toward the rivers, decreases, the ends of the strata simply being turned up steeply near the granite. This belt is not extensive, the fold soon coming in again and covering it. I was unable to get down to the rocks here, but they seemed to be mainly dark micaceous schists. From our point of view, no evidences of stratification were observed, though the dip is probably to the northeast, as was observed farther west.

On the creeks rising north of stations 47, 46, and 45, and flowing into Grand River, we have some narrow strips of gneissic rocks. On the most northern of these, the principal stream, (Little Dolores,) we have mica schists and quartzites dipping northeast at an angle of 60° to 70°. They are generally dark-colored, with seams of quartz and feldspar, and appear only at the bottom of the cañon. On them the red beds rest, dipping to the north, or perhaps a few degrees east of north, the inclination being from 3° to 5°. On the north side of the main stream the angle increases, throwing the red beds to the bottom of the cañon, and the granitic rock, therefore, does not show on that side. Grand River appears to be entirely in the red beds. Following the plateau around to the west side at station 47 we find ourselves again on the edge of an Archæan area, which commences south of stations 46 and 47 and extends toward the northwest in a narrow belt as far as we could see, marking a line of faulting. Here the red beds again show themselves resting directly on these older rocks. Going east of south from station 47 we come to Unaweep Cañon, in which the greater part of the walls are granitic. Commencing at the eastern end of the cañon, we find at first that the walls are simply of stratified rocks. Station 54 is on the Dakota sandstones, which dip approximately eastward. The bed of the creek is 679 feet below the station. Here we first meet with the granite as a narrow strip bordering the creek. As we go up the cañon the granite walls soon appear and gradually rise higher and higher. At first the walls were red sandstones, but as they have a dip of 4° to 5° and the stream-bed only an inclination of about 2° with the horizon, they soon form simply a capping on top of the granite wall. At station 40 the granite wall is about 173 feet high. At station 38, a distance of nearly six miles in an air-line west from station 40, the top of the granite is 815 above the creek-bed. Camp 31 was on the top of the granite, near the edge of the cañon close to this station. Here the rock was a bluish-gray porphyritic granite, with numerous feldspathic crystals. There was no trace of stratification, although in a number of places I noticed in the rock, spots that had a pebble-like form and might once have been bowlders, which would indicate that they are metamorphics of conglomerates. The red beds rest immediately on these rocks, but are thicker at station 38 than at station No. 40. They have a sloping, terrace-like edge to the granite, which forms a bench on both sides of the cañon, the level not varying materially on one side from that on the other. The cliffs are precipitous for nearly two-thirds of their height. The other third is a slope to the center of the valley caused by the weathering of the cliffs. In many places the cliffs present solid perpendicular faces, while at others they are broken into pinnacles and needle-like projections.

The divide between the two creeks is nearly two miles in length from the Gunnison branch (East Creek) to the Dolores branch, (West Creek,) and increases in width from half a mile on the east side, to a mile at the head of the Western Creek. The general level is very nearly preserved, being about 7,036 feet above sea-level.

At station 34 the granite walls are about fifteen hundred feet high and at station 39 they have increased to 1,917 feet. West Creek now begins to descend more rapidly, while the top of the granite still inclines at about the same angle to the eastward. This would give us, farther down the cañon, a wall of granite nearly three thousand feet high.

In all this length of the cañon we find only red sandstones (Triassic) resting on the gneissic rocks. They gradually increase in thickness as we go westward and end abruptly on the edge of the cañon and also along the crest of the plateau. When we emerge from the more rugged part of the cañon to the comparatively open valley, extending from the Dolores some four or five miles up the creek, we find older beds, with the ends tipped up against the coarse granitic rocks. The overlying red beds have been removed at the junction. The prevailing character of the rocks of the Archæan portion of the Unaweep cañon are coarse granitic and gneissic beds intersected with seams of quartz and feldspar, but as far as observed without the stratification observed in the exposures farther north. Whether they are of the same age it is impossible to say, although it seems probable that they are older. Without any chance to trace the connection between the two exposures, all opinions as to their relative age must be merely conjectural.

Along the western edge of the plateau we find three areas in which Archæan rocks are exposed. These will be more readily understood by reference to the general geological map, when published. The first is west of station 35, and is connected with the Archæan area of Unaweep Cañon by a narrow strip. The other two are farther south, and are isolated one from the other, the space between being covered by Triassic and fragments of Jurassic strata.

It is only where the continuity of the beds forming the monoclinal fold has been broken and the rocks removed that Archæan rocks are seen. This we find to be generally the case where the folding was accompanied by faulting. As we go south, the erosion subsequent to the folding has removed only a portion of the beds, and the Archæan rocks do not show even where the streams cut across the fold.

Near station 27 the rock is a coarse reddish granitic rock, in which I could find no traces of stratification in the limited exposure.

As we have already said, the rocks which we have been considering in this chapter probably underlie the entire district. They are metamorphic, and it is doubtful if any true igneous granitic rocks would be seen among them if we could have the later sedimentary coverings removed.

They were once deposited as sediments. Whence were their materials derived? We have no data from which we are able even to guess what was the extent of the Archæan continent, or what its character was.

Speaking of the granite in the Grand Cañon of the Colorado River, Professor Newberry* says:

The granite forming the base of the series is very compact and massive, scarcely showing any tendency to stratification. It is cut by veins of quartz of large size, and contains veins of handsome red syenite and coarse red feldspathic granite, with plates of silvery mica. All these seem to have been injected into fissures. The erosion of the cañon has beautifully displayed the ancient surface of the granite, and shows it to have been extremely irregular; hills several hundred feet high, many of which have precipitous sides and deserve the name of pinnacles, have been exhumed from the sediments in which they were enveloped. The sandstones and shales (Potsdam) are seen to have been deposited quietly around them, their strata, nearly horizontal, abutting against their sides. We have here evidence that at least *these* granite hills are older than any of the stratified rocks of the table-lands.

The description of the granite rocks is not dissimilar to that which might be given of those in the Unaweep Cañon. Major Powell,† speaking of the crystalline schists of the Grand Cañon of the Colorado, says:

We find these lower rocks to be composed chiefly of metamorphosed sandstones and shales, which have been folded so many times, squeezed, and heated, that their original structure, as sandstones and shales, is greatly obscured or entirely destroyed, so that they are called metamorphic crystalline schists.

After these beds were deposited, after they were folded, and still after they were deeply eroded, they were fractured, and through the fissures came floods of molten granite, which now stands in dikes, or lies in beds, and the metamorphosed sandstones and shales and the beds of granite present evidences of erosion subsequent to the periods just mentioned, yet antecedent to the deposition of the non-conformable sandstones. (*Sandstones below the Carboniferous, and unconformable to the latter.*)

From both these extracts we see that the Archæan rocks upon which the Potsdam sandstone was deposited present evidences of erosion previous to their deposition. The material thus carried away must have contributed to the formation of strata older than the Potsdam sandstone. May not the schists already noted be a portion of the strata thus formed? I have referred to the probability of their being of later origin than the Archæan rocks of Unaweep Cañon. We would then have to assume that the rocks of the cañon and those beneath the Potsdam sandstones in the Cañon of the Colorado are of the same age. We would have to assume, also, two elevations precedent to the formation of any Silurian layers. The first elevation would be that of the granite area. Then would follow a period of erosion, indicated by the irregular surface noted by Newberry, cutting the granite into hills. We will suppose the material derived from this erosion to be deposited at the bottom of the ancient sea, forming the beds which afterward were metamorphosed into the schists, an outcrop of which we are supposed to have seen near the Grand River, with a dip to the northeast at an angle of 60°. But why should the granite of Unaweep Cañon show so regular a surface as we note beneath the red beds resting on it there? It may have been near the shore of the sea, and therefore less liable to erosion than the country farther west, which was probably higher, or it may mark a portion of the bottom of the sea, on which the schists were deposited and afterward removed. Next we have a depression of the granitic area in the region of the Colorado. Contemporaneous with this there may have been an elevation in our district, for, although on the Colorado we find the Postdam sandstones deposited in the irregularities of the granite, here we find no stratified beds deposited on it until a later period. This elevation would account for the tipping up of the schists, a

*Report Ives's Colorado Exploring Expedition.

†Exploration of the Colorado River of the West.

fact we have already noted. If what is now the plateau was under the sea-level before this elevation, it then appeared as land, continuing so until the end of the Carboniferous, gradually subsiding, however; for there are evidences of a gradually encroaching shore-line from the westward. During Carboniferous times, the west edge of the plateau was a shore-line. In Triassic times, it was moved much farther toward the east. How much farther toward the south it moved we cannot tell.

The granitic area of which we have noted exposures in our district was, therefore, a portion at least of the land from which the materials of Pre-Triassic strata were derived. I have several times referred to the fact of there being a gradual subsidence. There may have been oscillations, some of which were merely local, but the general movement from the beginning of Silurian times until the period of elevation at the end of the formation of the Lignite Tertiary was that of subsidence.

The Archæan area along the northern edge of the San Juan Mountains and south of the Gunnison River probably formed a shore-line in Cretaceous times, and this shore-line was probably much farther north in more ancient times, though how far we cannot, with the present limited amount of knowledge, say. The area of the Archæan continent was probably of some considerable extent, and the area in our district was probably an extension of that farther east, where the main chain of the Rocky Mountains is now, rather than a separate island. Its boundaries cannot be determined until the entire Rocky Mountain region is studied more in detail.

The general level above the sea may not have been very great, but the western North American continent was outlined and we had indications of the future Rocky Mountains.

CHAPTER V.

STRATIGRAPHY—PALÆOZOIC ROCKS.

ABSENCE OF SILURIAN AND DEVONIAN.

As will be evident from the notes already given in the chapters on the general features of the district, there are no exposures of rocks older than the upper part of the Lower Carboniferous. Over a great part of the district the red beds (Triassic) rest immediately upon the Archæan rocks. In the extreme western limits of the district it is probable that older formations lie between. Along the western edge of the Uncompahgre plateau we have Permo-Carboniferous, and west of the Dolores two places where beds of Upper Carboniferous age appear, and when we go as far west as the Grand Cañon of the Colorado we find Silurian strata resting on the granites. Going east also we find Silurian strata, although along the eastern edge of the Front range both Silurian and Devonian strata are absent in most places. During early Paleozoic times there must, therefore, have been broad areas of land whose rocks were probably Archæan. There were probably numerous small islands, also, but what their areas and limits were we cannot at present say. A large portion of our district appears to have been above the sea-level throughout all Paleozoic time.

Devonian strata have been identified in various portions of the West, and doubtless a portion of the limestones that have been included with the Lower Carboniferous should be referred to a lower horizon. I had no exposures of Devonian strata in my district.

CARBONIFEROUS.

The existence of Carboniferous strata in Colorado is well established. Dr. Hayden refers to the Carboniferous rocks of Camp Creek, near Colorado Springs, in the report for 1869.* In 1873 I found fossils at the base of the Front Range, near Pleasant Park, which Professor Meek referred to the Carboniferous.† The same year I also found them abundantly in the Park Range,‡ and they have been gathered at several localities in the Elk Mountains.§ Mr. Marvine recognized the strata north of Grand River in 1874, and obtained characteristic Carboniferous fossils.

In Southern Colorado, Dr. Endlich has identified the formation and obtained typical fossils.

In our district of 1874 there is a considerable area, in which Carbonif-

* Report United States Geological Survey 1867, 1868, 1869, p. 145.
‡ Report United States Geological Survey 1873, pp. 198, 231.
‡ Report United States Geological Survey 1873, p. 198.
§ Reports United States Geological Survey 1873 and 1874.

erous rocks are entirely wanting, the red sandstones of the Trias? resting immediately upon Archæan rocks.

East of the Sierra la Sal there are several outcrops of beds that ought probably be referred to this horizon. At only one locality did I observe any fossils, and all that were obtained had to be abandoned during our difficulty with the Indians. The *exact* determination of the age of the beds from which they were obtained therefore remains in doubt. At the head of Salt Creek the following is the section of rocks referable to the Carboniferous. It is somewhat incomplete from the fact that the soft character of the beds causes them to be concealed by *débris*.

Section at head of Salt Creek.

Top.	Feet.
1. Pink and red shales with conglomeritic sandstones, becoming light-colored near the base and containing gypsum	700
2. Yellowish and black shales and sandstone with gypsum and salt. The creek, in passing the bluff where these beds are exposed, acquires a strong alkaline taste..................	300
3. Space filled with shaly sandstones and, perhaps, bands of limestone. Beds for most part entirely concealed.........	3,500
4. Light yellowish and greenish shaly sandstones.......... } 5. Blue limestone with *Productus*, *Crinoids*, and *Corals*..... }	300
Total	4,800

No. 1 dips to the eastward at an angle of 8°–10°, and No. 2 in the same direction 25°, while at No. 5 the angle is 60°, the beds being tipped up and faulted against the ends of the red beds. Taking an average dip of 30° for the space No. 3 we would get a thickness of over 4,000 feet of beds, which is probably too great. I have estimated it at 3,500, which may also be too much. The steep angle hardly extends far to the eastward.

Whether the layer (No. 5) containing the fossils is of Subcarboniferous or of Carboniferous age I am unable to determine. I am inclined, however, to place it near the line separating them, calling the beds in Nos. 3 and 4 the representatives of the Coal-Measures. Eastward the beds rapidly thin out and Nos. 2, 3, 4, and 5 disappear. No. 1 on West Creek rests on the granite and is made up of coarse conglomerates, especially at the base, showing the near proximity of land during their formation. There was evidently a shore-line along the crest of the Uncompahgre plateau, or just west of it, and the pebbles forming the conglomerate were derived from the adjacent granites. Along the Dolores River the pink conglomerates and sandstones appear beneath the blood-red shales and sandstones that lie immediately below the massive red sandstones that cap the bluffs. These beds will be referred to again farther on.

In Labyrinth Cañon, which is the lower part of Cañon Colorado, Professor Newberry gives the following section of Carboniferous rocks:*

	Feet.
1. Blue slaty argillaceous limestone, with nodules of chert, and containing crinoidal columns in great numbers, *Athyris subtilita*, *Bellerophon*, *Productus*, &c..................................	20
2. Massive blue limestone, portions of which are quite sandy, generally variable in color and composition..................	50

* Exploring expedition from Santa Fé to junction of Grand and Green Rivers. Geol. Report, 198.

	Feet.
3. Slaty blue argillaceous limestone, somewhat cherty, crowded with fossils, among which are *Athyris subtilita*, *Spirifer cameratus*, *Productus semireticulatus*, *P. scabriculus*, *P. Rogersi*, *P. punctatus*, *P. nodosus*, *Orthisina umbraculum*, *Myalina ampla*, *Pleurotomaria excelsa*, &c.	40
4. Red shale, no fossils	6
5. Bluish-white or red mottled sandy limestones, no fossils	35
6. Red calcareous shale, no fossils	7
7. Red or bluish-white mottled sandy limestone; massive; no fossils	25
8. Coarse blood-red sandstone, in some localities becoming red shale; no fossils	22
9. Hard cherty blue limestone, with a few fossils of the same species as found in No. 3	36
	241
On Grand River he gives substantially the same section, adding to it "alternations of blue limestone, red and gray sandstone to bottom of cañon"	1,000
Making a total of	1,241

The locality of this section is about 40 miles west of that of my section on Salt Creek. It is west of the Sierra la Sal. On Salt Creek the beds appear to be more shaly in character, and they were undoubtedly formed near a shore-line, for, only 8 or 10 miles east they do not appear, the higher beds resting immediately on the granite. On account of these differences it is difficult to correlate the two sections. I think, however, that the equivalents of the limestones (Nos. 1, 2, and 3 of Newberry's section) occur somewhere in the upper part of No. 3 of my Salt Creek section.

Professor Newberry was unable to correlate the Grand River section with that of the Colorado River made by him when with Lieutenant Ives.

What relations my section bears to those of Mr. Gilbert and Professor Powell in the Colorado Plateau region I am unable to say. In the latter region limestones are more abundant, deeper seas seeming to have prevailed from Subcarboniferous to Permian times.

Beds Nos. 1 and 2 of the section of Salt Creek I am inclined to call Permian or Permo-Carboniferous. Their thickness is about 1,000 feet. The beds are gypsiferous and shaly. It is difficult to draw any line separating theUpper Carboniferous from the Trias, the pink shales grading into the blood-red sandstones, and shales resting upon them. It seems possible that a portion of the beds I have referred to the Upper Carboniferous are represented by a portion of the Shinarump group of Powell's section.* The data upon which I first referred the gypsiferous series, immediately underlying the "red beds" to the Upper Carboniferous, calling Permo-Carboniferous, are fully detailed in the reports for 1873 and 187.

Dr. Hayden referred a set of beds in the Black Hills to the Permian, and he and Meek identified the horizon in Kansas. Professor Newberry has also recognized the formation in Kansas on Dragoon Creek, with beds below in which there is a mingling of Permian and Carboniferous forms.†

* Geology of the Unita Mountains, pp. 41, 53, 54.

† Report Exploring Expedition to Junction of Grand and Green, p. 19.

Clarence King, on his map of the Green River basin, (Map II, Geological Exploration of the fortieth parallel,) has colored a narrow strip between the Triassic and upper Coal-Measures to represent the Permo-Carboniferous. Prof. Theo. B. Comstock, speaking of the Carboniferous in the North, says:

Near the head of Wind River, overlying conformably the Subcarboniferous ? limestone, there is a thick formation of arenaceous and calcareous beds underneath the brick-red sandstones, usually regarded as Triassic ? If the limestone referred doubtfully to the Subcarboniferous be really the equivalent of Hayden's Carboniferous east of our district, this formation would seem to occupy the position of his Permian*.

Professor Meek, in the Paleontological Report of Simpson's Expedition of 1859, describes fossils of Permian affinities from Timpanogos River in Utah.

It would seem, therefore, that the series is comparatively well marked at widely separated localities.

Prof. John J. Stevenson (in Report of Geographical and Geological Explorations West of the One Hundredth Meridian, vol. iii, page 639) refers the gypsum series of Eagle River, Colorado, to the Carboniferous. These are the beds that in 1873 I referred to Permian or Permo-Carboniferous.† Professor Newberry, in his section of the cañon of the Colorado,‡ notes the occurrence of "red calcareous sandstones with gypsum," lying above the "Lower Carboniferous ? limestone." In speaking of the fact that the comparison of the section on Grand River with that of the Grand Cañon cannot be made, he says, "But the great beds of gypsum of Cataract Creek are certainly wanting here (on Grand River§).

In the "red wall limestone," which corresponds to a portion of Newberry's Lower Carboniferous ? limestone, Mr. G. K. Gilbert found fossils referable to the Coal-Measures about the middle of the series. He says‖:

With these fossils in view the provisional assignment by Dr. Newberry of the whole limestone to the Lower Carboniferous and Devonian is seen to be erroneous, but we are not yet enabled to demonstrate a complete correlation. Of the 4,000 to 4,500 feet of strata that I have assigned to the Carboniferous, a very few feet at the top may be called Permo-Carboniferous, and not less than 3,000 feet are to be referred to the Coal-Measures.

In a foot-note he says:

Professor Marcou (Geology of North America, pp. 23, 24, and 62) calls the Aubrey limestone Permian, the Aubrey sandstone Coal-Measures, and the red wall limestone "Carboniferous limestone" or "Mountain limestone."

The following table will give a comparison of Dr. Newberry's and Mr. Gilbert's sections:

Newberry.	Feet.		Gilbert.	Feet.
Upper Carboniferous limestone; Cross stratified sandstones; Red calcareous sandstones with gypsum	1, 200	Aubrey group.	Cherty limestone; Cross-bedded yellow sandstones, massive; Red and white shales and calcareous sandstone, gypsiferous in some localities	1, 300
Lower Carboniferous ? limestone	1, 000		Red wall limestone group	2, 675

*Reconnaissance of Northwestern Wyoming, p. 114.
† Report United States Geological Survey, 1873, p. 245.
‡ Ives's Colorado Exploring Expedition, p. 42, Geological Report.
§ Exploring Expedition from Santa Fé to Junction of Grand and Green, p. 98.
‖ Report Geographical and Geological Exploration West of One Hundredth Meridian, p. 178.

The Lower Carboniferous of Newberry represents only a portion of the "Red Wall" group. In the upper portion of the Aubrey limestone Mr. Gilbert found fossils suggesting the Permo-Carboniferous of the Mississippi Valley.* In the Report on the Invertebrate Paleontology of the Plateau Province, Dr. C. A. White, speaking of the fossils collected by Professor Powell's party from Carboniferous rocks, says:

Few or none of the fossils of the collections are of such a character as to suggest the Permian age of the strata from which they were obtained, not even those of the Upper Aubrey group. I have elsewhere shown that the prevalence of certain types which have been relied upon to prove the Permian age of the strata containing them may be due to peculiar physical conditions, and I therefore regard it as not improbable that the time of the Permian period may be represented in the Plateau Province by the Upper Aubrey group, although the distinguishing types are wanting there.

Mr. Gilbert in his sections † has a series of Gypsiferous beds above the Aubrey group, which he refers to the lower part of the Trias.

Under the head of the Triassic Dr. Newberry, speaking of the Gypsiferous series, says‡:

In the Pecos section the red sandstone and shales rest directly upon the Coal-Measure limestones, and the Permian magnesian rocks of Kansas are entirely wanting. It is possible, however, as I have before stated, that they are represented by the extreme upper portion of the Calcareous beds, and by a part of the overlying red sandstones and shales—the Saliferous group of my former report; the "*Bunter Sandstein*," or lower division of the Trias of Marcou.

Speaking of the fossils, he says:

As it is they give us reason to suspect that the lower portion of the Gypsum series should be regarded as of Permian age.

Again he says:

Those fossils which I obtained are insufficient to decide any of the questions which have been raised in regard to the parallelism of the beds containing them, with those of other countries, while they may perhaps justly afford ground for a suspicion that the classification which refers *all* the Gypsum formation to the Trias may be erroneous.

In my own district I had an outcrop of the Trias resting on the granite, which I traced continuously for twenty miles. Here the lower part of the Trias consisted of shaly sandstones, red and brownish in color. The Gypsum series which lies beneath farther west was absent.

The evidence upon which I refer the Gypsum series to the Permian or Permo-Carboniferous is as follows:

1st. The existence of the series has been proved at widely-separated localities in the West, and has been so referred.

2d. The upper part of the Aubrey group in the region of the Colorado River has no Permian fossils, although some of them suggest the Permo-Carboniferous.

3d. Vegetable impressions from the lower part of the red beds, found by Professor Newberry in New Mexico, gave him reason to suspect the Permian age of the lower part of the gypsum series.

4th. On Eagle River, at the base of the series, I found fossils referred by Professor Lesquereux to the Permian. Professor Stevenson also refers the same beds to the Carboniferous.

5th. During the season of 1874, I found the red beds resting upon the granite without the gypsum series between, while farther west it was present beneath the red beds, with undoubted Carboniferous strata below it.

I have called them Permo-Carboniferous because there seems to be a

* Geology of Eastern part of the Uinta Mountains, p. 80.
† Rept. Geograph. and Geol. Expl. W. of 100th Meridian, pp. 160, 161, &c.
‡ Expl. Exped. to Junction of Grand and Green, pp. 48, 49.

mingling of Carboniferous and Permian forms, and I have found no distinctively Permian fossils in the lower part. The same condition is found in the lower part of the Carboniferous—Subcarboniferous and Carboniferous types being found in the same strata north of Grand River. Mr. Marvine assured me, in 1874, that the gypsiferous series extended down into the Carboniferous.

Professor White, speaking of the Plateau Province, is inclined to think that the whole Carboniferous age, including its three periods, Subcarboniferous, Carboniferous, and Permian, is represented by the four groups recognized in the Plateau Province.

In the region of Eagle River there is a lithological distinction that is marked, the Subcarboniferous consisting of limestones, the Carboniferous of sandstones and shales, and the Permian, by calcareous and gypsiferous beds, although it is difficult to say where the lines of separation are. It is also impossible to correlate the section with those made farther westward where limestones prevail. It may be that the upper limestone of the Aubrey is wanting East, and that the gypsiferous beds below it are equivalent, in part at least, with a portion of the gypsum series of Eagle River.

Over the greater part of our district the Upper Carboniferous rocks are wanting. During Upper Carboniferous times there was a shore-line to the west of station 33; what the other boundaries of the ancient sea were, it is impossible to say. On Eagle River the characters of the strata through the Coal-Measures and into the Permo-Carboniferous indicate that there was marshy land of considerable persistence in that neighborhood. In the Park range again, the strata indicate shallow waters and a shore-line not far to the westward. The area, therefore, must have been of considerable size. As we go to the north and westward, limestones are more abundant, evidencing the existence of an extensive sea, of considerable depth. East of the Rocky Mountains, the facts point to the same state of things. The paleozoic continent was mainly composed of Archæan rocks which were gradually subsiding, and in Triassic times were probably altogether under water in our district. As we have seen already, fragmental rocks derived from the erosion of the Archæan continent or islands were formed over our district. The laminated and conglomeritic conditions of the strata prove that there was a general subsidence. Judging from the thickness of the beds, from the lowest limestone we discovered, to the base of the Triassic, this subsidence, during Carboniferous times, was at least 4,000 feet. It was probably more, for it is not likely that the limestone referred to was the lowest bed of the Carboniferous. The rate of subsidence was probably not not much, if any, greater than the rate of deposition of the strata.

In the Elk Mountains we find a considerable thickness of Carboniferous limestones. Some of the fossils obtained by Mr. Holmes from the lower layers indicate that they are Subcarboniferous. When these beds were formed, therefore, the Elk Mountains were beneath the level of the sea, and there must have been a shore-line southwest of the Elk Mountains, between them and the Grand Cañon of the Gunnison, for in the latter place there are no Carboniferous strata on the gneissic rocks. There was, then, in early Carboniferous times, a belt of land, about 50 miles in width, lying between the present position of the Elk Mountains and that of the Sierra la Sal.

In Silurian ages the area was probably larger. We cannot say positively that Silurian strata are seen in the Elk Mountains, nor how far westward we must go to find the formation. In the Park range, in 1873, I found Silurian fossils, and, north of Grand River, Mr. Marvine, the following year, obtained primordial fossils. In New Mexico, Dr. Newberry found the Carboniferous in immediate superposition with the granite.

Was the land in our district in Carboniferous times an island or a continental projection? A great portion of what is now the Sawatch range was above water, and the area west of the Uncompahgre may have been connected with the Sawatch area, but in what manner it is impossible to say.

In the Elk Mountains the gypsum series has not been positively recognized. Next to the micaceous sandstones at the top of the Coal-Measures is a conglomerate composed of granitic and limestone pebbles.* Above this are beds of maroon-colored shales and sandstones, followed by red sandstones. The conglomerate was derived from the degradation of land that was composed in part of granitic rocks, and also of stratified. There were no remains to tell whether the pebbles were from Silurian, Devonian, or Carboniferous strata. If the Permian rocks are absent, it would imply an interval between the Coal-Measures and the Trias, to which the conglomerate would have to be referred, during which a portion of the land above sea-level must have been composed of Carboniferous rocks. If so, the gradual subsidence of the land carried them beneath the level of the sea as the deposition of the Triassic sandstones progressed.

It is probable, however, that the conglomerate marks the base of the Permian rocks, and that the maroon-colored beds should also be referred to the Permian. If so, the gypsum which characterizes the beds elsewhere is wanting in the Elk Mountains.

The greenish-gray micaceous sandstones beneath the conglomerate in the section just quoted seem to be identical with those of the Eagle River section, and also with those in Four Mile Creek Cañon west of South Park. This identity is not only lithological but paleontological. All contain fossils typical of the Coal-Measures. I have therefore divided my Carboniferous into three divisions, as follows:

Subcarboniferous—Mainly massive limestones grading below into Devonian ?.

Carboniferous (Coal-Measures)—Micaceous sandstones with limestones near the base.

Permian or Permo-Carboniferous—Gypsiferous and calcareous shales and sandstones, limestone near base.

Mr. Marvine, in 1874, recognized four divisions, the upper one of which was red sandstone and those below as I have them. Dr. Endlich, in Southern Colorado, recognized the following:

Lower Carboniferous—limestones.

Upper Carboniferous—red sandstones.

Near the top of the latter in some localities he finds a band of limestone. I give the following table for comparison in my own districts:

*See section of inverted beds, Report United States Geological Survey, 1873, p. 251.

Carboniferous strata.

In the region of the Dolores River. District of 1875.	On the Eagle River. District of 1874.*	In the Elk Mountains. District of 1873. †	Park Range‡ west of South Park on 4-mile Creek. District of 1873.
Pink conglomeritic sandstones and red gypsiferous shales, Thickness, 1,000 feet.	Micaceous sandstones and gypsiferous shales of variegated colors, with thin beds of limestone at the base. Thickness, 2,000. feet. Fossils—*Calamites Suckovii*, *C. gigas*, *Stigmaria fucoides*, *Spirifer*, *Productus*, *Orbicula*. Thickness, 2,000.	Maroon-colored sandstones and shales, with conglomerate at base. No fossils. Thickness not estimated.	Red, pink, and maroon-colored sandstones, gypsiferous and calcareous, with limestones in thin beds. No fossils. Thickness 2,000 to 2,500 feet.
Shales mostly arenaceous with calcareous and gypsiferous beds at the top. The beds are generally concealed; *débris* is light yellow color. No fossils. Thickness, 3,500 feet.	White, greenish, and reddish, laminated, micaceous sandstones and black shales with patches of carbonaceous material; near the base are limestones,§ with *Avicula*, *Aviculopecten*, *Pleurophorus*. Thickness, 2,500 feet.	Yellowish, gray, and reddish sandstones and shales, with bands of limestone. Lower part of series is gray and greenish micaceous sandstones. Fossils. Third layer (top). *Loxonemia*, *Productus muricatus*, *Spirifer*. Second layer.—*Productus muricatus*, *Athyris subtilita*, *Rhynconella asagensis*, *Hemipronites crassus*, *Terebratula bovidens*, *Retzia punctulifera*. First layer.—*Productus muricatus*. Thickness, 1,300 to 2,000 feet.	Conglomeritic sandstones, green and gray micaceous sandstones and shales, bluish limestones and interlaminated sandstones. Fossils from below. Second layer.—*Productus nebrascensis*, *Productus prattenanus*, *Productus semireticulatis*, *Spirifer opimus*, *Pleurotomaria taggarti*. First layer.—*Productus*, *Spirifer*, *Trilobites*. Thickness, 2,000 feet.
Limestone, only upper part showing fossils, indistinct and not determined. *Productus*, *corals*, and *crinoidal* stems. Thickness, 300 feet, as far as seen.	Limestone, somewhat shaly above but massive as we descend. Thickness about 500 feet.	Limestones and limestone shales. Beds so distorted that thickness not positively taken. Fossils of Subcarboniferous type not yet examined.	Blue limestones and sandstone shales, limestones predominating; fossils are indistinct. Thickness, 300 to 400 feet.
4,800 feet to 5,000 feet.	5,000 feet.	4,000 to 4,500 feet.	4,300 feet to 4,800.

* See sections Report of 1874, pp. 115–119.
‡ See section No. 22, p. 243, Report 1873.
† See pp. 21, 225, 230, 232, Report of 1873.
§ This layer may possibly be Subcarboniferous.

The following table of Carboniferous strata is given for comparison with the preceding:

Montana—Hayden.*	Wind River Mountains—Comstock.†	Plateau province—Powell.‡		Interior basin of United States—Missouri, Iowa, and Illinois. §	
Limestones, both in the Subcarboniferous and Carboniferous. The line separating them cannot be defined. Permian beds have not been recognized.	Arenaceous and calcareous beds with limestone at the base. Limestones compact, thickly bedded, Subcarboniferous. Thickness of Carboniferous limestones, equivalent of Upper Coal-Measures of the eastern United States, not less than 2,000 feet.	Upper Aubrey, 1,000 feet.	Sandstones and limestones, the latter cherty. To the north there are two members of this group, viz, *Bellerophon limestone*, and *Yampa sandstone*. Farther south cherty limestones prevail.	Carboniferous Coal-Measures.	Generally limestones with few shales and sandstones. Thickness, 530 to 1,250 feet.
		Lower Aubrey, 1,000 feet.	Sandstones and limestones massively bedded. In some localities sandstones prevail and are friable.	Subcarboniferous.	Limestones with shales and sandstone at the base. Thickness, 600 to 2,500 feet.
		Red Wall, 2,000 feet.	Chiefly limestones. In the Uintah Mountains massive limestones are separated by thin strata of sandstones. In the Grand Cañon a massive limestone, a thousand feet in thickness, is found with thinner strata of limestone and sandstone beneath.		
		Lodore, 460 feet.	Sandstones and shales, supposed to be the equivalent in the Uintah Mountains to the Tonto group in the Grand Cañon.		
Total thickness, 1,000 to 3,000 feet.		Total thickness, 4,460 feet.		Total thickness, 1,130 to 3,750 feet.	

* Reports United States Geological Survey 1871, 1872.
† Reconnaissance of Northwestern Wyoming, by Captain Jones.
‡ Geology of the Eastern Portion of the Uintah Mountains.
§ Dana's Manual of Geology.

Comparing the tables just given we find that during Subcarboniferous times there was a period of limestone-making which was pretty general over the west, more marked towards the north, in Montana and Wyoming Territories, and in the Mississippi Valley. Deep seas seem to have prevailed, with land somewhere in Colorado, probably as islands. Thus we have seen that a portion of the Sawatch Range, and perhaps a portion of the Front Range, and a considerable area in the western part of our district must have been above the level of the sea.

In the succeeding period limestones continued in the Mississippi Valley and in Montana, and also in the plateau region bordering the Colorado River. In Colorado the rocks show that numerous oscillations took place, and that, as the time advanced, they became less and less, and shallow seas prevailed, with considerable areas above sea-level, in which the rocks, judging from the character of the sandstones then formed, were mainly Archæan.

In New Mexico also Professor Newberry found the equivalents of the Coal-Measures resting directly on the granite.* He also finds evidence of the proximity of land, while to the southward there is "proof of the uninterrupted existence of an open sea" "throughout the entire Carboniferous epoch."† In Permian times shallower seas seem to have prevailed over wider areas, with oscillations of the surface, although, in Colorado, the general movement was one of subsidence.

The following shows the difference in thickness of the Carboniferous rocks in the Appalachian region, the Interior basin, and Colorado:

	Appalachian.	Interior.	Colorado.
Maximum	16,125 feet.	3,750 feet.	5,000 feet.
Minimum		1,130 feet.	4,000 feet.

We see that in Colorado the thickness is intermediate between that of the Appalachian and that of the interior region. In regard to the character of the rocks we notice the same fact. Fragmental rocks form 16,000 feet in the Appalachian region; 500 to 1,000 feet in Colorado, and in the interior region 1,000 to 3,000 feet.

From what has been written, therefore, it will be seen that the areas of highest elevation in Palæozoic, and perhaps in Pre-Palæozoic times in the Rocky Mountain region were in Colorado, and it is an interesting fact that at the present time, as far as known, the highest mass of mountain elevation is also found there. This is also true of the plateaus, which range from 8,000 feet to 9,000 feet. Taking the mean elevation of Colorado, 6,600 feet, we find it greater than that of any other State or Territory, Wyoming being next, with a mean elevation of 6,450 feet.‡

Although the Rocky Mountains, as we now know them, had no existence until Tertiary time, still, as pointed out by Dr. Newberry,§ the western part of North America was outlined from early times by groups of islands and broad continental surfaces of dry land.

A portion of this land, perhaps as islands, existed in Colorado, as we have noted in preceding portions of this chapter. In regard to coal in the Carboniferous, none has been found in Colorado. On Eagle River there were patches of carbonaceous material in the Coal-Measure rocks, and in New Mexico a thin bed of coal occurs in the Coal-Measures near Santa Fé. Still the conditions do not seem to have been very favorable for the formation of coal.

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*Report of Exploring Expedition from Santa Fé to junction of Grand and Green, pp. 42–47.

† *Ibid.*, p. 17.

‡ List of Elevations, by H. Gannett, United States Geological Survey, third edition, p. 72.

§ Ives's Colorado Expedition, Geological Report, p. 47.

CHAPTER VI.

STRATIGRAPHY—MESOZOIC FORMATIONS.

The mesozoic formations of our district are divided about as follows:

Triassic	300 to 1,600
Jurassic	300 to 800
Cretaceous	1,000 to 2,000
	1,600 to 4,400

The entire thickness of the Cretaceous does not appear in the district, and in regard to the Triassic in the Unaweep Cañon there is a gradual thinning of the beds towards the eastward.

TRIASSIC.

No data were obtained from which anything new can be predicated in regard to the series of red beds which we have been in the habit of referring to the Triassic. The reasons for such reference have been given in the preceding reports upon Colorado. The general character of the beds is as follows: A massive yellow, white, or pink sandstone forms the top of the series. Toward the western part of our district this sandstone is calcareous. In many places the sandstones are markedly cross-stratified. The color is subject to much change locally, passing from white, through orange and pink, into deep red. Below the massive sandstone are blood-red shales, followed in most by massive brick-red sandstone places. In Unaweep Cañon the sandstones are laminated, while northward and westward they seem to be consolidated into one massive bed. They are followed, as we descend in the series, by shales and blood-red sandstones, which, on the Dolores, change gradually into gypsiferous shales and sandstones. The latter I have considered as belonging to the Permian. It is difficult to draw any line between the Trias and the Permian, and I have been obliged to do so arbitrarily.

The Triassic rocks are the surface formation over about 600 square miles of the district, while Carboniferous rocks form the surface over only 60 square miles. The area in which Triassic rocks are present beneath the overlying Cretaceous formations is very much larger than that in which we have reason to suspect the presence of Paleozoic formations beneath the Trias. At the end of the Carboniferous period, the subsidence of the land appears to have allowed the sea to spread over much wider areas, and it seems that the sea encroached on the land gradually, as the Triassic period advanced, until it covered almost all of it. We see that in all parts of our district the upper portion of the series presents the same character, and as I shall show in a subsequent portion of the chapter, agrees closely with the upper part of the series at other localities in Colorado, and in Utah, and New Mexico. The conditions, therefore, that existed in our district during its formation were present over a wide area. It is impossible to define the area in our district in which the red beds have never been present. It could not have been of any extent north and south, as we find them resting on the granite in the Grand Cañon of the Gunnison, and Dr. Endlich noted the existence of red sandstones, probably of the same age, at the heads of the southern branches of the Uncompahgre and Gunnison Rivers, a distance of ten or twelve miles farther south. On the south side of the Gunnison, between these points I found several places where Cretaceous stata rested on the granite, without any evidence that the red beds had ever been present and subsequently removed by erosion. The gradual thickening of the series as we go westward also points to the fact of there having been land in this portion of our district in Triassic times. Toward the east and southeast, the area may have been larger. In New Mexico, however, we again find the red beds resting on beds containing Carboniferous fossils. Northward, we have to go only as far as the Elk Mountains to find them. Westward, the area west of the Uncompahgre River is probably underlaid with them, although the first outcrop is not seen until we reach the crest of the plateau overlooking the San Miguel River. I shall now consider the series as it occurs at different points throughout the district.

In the Grand Cañon of the Gunnison there is shown only a narrow belt of red sandstone, probably the upper part of the series, resting on the granitic portion of the chasm. This outcrop thickens as we follow the river north, and southward it gradually thins out and disappears. In the lower cañon of the Gunnison, about 150 feet of massive red and pink sandstone borders the river.

In the area between Unaweep Cañon, Gunnison, Uncompahgre, and San Miguel Rivers, Triassic rocks form the surface over about 180 square miles, with patches of Jurassic shales resting upon them. As we go southward, the Jurassic disappears beneath the Dakota sandstone, and we do not see any Triassic until we reach the crest of the plateau where the red beds show in the cañons which the creeks cut as they flow across the monoclinal fold. The following is a section at this point:

Yellowish sandstones.
Light-red sandstones.
Blood-red sandstones and shales.
Purplish shales.

Following the crest to the northwest, we find the overlying beds on the fold removed, and the red beds alone continuous. Still farther along these are broken and probably faulted at some places. On the plateau they dip to the eastward at an angle of 4° to 5°, and below the crest the inclination is 60° to 70° to the westward. This decreases toward the west, and the red beds disappear beneath the Jurassic and Cretaceous beds to re-appear at the top of the bluffs along the Dolores River with Permian? beds beneath them.

In the Unaweep Cañon the red beds show on top of the granite, preserving the same level on both sides of the cañon. The dip is to the eastward, and the outcrops are continuous for from 20 to 25 miles. The white or orange colored cross-bedded, massive sandstone forms the top of the series. The sandstones below are more laminated than they are on the Dolores. Going through the cañon from east to west, we notice a gradual thickening of the strata. At station 40 it is 270 feet. At 38, 6 miles farther west, it is 342 feet, and west of station 34, about 10 miles farther, the thickness is between 500 and 600 feet, while across the Dolores it is over 1,000 feet. North of the cañon the area covered by the red beds is nearly 200 square miles. On the highest part of the plateau there is a tongue of Jurassic and Cretaceous rocks extending from the Gunnison to the western side of the plateau a few miles north of the cañon. (See Fig. 3, Plate IV.) North of this, the surface formation is the cross-bedded white sandstone of the Upper Trias, dipping 5° to the northward, with granite showing on the bottoms of the cañons of the streams flowing toward the Grand. The upper member of the series is subject to much change, becoming red and salmon colored as we approach the Grand, where isolated patches of Jurassic shales cap buttes composed of these sandstones. Between this upper member of the Trias and the granite, are laminated blood-red sandstones, separated in places by a band of white sandstone. The latter becomes pink and blood-red as we follow it northward, and the laminated sandstones change to massive sandstones with a few shales at the base. The thickness is as follows:

	Feet.
Cross-bedded sandstone somewhat laminated at base, yellow, white, or salmon colored	300–400
Massive sandstone, blood-red in color, with shales at base resting on granite	400
	700–800

The lemon-yellow, pink, and salmon-colored sandstones are composed generally of very fine material, and the buttes into which they have been eroded present most beautiful examples of rock-coloring. On the sides of the buttes great caves have been worn into the rock, and others have the form of pinnacles and towers.

On the western side of the plateau there is a fault of about 800 feet, with the beds below tipped up against the granite. The area between the crest of the plateau and the Dolores is occupied mainly by red beds, with Jurassic and Lower Cretaceous strata appearing as we approach Grand River. Between the Dolores and the Salt Mountains the red beds again are the surface formation, with the exception of several small areas of Jurassic and the Carboniferous area of Sindbad Valley. This valley lies on the line of a fold extending from a point south of the Dolores to the Grand and northwest of the Grand. As explained in a previous chapter, in the valley which we named Sindbad there is a fault, with the ends, of Carboniferous strata, tipped up against the red beds on the west side. The following is a section on the east side of the valley, on Salt Creek, which drains the basin:

	Feet.
1. Light-red sandstones, massive 2. Dark-red shales	600
3. Massive blood-red sandstone	700
4. Brown sandstones with interlaminated red shales	300
	1,600
5. *Pink and red gypsiferous shales and sandstones, conglomeritic at the base*	700

Layer No. 5 was included in the section of Permian beds, page 71.

The section on the Dolores is like that of Salt Creek, except that the beds are lighter colored near the base and contain large, angular fragments of granite. On Grand River, north of the Sierra la Sal, I made the following section. The thicknesses were measured by angles taken with the gradienter, as it was impossible to descend the cliffs to measure the strata in detail.

	Feet.
1. Light-red and white sandstone	400
2. Massive blood-red sandstone	500
3. Fine soft red shales	280
4. Shales and sandstones, dark red and brown	520
5. Purplish-red shales, reaching to base of cliffs	440

Some of the lower beds in this section are probably Permian; but it is impossible to draw any line between them and the beds that are undoubtedly Triassic. South of the Salt Mountains, I am inclined to believe that the red beds prevail. On the west, in the immediate vicinity of the mountains, I think the red beds are covered by the Jurassic shales and Dakota sandstone, (No. 1 Cretaceous.) Farther west, the red beds show as seen from the summits of the mountains, and at one place seemed to be worn into huge *roches moutonnées.* We were too far away, and too high above the level of the country, to obtain any details of the structure in that direction.

In the Cañon Colorado, Professor Newberry gives the following section:*

	Feet.
7. Red, yellow, or white massive calcareous sandstone; no fossils	550
8. Red thin-bedded sandstones, with red shales; no fossils	150
9. Red and brown massive sandstone, fine grained, not hard; no fossils	270
10. Soft red sandstone, in thin layers, separated by beds of red or dark-brown shales	350
11. Greenish-gray micaceous conglomerate and gray sandstone, separated by red and purple shales	92
12. Soft liver-colored sandstones, becoming, suddenly and locally, nearly white, with partings of shale	350
13. Brick-red, massive, calcareous sandstones, with some like the last	164

The following is a comparison of the thicknesses of the sections just given:

	Salt Creek.		Grand River.		Cañon Colorado—(Newberry.)	
	No. 1, No. 2,	600 feet.	No. 1,	400 feet.	No. 7, No. 8,	700 feet.
			No. 2,	500 "		
	No. 3,	700 "	No. 3,	280 "	No. 9,	270 "
	No. 4,	300 "	No. 4, No. 5,	960 "	No. 10,	350 "
	No. 5,	700 "			No. 11, No. 12, No. 13,	606 "
		2,300 feet.		2,140 feet.		1,926 feet.
Deducting, probably: Permian?		700 "		960 "		606 "
Triassic?		1,600 feet.		1,180 feet.		1,320 feet.

In the section on Grand River we hardly have the top of the series, and at the base we probably extend farther into the Carboniferous than in the other sections, as the beds are partially concealed, and we could not draw any lines of demarkation.

Between the Dolores, San Miguel, and Lone Cone, there are outcrops of red beds, but their consideration will have to be deferred until the region has been visited. They were seen from too great a distance to give any details. There appear to be several folds which bring the

* Exploring Expedition to Junction of Grand and Green, p. 99.

Trias to the surface. At the sources of the Uncompahgre and San Miguel Rivers there are outcrops of red beds, probably Carboniferous in part.

I have adhered to the name Triassic, for the series just described, because the evidence is conflicting, and the beds are usually called Triassic as a provisional name. In New Mexico, Cope has found fossils that he says are favorable to the identification of this horizon with the Trias.* These fossils are remains of a new genus *Typothorax coccinarum.* He also obtained, from the same horizon, other vertebrate remains, and a new species of *Unio*, the latter showing that at least a portion of the Trias of the West is of fresh-water origin.

Near the Abajo Mountains Dr. Newberry found saurian bones and silicified wood in shales just above the massive yellow and red calcareous sandstones that form the top of his Triassic series in the section I have already quoted. These bones were associated with fossil shells resembling *Natica.*†

At the *Cobre* or old copper-mines of Abiquiu he found fossil plants, of which he says:

> We have, therefore, in these plants evidence of the Triassic age of *all* the variegated gypsiferous rocks of Northern New Mexico; for the Lower Cretaceous sandstones immediately overlie the plant-bed of the Cobre.‡

In Utah, Mr. E. E. Howell obtained fossils from the base of the Trias. Dr. C. A. White describes these,§ and says:

> If the collections had been placed in my hands for determination, without any statement of their stratigraphical position, I should have referred them to the Jurassic period, with no other doubts than those suggested by the imperfection of the specimens.

In the Black Hills, Dr. Hayden also found Jurassic fossils near the base of the Triassic.||

The plants that Dr. Newberry refers to the Triassic were immediately beneath the sandstones of the Dakota group. While in Utah, Howell found Jurassic fossils in nearly the same position. That the beds are near the same horizon I will attempt to show farther on. In New Mexico, Mr. Gilbert is inclined to think that the Jura is absent. The summit of his Trias corresponds with that of Powell, Newberry, Howell, and mine, in Colorado. Above the Trias he has a series of sandstones and shales which he refers to the lower part of the Cretaceous. These beds agree with the descriptions of those usually referred to, the Jurassic, with, perhaps, the exception of the gypsum, which appears to be absent in Gilbert's section. In some parts of Colorado the beds below the Dakota group are destitute of gypsum to the top of the red sandstones. From what I have written, it appears that the evidence supplied by vegetable paleontology is opposed to that derived from the animal remains. This is also the case in Eastern North America, where the Triassic may eventually prove to be Jurassic.

The following sections include also the Jurassic strata:

*Report of the Chief of Engineers, p. 981.

† Exploring Expedition to Junction of Grand and Green Rivers, pp. 91, 92.

‡ Exploring Expedition to Junction of Grand and Green Rivers, pp. 68, 69.

§ Geology of Eastern Portion of the Uinta Mountains, p. 81.

|| Geological Report of the Exploration of the Yellowstone and Missouri Rivers, 1859–'60, p. 11.

HOWELL.

Near Paria Settlement, Southern Utah.

JURASSIC.	
9. Pale-red, massive, cross-bedded sandstone	125
10. Variegated gypsiferous shales, with green and slate colors at top, (*Camptonectes*, *Trigonia*, *Aviculopecten*, *Gryphæa?*)	175
11. Pale-yellow, cross-bedded, calcareous sandstone	75
12. Red, yellow, and gray marly shales and sandstones	125
Total, feet	500
TRIAS.	
13. Buff, massive, cross-bedded sandstone	800
14. Pale-vermilion, massive, cross-bedded sandstone	600
15. Variegated gypsiferous marls, containing silicified wood	400
16. Shinarump conglomerate, a gray conglomerate with large quantities of silicified wood	50
17. Chocolate arenaceous and gypsiferous shales and marls	400
Total, feet	2,250
Jura	500
	2,750

POWELL.

Plateau Province.

	JURA AND TRIAS.	
Flaming Gorge group.	Bad-land sandstones, sometimes argillaceous, with much gypsum, massive sandstones, and limestones. Thickness, 1,200 feet.	
White Cliff group.	1. Light-gray or white sandstone, massive, cross-bedded	600
	2. Bright-pink and vermilion sandstone, cross-bedded	300
	3. Gray, red, and brown sandstone, cross-bedded, of many colors	200
Vermilion Cliff group.	4. Red, friable sandstone	50
	5. Massive, cross-bedded sandstone and bands of limestone	180
	6. Red sandstone thickly bedded	320
	7. Calciferous sandstone	2
	8. Orange or vermilion sandstone	100
	9. Light-gray sandstones	5
	10. Orange sandstones massively bedded	400
Upper Shinarump.	Bad-land sandstones with much gypsum, often argillaceous; sometimes indurated sandstones.	
Shinarump conglomerate.	Fine conglomerate.	
Lower Shinarump.	Bad-land sandstones, with much gypsum; sometimes argillaceous.	
	Thickness of Shinarump, feet	1,800
	Thickness, feet	3,957
		1,200
		5,157

GILBERT.

Near Fort Wingate, N. M.

CRETACEOUS.		
8. Shale sandstone and coal		30
9. Purple to white conglomerate		80
10. Pink and variegated arenaceous shales		30
Thickness, feet		110
TRIAS.		
11. Massive, cross-bedded sandstone:		
a. Pale purple, white at top	90	
b. Pale pink, friable	80	
c. Cream-colored, incoherent	120	
d. Red and white banded	200	
e. Crystalline limestone	2	
f. Red and compact, with white band at base	220	
		712
12. Red and variegated shales		100
13. Purplish limestone		6
14. Variegated gypsiferous clays, with beds of sandstone, (there is 10 feet of conglomerate toward base)		975
15. Calcareous chert		25
Thickness, feet		1,818
		110
		1,928

NEWBERRY.

Near Abajo Mountains, Southeast Utah.

JURASSIC.	
6. Red and green shales, with bands of soft, white, red, or greenish micaceous sandstones. Fossils, saurian bones, and silicified wood. Thickness, 350 feet.	
TRIAS.	
7. Red, yellow, or white calcareous sandstone	550
8. Red, thin-bedded sandstones and shales	150
9. Red and brown massive sandstone	270
10. Soft, red sandstones and dark-red shales	350
11. Greenish-gray micaceous conglomerate and gray sandstone, with red and purple shales	92
12. Soft, liver-colored sandstones locally white with shales	350
13. Brick-red, massive, calcareous sandstones with shales	164
Thickness, feet	1,926
Jura	350
	2,276

In Gilbert's section the whole Cretaceous section is not given. He says the lowest Cretaceous bed is No. 8 or No. 10.

In a previous page I have compared my sections with that of Dr. Newberry, and the table just given will show how closely all the sections of the Trias agree.

JURASSIC.

Immediately above the red beds is a group of shales and marls, with thin bands of limestone near the base. These beds are variegated in color, and correspond, lithologically and stratigraphically, with the beds that, in Eastern and Central Colorado, I referred to the Jura. I was unable to make any detailed sections, but, as far as seen, they appeared to correspond closely with the beds measured in the sections on the Gunnison in 1874.* In that locality the series consisted of soft argillaceous and arenaceous shales, often gypsiferous and variegated in color, with bands of yellow siliceous sandstone and gray and bluish-gray limestones in thin beds. The total thickness was nearly 250 feet. In the district under consideration, the thickness is probably greater than that on the Gunnison. The areas in which this series is exposed are comparatively small. In the "Great Uncompahgre Plateau" there are several areas where these variegated beds are the surface formation. These will be readily understood by glancing at the map. In the monoclinal fold toward the southwest, the creeks that cut across it expose the Jurassic beneath the Dakota group. The Jurassic is also seen in the bottoms of the cañons draining the plateau bordering the San Miguel on the west. As we go northwest, the Dakota sandstones are absent, having been eroded away; and still farther along, the Jurassic shales are also absent.

In the region about the Sierra la Sal, there is also a limited area of Jurassic dipping from the mountains.

In a preceding portion of this chapter I have spoken of the conflicting evidence in regard to the Trias, and showed that Jurassic? fossils have been found at the base of the Trias. The sections given on page 85 will show the relations of the Jurassic strata to those of the Trias. In Mr. Gilbert's section I am inclined to think that a portion of the beds referred by him to the Cretaceous are Jurassic.

* Report United States Geological Survey, 1874, pp. 126, 127.

The following are lists of fossils from the Jurassic strata described in those sections:

Howell and others in Southern Utah.	Powell in Plateau Province.
Pentacrinus asteriscus.	*Pentacrinus asteriscus.*
Ostrea strigilecula.	*Ostrea strigilecula.*
Camptonectes stygius.	*Camptonectes stygius.*
bellistriatus.	*bellistriatus.*
Inoceramus crassalatus.	*platessiformis.*
Myophoria ambilineata.	*Myophoria* ——— ?
Trigonia ——— ?	*Trigonia* ——— ?
Neritina ? phaseolaris.	*Trigonia americana.*
	montanensis.
	Conradi.
	Trigonella ——— ?
	Neritina ?? Powelli.
	——— ?
	Rhynchonella gnathophora.
	myrina.
	Ostrea (Alectryonia) procumbens.
	Gervillea ——— ?
	Pinna ——— ?
	Myacites ——— ?
	Belemnites densus.
	Ammonites cordiformis.
	Undetermined Conchifers and Gasteropods.

As I have already stated, Professor Newberry found plants at the top of the variegated series, and refers the whole gypsum series to the Triassic; and Professor White noticed fossils found by Mr. Howell at the base of the Triassic, and says they are of Jurassic affinity. It seems, therefore, a disputed point whether we should consider both periods represented, and call the formation Jura-Trias, as Powell has done, or treat them as two distinct formations.

Mr. Howell is of the opinion that the Jurassic thins out, and probably disappears in Eastern Arizona and New Mexico. I think that the sections show that it is probably present, although it is difficult to define it at all localities, as the rocks grade into those that belong to the Cretaceous above and the Triassic below.

In the future we may have to consider the whole formation as Jurassic. It may be that the fossils represent both the formations. In Eastern North America the line between them has not been definitely drawn, and in the West we will have to wait until we have more evidence. At present, it seems to be in favor of the Jurassic.

CRETACEOUS.

The Cretaceous strata in our district are comprehended under the Lower division, (Dakota group,) Middle division, and the base of the Upper division. The latter is exposed at only one locality, and the middle division is only partially seen at most localities. The Dakota group is the only formation occupying much area in the district.

In the table given on page 128 of the Report of United States Geological Survey for 1873, I included the Fort Pierre group (No. 4) in the Middle Cretaceous, because I was unable to draw any line between No. 3

and No. 4. The division was made lithologically, and the line perhaps should be drawn somewhat lower down, so as to include a portion of No. 4 with the upper division. Professor Meek is inclined to place the line separating the Middle Cretaceous from the Upper at the base of No. 4. He says the fossils never cross the line, and that the division corresponds more nearly with the European divisions. The Cretaceous strata once probably extended over our entire district, and where now absent it is due to erosion.

LOWER CRETACEOUS.

Dakota group.—(Formation No. 1.)—Nothing was obtained from the Dakota sandstone during the season from which anything new can be predicated in regard to the formation. The massive yellow siliceous sandstone, in some places quartzitic, at the base of the Cretaceous is so well defined lithologically that there has never been any difficulty in separating it from the overlying shales. Along the edge of the plains in Colorado it is underlaid by greenish shaly beds, sometimes lignitic near the top, generally in part or wholly covered, which have always been referred to the upper part of the Jurassic. In the West these shaly beds still persist, and the massive sandstone, although still recognizable without difficulty, is much thinner, being only from 50 to 100 feet, and as we descend in the sections carried below we find other beds of siliceous sandstone separated by shaly beds that are arenaceous, calcareous, and argillaceous. In these beds, in 1874, I found a sassafras-leaf, which led me to refer these lower beds to the Lower Cretaceous. I drew an arbitrary line separating the Cretaceous and Jurassic. The beds below have the same lithological characters to the top of the red beds, with this exception, that limestones occur more frequently toward the base. In New Mexico and Southwestern Colorado, Dr. Newberry describes two groups, which he refers to the Dakota group or Lower division of the Cretaceous. In Mr. Holmes's district these groups are distinct, and he proposes to call them Upper and Lower Dakota. In Middle Park, in 1873, Mr. Marvine found a series of shaly beds with thick beds of siliceous sandstone resting on the granite, with the massive sandstone of No. 1 above. These lower beds he referred to the same formation.* In the Black Hills the Dakota group is represented by a series of alternating sandstones and clays.†

In Arizona, G. K. Gilbert found Jurassic and Cretaceous fossils associated in beds, resembling those usually referred to the Jurassic. I am of the opinion that we cannot draw any line between the two formations, paleontologically nor lithologically, but for convenience in description it is best to draw an arbitrary line, which may be changed as we obtain more facts in relation to the formation. These beds and those just beneath, that I have referred to the Jura, are those that have been called the variegated marls in Arizona and New Mexico. The upper massive sandstone of the Dakota group forms the surface generally, with the lower shaly beds outcropping in the cañons.

On the south side of the Gunnison, above the Grand Cañon, there is a narrow outcrop of No. 1 between the breccia and the granite. A few miles south of the Gunnison it has disappeared.

At the head of the Uncompahgre River and on the Dallas Fork, No. 1 appears, and is faulted, the latter stream flowing on the line of the

*Report United States Geological Survey 1873, pp. 155, 156.

†Geological Report Exploration of Yellowstone and Missouri Rivers, pp. 15, 42, 43.

fault. Between this creek and the San Juan Mountains the Dakota group rises until it reaches the summit of the foot-hills, appearing from beneath the shales. On the Uncompahgre Plateau the Dakota group, dipping gently to the eastward, is the surface formation until we approach Escalante Creek. Between the latter and Roubideau's Creek, there are some isolated patches of No. 1. Along the western side of the Gunnison, also, we find the Dakota group. The floor of the San Miguel plateau is made of the Dakota group, and in the deeper cañons cut in it, a narrow band of Jura shows. The consideration of the Dakota group west of the San Miguel will have to be reserved. Going north on the San Miguel plateau, we find the massive sandstones of the Dakota group broken and forming the tops of mesas between the streams rising in the Uncompahgre Plateau and flowing into the San Miguel and Dolores Rivers. Still farther north the No. 1 disappears altogether, until we approach Grand River, near the mouth of the Dolores. In the Uncompahgre Plateau, as I have already noted, the No. 1 dips toward the Uncompahgre. This plateau is separated from the San Miguel by a monoclinal fold, which at first is complete as far as the Dakota group is concerned. In the San Miguel Plateau the beds are nearly horizontal. There is a slight anticlinal swell between the San Miguel River and the monoclinal fold. As we follow the latter north, we find the fold more abrupt, and the upper beds eroded away, and still farther along, as has been described in previous portions of the report, we have a fault.

In the region of the Sierra la Sal, No. 1 is present, on the west side, dipping away from the mountains at a steep angle. The reference of the sandstones and shales just described to the Dakota group rests mainly on lithological and stratigraphical evidence. In Eastern Colorado, Dr. Hayden has considered them identical with the Dakota group in Kansas and Nebraska. In both localities they are underlaid by the same character of beds, and above are well-marked Cretaceous fossils, and there is a general resemblance lithologically. The list of fossils obtained from the beds in Colorado is meager as yet. It is as follows:

Proteoides like *P. acuta*, Heer, edge of plains on South Platte River.

Sassafras like *S. mirabile* on Gunnison River.

Salix ——— ? in the Elk Mountains.

Fragments of dicotyledonous leaves, on the Gunnison and in the Elk Mountains.

Scaphites ——— ? on Gunnison River.

Lingula ——— ? near Colorado Springs.

In the Report for 1874 I pointed out the resemblance of my sections to those of Dr. Newberry. In Northeast New Mexico and Southeast Utah Dr. Newberry recognizes the Dakota group, and the beds are the same that I have so referred and traced from Eastern Colorado to Western Colorado and Southeastern Utah, joining the region investigated by Dr. Newberry. Additional facts in regard to the Dakota group in that region will be presented by Mr. Holmes in his report. Powell, in speaking of what he calls the Plateau Province, says:*

> Planes of demarkation in the Cretaceous group are not easily drawn. The relation of these groups to those established by Professors Meek and Hayden on the Upper Missouri is not well determined. I have carefully tried to use their system, and have failed.

The Henry's Fork group, which Powell places at the base of the Cretaceous, is *evidently*, in part at least, the Dakota group of Meek and Hayden. In the report† he gives the south side of Henry's Fork,

* Report on the Geology of the Eastern Portion of the Uinta Mountains, &c., p. 67.
† *Ibid.*, pp. 50, 51.

two miles above its mouth, as the typical locality of the group. Dr. Hayden visited this locality in 1870, and recognized the Dakota group, and gives a section of the rocks.*

Clarence King, on map II, Green River Basin, at the mouth of Henry's Fork, has the Dakota group colored, and on Powell's map of Green River the same area is colored as the Henry's Fork group.†

The following table will show the similarity in lithological structure:

Upper Missouri region, Meek and Hayden.‡	New Mexico and Arizona, Professor Newberry, lower division of Cretaceous.§	Plateau Province of Major Powell, Henry's Fork group.‖
Reddish, yellowish, and occasionally white sandstones, with, at places, alternations of various colored clays and beds and seams of impure lignite, also silicified wood, and great numbers of leaves of the higher types of dicotyledonous trees.	Yellow and brown sandstones and green shales in New Mexico. White and yellowish sandstones, green, blue, and gray shales, with impure lignite and carbonaceous shales, also thin bands of siliceous limestone in places, in Arizona.	Sandstones, bad-land rocks, conglomerates, and shales, with carbonaceous shales and lignitic coal.

The following list compares the fossils of the Henry's Fork Group with those from Newberry's lower division. None of Powell's Henry Fork group fossils come from the typical locality.

Newberry¶, New Mexico, lower division Cretaceous (Dakota group).	Howell** Plateau Province, Henry's Fork group.
Plicatula arenaria, M.	*Plicatula hydrotheca*, White.
Gryphæa ——— ?	*Gryphæa Pitcheri*, Morton.
Exogyra columbella, M.	*Exogyra læviuscula*, Rœmer.
	Exogyra ponderosa, Rœmer.
	Ostrea prudentia, White.
Gervillia ?	*Inoceramus Howelli*, White.
	Avicula linguiformis, Shumard.
Pinna ——— ?	
Prionotropis Woolgari, (*Ammonites pericarinatus*, H. & M.)	
	Camptonectes platessa, White.
	Undetermined conchifers, White.
	Cardium ——— ?
	Callista Deweyi, Meek & Hayden.
	Arca ——— ?

* Report United States Geological Survey 1870, pp. 60, 61.

† King's map is dated November 15, 1875, and Powell's map bears date 1873. The latter is evidently a mistake, as the atlas containing it bears date 1876, and was issued during the year. King's map, therefore, has the priority.

‡ Exploration of the Yellowstone and Missouri Rivers, p 14.

§ Ives's Colorado Exploring Expedition and Macomb's Expedition to Junction of Grand and Green.

‖ Geology of Uinta Mountains.

¶ Exploring Expedition from Santa Fé to Junction of Grand and Green Rivers; Descriptions of Cretaceous Fossils, by F. B. Meek, pp. 121, 122.

** Geology of Uinta Mountains; Invertebrate Paleontologyby, C. A. White, M. D., pp. 94, 95.

In Arizona, Dr. Newberry found the following fossils in the lower division of the Cretaceous; *Ammonites pericarinatus*, *Inoceramus Crispii*, *Gryphæa Pitcheri*, and *Pinna? lingula*. He has no doubt of the parallelism of the group of sandstones from which they were obtained with those of the base of Meek and Hayden's Cretaceous section.*

Professor Meek refers the beds from which Newberry obtained the fossils given in list above to the Dakota group. The animal remains found in the Dakota group in Kansas are distinct in species from those found in the Upper Missouri region, and the identity of the beds is based on the fossil leaves found in them and by their lithological position. In the two sections given above we have a much greater resemblance, and, taken in connection with the position at the base of the Cretaceous, I think there is but little doubt of the identity of the beds. It is possible that Powell includes a portion of the Fort Benton group with the Henry's Fork, as some of the fossils would seem to indicate. It is more likely, however, that, as our knowledge of the animal life of the Dakota group is extended, we will find that paleontological lines cannot be sharply drawn, and that we will have to divide the Cretaceous formation lithologically. The following genera of fossil plants are represented in the Dakota group in Kansas, the Upper Missouri region, and in New Mexico and adjacent parts of Arizona, Utah, and Colorado: *Sphenopteris*, *Salix*, *Quercus*, *Plantanus*, and *Phyllites*. There are other genera common to Arizona and Kansas.

From what has been written, I think it is evident that Powell's Henry's Fork group is the equivalent of the Dakota group, and should be so called, especially as King has called it so at the typical locality mentioned by Powell.

The formation has been recognized without difficulty in British America, in Arizona, Kansas, New Mexico, Wyoming, and Montana.

Coal in the Dakota group.—In the report for 1874, I noticed the existence of lignite in the Dakota group, just below the upper massive sandstone. This lignitic band seems to be persistent in this portion of the West, as in Eastern Colorado. At most localities the coal is of no economic importance. In the cañon of Uncompahgre River, below the mouth of the Dallas Fork, there is a bed of coal which has been changed to anthracite by a dike of trachytic rock.

MIDDLE AND UPPER CRETACEOUS.

In the Uncompahgre Valley, on both sides of the river until the cañon is reached, there are exposures of shales belonging to No. 2 and No. 3. They are generally so much concealed that perfect sections cannot be made. East of the Uncompahgre Agency the thickness of the beds is about 3,000 feet. At the base are the black shales of No. 2 and No. 3, with characteristic fossils. Above these are yellow and light-gray shales, passing into more arenaceous layers that are exposed near the top. In the latter, near the summit of the divide between Uncompahgre and Cebolla Creek, there are bands of lignite. It is of rather poor quality as far as seen, crumbling rapidly on exposure to the atmosphere. On the west side of the Uncompahgre, only the lower part of the series shows, while on the divide just mentioned we have a portion, at least, of the Upper Cretaceous, forming the top of the ridge. It is the only place in the district where it occurs. As we go west from the Uncompahgre, on the Uncompahgre plateau, the shales soon disappear, and the Dakota comes to the surface, on account of a slight monoclinal

*Ives's Colorado Exploring Expedition; Geological Report, p. 85.

fold, the axis of which is approximately parallel to the course of the Uncompahgre River. Toward the southern end of the plateau there are remnants of the shales, as at station 15, which give a more broken appearance to the surface. Between Dallas Fork of the Uncompahgre and the San Juan Mountains, the lower portion of the shales forms rounded hillocks between the branches of the stream.

Near the base of Lone Cone on the north, remnants of the shales are again seen, extending northward. These will be described by Mr. Holmes.

On the highest peak of the Sierra la Sal is a capping of sandstones and shales, all very much metamorphosed. They are probably a portion of No. 2 Cretaceous, and perhaps a portion of the upper part of the Dakota group. In the eruption of the rock they were evidently not broken through, as the lower rocks were, but were carried to the summit of the mass. In other peaks near the one just referred to, patches of black metamorphosed shales are seen on the sides of the peaks imbedded in the eruptive rock.

CHAPTER VII.

ERUPTIVE ROCKS—TRACHORHEITES—BRECCIA—PORPHYRITIC TRACHYTE—BASALT.

The volcanic areas of the district are readily divisible into three classes:

1st. Those covered with a flow of trachytes, partially described under the head of Trachorheites in the Report for 1874. These are in many places underlaid by a trachytic breccia.

2d. The areas of porphyritic trachyte.

3d. Basaltic areas.

TRACHORHEITES.

In the description of the south side of the Gunnison River, in a preceding chapter, I mentioned the fact that a large portion of the region was covered with trachytic rock, forming plateaus and mesas between the different streams tributary to the Gunnison from the south. The source of the lava-flows is somewhere in Dr. Endlich's district, where these volcanic rocks prevail to a much greater extent. Dr. Endlich's report for 1874 contains a detailed description of the rocks. He has divided them into four groups, as follows:

No. 1. White, yellow, green, orange, red, brown, and gray trachytes, decomposing readily, frequently weathering in picturesque forms.

No. 2. Red and brownish stratified trachyte; not infrequently contained interstrata of obsidian and of pitchstone resembling obsidian. Sanidite is the predominant one of the segregated minerals. Small crystals of brown to black mica occur dispersed throughout.

No. 3. *Upper*, red to brown trachyte; *lower*, red to brown trachyte, laminated.

No. 4. Trachytes variable in lithological characteristics, red stratum below, variegated beds next, and rhyolite, dolerite, and basalt above, the latter members not in such continuous masses nor in so regular succession as those below.

Along the Gunnison the rocks seem to represent a portion of No. 2. The following section gives the succession of the rocks, and it will be seen that they agree more closely with those of Dr. Endlich's group No. 2 than with any of the others. It is possible that a portion of No. 3 may be represented in some places:

1. Hard gray laminated trachyte.
2. Obsidian porphyry.
3. Spherulitic and porphyritic obsidian.
4. Brown to purplish red rhyolitic trachyte.
5. Purple vesicular rhyolitic trachyte.
6. Bluish-gray laminated rhyolitic trachyte.

It will be noticed, when the heights of the plateaus are compared, that there is a general slope to the east and northeast. The thickness of the rocks on the Gunnison is much less than in Dr. Endlich's district. His group of No. 2 is 1,200 feet thick farther south, while the beds I have given above are only about 100 feet where measured, and probably at no place exceed 500 feet, and they possibly include a portion of the groups above and below.

The rocks, therefore, represent the northern and northeastern edges of one flow, the one preceding and the one following scarcely reaching so far, or, if they did, having been entirely removed prior and subsequent to the flow of No. 2.

Throughout a large portion of the area the volcanic rocks rest immediately on the granites. Along the Gunnison, particularly on the north side, the following is the order of the rocks:

1. Trachytes.
2. Breccia.
3. Remnants of Cretaceous sandstones.
4. Granitic rocks.

As we go south layer No. 3 disappears very soon, and next the breccia is absent, leaving the trachytes on the granite, and in places the granite projects through, forming hills that rise above the plateau-like mass of trachyte.

Between the branches of Cebolla, Cimmaron, and Blue Creeks are long, tongue-like mesas, which appear to be capped with trachyte resting on breccia.

Between the Cimmaron and Blue there is a dike of trachyte in Cretaceous rocks, from which the volcanic material appears to have flowed and covered an area of some extent. This area is at a lower level than that covered by the flow which caps the mesas to the south and between the Gunnison and Cimmaron. In the latter the trachyte rests on granite. The dike may be of more modern age. More particulars in regard to these volcanic rocks will be found in the Report for 1874, (pp. 168, 171, 193, 209.)

BRECCIA.

The breccia underlying the trachytes just described is best exposed north of the Gunnison River, in which region it was described in the Report for 1874. Its stratified character indicates its deposition in water.

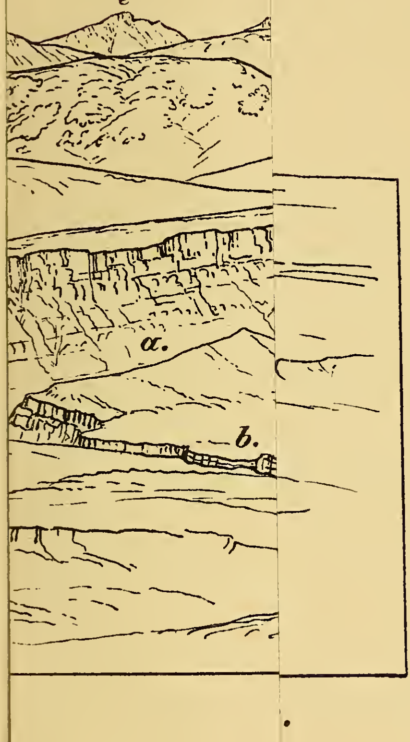
South of the Gunnison it soon disappears, although Dr. Endlich finds it again south of the San Juan Mountains. The shore-line of the lake or sea appears to have been irregular. From the mouth of Cochetopa Creek to Mountain Creek it seems to have been not far south of the Gunnison River, and approximately parallel to the course of the river. As we approach the Cimmaron and Cebolla Creeks, the breccia extends much farther southward, but it is impossible to trace the lines beneath the accumulations of volcanic rocks resting upon it. West of the Uncompahgre the breccia is entirely absent until we approach the mountains, where remnants are seen on the lower slopes. The matrix of the breccia is of a gray ashen color, and the included masses are generally dark trachytes of all shapes and sizes. In most places they are angular and of large size. Along the Gunnison a pink tufa separates the breccia from the overlying trachytes.

PORPHYRITIC TRACHYTE.

In the Report for 1874, under this head, I described some isolated mountains just west of the Elk Mountains. The rocks in that region dif-

I.

Nort



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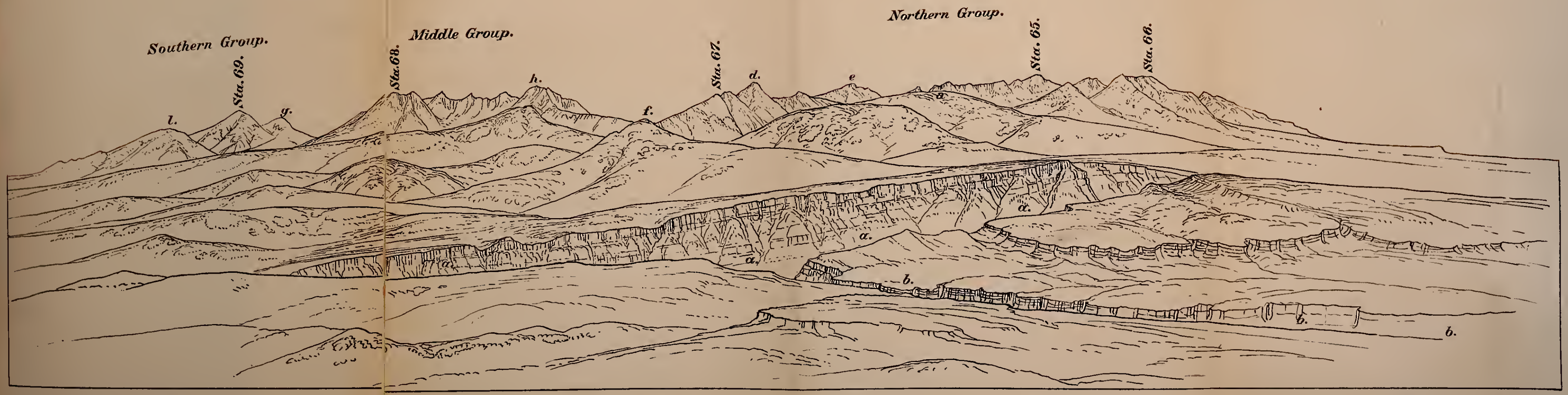
ORNE'S PROCESS)

ra la Sal.

Plate VII.



aaaa. Sinbads Valley.

bbb. Salt Creek.

AM. PHOTO-LITHOGRAPHIC CO N.Y. (OSBORNE'S PROCESS)

Sketch of the Sierra la Sal.

fer considerably from each other in detail, but there was a general resemblance. All were more or less porphyritic, and in some places their trachytic character was undoubted. In the absence of any microscopic or chemical analyses of the rocks, I included them all under the general heading of porphyritic trachyte. In the Sierra la Sal, we have rocks similar to those of Mount Marcellina and other groups west of the Elk Mountains. As their mode of occurrence is the same, I have adopted the same name. It is, of course, provisional, as the rocks have never been critically examined. All the specimens collected on the Sierra la Sal were lost, and therefore no complete description of them can be given. The following remarks are given simply as a sketch, as the western side of the mountains was not visited, and the limited time we had to examine this interesting locality precludes our giving as detailed a description as I could wish. Enough, however, was seen to leave no doubt as to the structure of the mountains, which is the same as that of Mount Marcellina and its surrounding groups, (see Report for 1874, pp. 163, 168,) and the Elk Mountains, viz, *eruptive*. By this, I mean that the sedimentary strata have been lifted up by eruptive rock, which has broken through them in some places, and in others is seen only as the result of subsequent erosion. In the Reports for 1873 and 1874, the eruptive character of the Elk Mountains is frequently referred to.* In that region there is so much complication, the sedimentaries being overturned and penetrated by dikes in every direction, that it is only when we glance at the range generally that we begin to comprehend its structure. In the isolated groups southwest of the Elk Mountains, described in the Report for 1874, (pp. 163–168,) there is more simplicity, the structure being much more apparent. Even there, however, there are difficulties met with in the study of the mountains, arising from the fact that the line of junction between the volcanic rocks and the surrounding sedimentaries is generally concealed by the *débris* from the peaks. There are also a number of centers of eruption close to each other, and numerous dikes radiating from the main masses.

In the Sierra la Sal the structure is comparatively simple, and there can be no doubt of the eruptive character of the mountains.

As a group, the mountains are isolated, and rise for 5,000 to 6,000 feet above the general level of the surrounding country. As we approach the peaks, sedimentary beds rise, and form the lower outstanding eastern peaks, dipping steeply to the eastward. At one place there is a capping of sedimentaries on the summit of the peak, showing that they once extended over the mountains. The general trend of the mountains is about north and south as a whole, but we find that they are separable into three groups, which seem to mark three centers of greatest uplift. There are three high areas of volcanic rock separated by saddles of sedimentary rocks, beneath which the volcanic rocks may be connected. I shall take up these groups in order, naming them northern, middle, and southern.

Northern group.—This group contains the largest number of peaks and is nearest in resemblance to a range trending approximately northwest and southeast. At the north end, on the east side, the red beds (Trias ?) are seen rising up and forming outlying peaks, dipping steeply to the eastward. At the south end, near station 67, is a gray sandstone (probably Dakota group) reaching nearly to the summit of the station. The saddle south of the group has an elevation of 10,800 feet, and is probably underlaid by Lower Cretaceous sandstones, which extend

*Report United States Geological Survey 1873, pp. 59–69, 247–261; Report United States Geological Survey 1874, pp. 55, 63, 70.

around the western side of the group, and there dip to the westward. The central peaks of this northern group are all trachytic, and range in elevation from 12,000 feet to 12,600 feet.

Middle group.—This group lies due south of the center of the northern group, and contains four principal peaks of the following elevation: 12,300 feet, 12,724 feet, 12,890 feet, and 12,980 feet. The area occupied is much smaller than that of the northern group, but it is interesting from the presence of sedimentary beds on station 68, the highest peak. These consist of sandstones and shales very much metamorphosed, forming a capping to the peak. There is at present no connection with the sedimentaries at the base of the peak. This remnant is horizontal in position, and appears to have been carried up by the eruptive material. It may be a remnant of beds that once extended uninterruptedly across the mountains, or it may be that in the upheaval it was torn abruptly from the beds whose upturned edges rest against the mountains.

On the sides of the peaks, just north of station 68, fragments of black shales are seen included in the volcanic rock. The eruptive material appears not only to have carried up fragments, but also to have spread laterally and included portions of the sedimentary rocks. These beds appear to be remnants of the Cretaceous, and the beds surrounding the group are probably of Lower Cretaceous age. The height of the peaks and the steepness of the slopes has caused the accumulation of *débris* at the base of the mountains, so that it is difficult to get at the relations without more time than was at our disposal. Wherever the beds are exposed, they are seen rising toward the mountains.

Southern group.—This is the smallest group of the Sierra la Sal. It is a little to the west of south from the middle group, and is separated from it by a saddle 10,200 feet in elevation, across which sandstones of probable Lower Cretaceous age extend. I am of the opinion that but one of the peaks shows the volcanic rock, viz, the highest peak, the elevation of which is 12,004 feet. The other peaks probably have sedimentary rocks extending over them. On the main peak they extend to about timber-line, (11,000 feet,) and on the east, south, and west sides of the group, a sandstone (probably Dakota) is seen dipping away from the mass 50° to 60°, and flattening out as we recede from the group.

From the summits of the mountains little can be determined, except that the sedimentary beds dip away from them, as we are so high above the surrounding country. We are, therefore, left simply to conjecture the exact age of the beds on the west side, being guided to a certain extent by our knowledge of the eastern side. Dr. Newberry, when with Macomb's expedition in 1859, was at Ojo Verde, about twelve miles southwest of the southern group. From the view he obtained of the Sierra la Sal, he was of the opinion that rocks of Cretaceous, Jurassic, and Triassic age rise on the base of the mountains from the east, south, and southwest. He says, also, "It is evident, therefore, that the rocks composing the Colorado plateau are there locally upheaved, precisely as around the Sierra Abajo and the other isolated mountains, which I have already before enumerated." * A closer investigation confirms the truth of this opinion.

The only difficulty met with in the study of this interesting region is the great amount of *débris* that has accumulated at the base of the mountains. There has been an immense amount of erosion since their upheaval—probably glacial, at least in part. The erosive forces appear to have had greater play toward the north, for we find there

* Exploring Expedition from Santa Fé to Junction of Grand and Green, p. 93.

Plate VIII

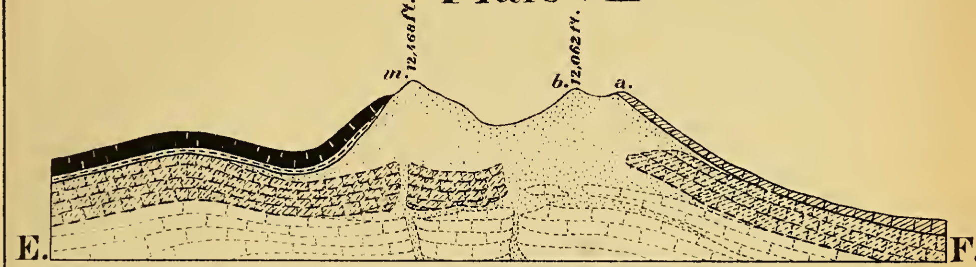


Fig. 1. Section across Northern Group.
7 miles.

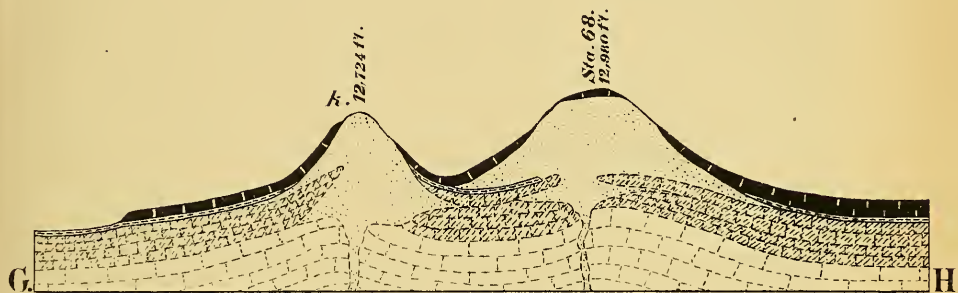


Fig. 2. Section across Middle Group.
7 miles.

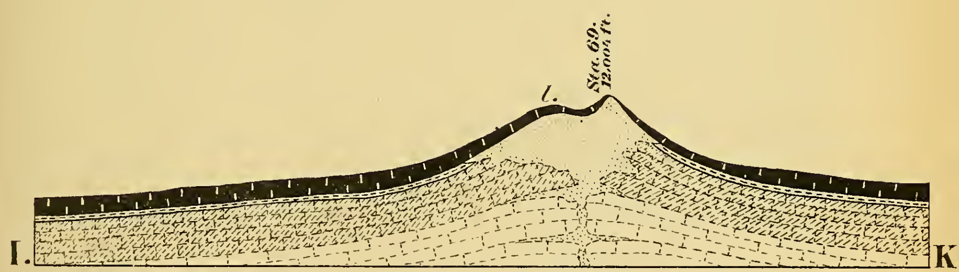


Fig. 3. Section across Southern Group.
7 miles.

Dakota Cretaceous. *Jura Trias.* *Paleozoic.* *Trachyte.*

Sections across the SIERRA LA SAL.
for lines see map on Plate V.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROC

no evidence of the sedimentary beds continuing across the mountains, and the red beds form the surface formation to the northeast and north, and even on some of the peaks. This may be explain d by the fact that the center of greatest force was at the north, and he force of upheaval being greater, broke the strata to a greater extent, rendering them more easily acted upon by eroding influences. Whether any of the sedimentaries extended across the mountains uninterruptedly at all points to the north, we cannot say. They did so at the south, but there were in all probability places where the eruptive material broke entirely through, reaching the surface. At present we find the highest peaks in the middle group, where there is a capping of sedimentary beds on the principal summit. The elevations in the northern group differ from those of the middle group by a few hundred feet. Is this difference due simply to the removal of the sedimentaries from the former? If so, the two groups may have had the same original elevation. I think it likely, however, that the northern group was originally the highest.

A closer investigation than we were able to make would doubtless reveal dikes, extending from the main masses into the sedimentaries, as in the Elk Mountains and adjacent groups. The upheaval would naturally cause fractures across the sedimentaries and separations of some of the strata, which would be filled with the eruptive material. This would be of more frequent occurrence near the surface. As we descend we naturally expect to find less disturbance in the sedimentaries, on account of the greater resistance the eruptive material would have to overcome. As it nears the surface this becomes less, and some of the overlying beds may be carried to the summit, as in the case of station 68.

The rock of the Salt Mountains resembles that of Mount Marcellina. It is light-gray rock—a feldspathic matrix, with crystals of feldspar and hornblende, giving it a porphyritic appearance. In Mr. Holmes's district there are several eruptive areas, in which the rocks are of the same general character. These will be described in his report. The Abajo Mountains were not visited during the season, but they are of the same character as the Sierra la Sal. Dr. Newberry visited them in 1859, and thus refers to them:* "The Sierra is composed geologically of an erupted nucleus, mainly a gray or bluish-white trachyte, sometimes becoming a porphyry, surrounded by the upheaved, partially eroded, sedimentary rocks." He says, also, that the Lower Cretaceous sandstones and Middle Cretaceous shales are exposed in all the ravines leading down from the mountains, and that the sedimentary strata rise on to the trachyte core, as though it had been pushed up through them. This is exactly what has been done in the Sierra la Sal. In the Sierra Abajo there appears to have been little erosion as compared with the Sierra la Sal. The accompanying sections (Plate VIII) will help in giving an idea of the structure of the Salt Mountains.

Lone Cone Mountain will be fully described in Mr. Holmes's report, as it is an extension of one of his volcanic groups.

As to the age of the eruption that caused the elevation of the Sierra la Sal, all that can be said is, that it was Post-cretaceous, and probably Pre-glacial. When on one of the peaks, I noticed what appeared to be *roches moutonnées* forms in the red beds some distance to the northwest of the mountains. I think it likely that much of the erosion of the mountains was effected by glacial action. The elevation of the mountains above the surrounding country and the steepness of the slopes are

* Exploring Expedition from Santa Fé to Junction of Grand and Green Rivers, p. 100.

both so great that the results of more modern erosion have concealed the evidences of glacial action. A detailed study would doubtless reveal abundant evidence of the former existence of glaciers.

The Sierra la Sal presents one of the most promising fields for future detailed investigation to be found in any part of the West, and will well repay the labors of the geologist who shall devote himself to their special study.

BASALT.

The basaltic areas of the district are very few, and are limited to a few cappings south of the Gunnison. One of these is near the White Earth, and the basalt rests on granite. It was described by Dr. Endlich in the Report for 1874, (p. 202, station 7.) On the west side of the Lake Fork, at station 2, there is a capping of black vesicular basalt, and again at stations 4 and 5. In all these localities it rests on trachyte, and, although it is at different levels, it is evidently the same flow, and all probably of the same age, being the youngest of the volcanics.

In preceding chapters the general description of the areas has been given.

CHAPTER VIII.

ECONOMICAL GEOLOGY.

The greater portion of our district is so covered with sedimentary formations in which mineral deposits, with the exception of coal, are rare. In the Unaweep cañon, where the trail crosses to the north side from the south, there are some indistinct mineral veins with quartz, carbonate of copper, and hematite. The Uncompahgre mountains are penetrated in all directions by veins of mineral matter. These, however, are properly in Dr. Endlich's district of 1874, and the greater part of the mines were referred to by him in his report for that year. Since then, however, a new mining town, "Ouray," has been located at the head of the Uncompahgre River, and promises to be the center of an important mining region. But little has been done except to prospect and plan the town. The latter is situated in a beautiful little park, caused by the expansion of the valley below the junction of two forks. Below the town the river passes through a narrow cañon, and the road from Uncompahgre park to Ouray in some places follows the bed of the stream.

Lake City is also a new town, situated on the Lake Fork of the Gunnison at the mouth of Hensen's (Goodwin) Creek. This locality is described by Dr. Endlich (Report 1874, page 236,) as a mineral-bearing region, although when he visited the region there was no town there. What lodes were then located were worked for silver. The volcanic rocks of the Uncompahgre and San Juan mountains are to a large extent impregnated with mineral matter.

On the San Miguel River, in the cañon at the edge and just below the mountains, a number of claims have been located on placer bars. Little has been done beyond locating claims. Much, and indeed the greater part, of our district is within the limits of the reservation for the Ute Indians, and if lodes did occur could not be lawfully worked at present.

COAL.

Coal is more widely distributed in the district than either gold or silver. The sandstones of the Dakota group have in most localities a band of bituminous coal or lignite below the massive upper portion. In many places this thins out and in others is of very poor quality.

In the Uncompahgre cañon a few miles above the site of the agency this lignite, or rather bituminous coal, has been changed to a semi-anthracite. For the cause of this change we do not have to look far. Below the coal on the edge of the river is a bed of trachyte, evidently intrusive. The coal is distinctly laminated, is black, has a submetallic luster, and cuboidal fracture. The following analysis has been made by Dr. F. M. Endlich:

	Per cent.
Water	1.86
Fixed carbon	77.32
Ash	10.12
Volatile matters by difference	10.70
	100.00
Specific gravity	1.78

It will not coke.

In the divide between the Uncompahgre River and Cebolla Creek coal is found in Upper Cretaceous strata. The Indian trail passes directly over the outcrop.

The coal is soft, breaks down readily on exposure to the atmosphere, and has a dull luster. The following is the analysis by Dr. Endlich:

	Per cent.
Water	7.26
Fixed carbon	41.72
Ash	7.60
Volatile matters by difference	43.42
	100.00

Specific gravity 1.45.

This coal may be characterized as a free-burning, non-coking, bituminous coal.

No mining has been attempted at either locality. The blacksmith at the Uncompahgre agency has tried both coals, but with little success.

SALT.

As noted in previous portions of the report, salt is found in Sinbad's Valley, at the head of Salt Creek, a branch of the Dolores. It appears to impregnate the sandstones of the Upper Carboniferous and Lower Trias, and the water of Salt Creek is strongly saline.

CATALOGUE OF MINERALS.

The catalogue of minerals is naturally small; there is no catalogue of rocks, all specimens having been lost at the Dolores supply camp.

AGATE. In the valley of the Gunnison River and southward between White Earth Creek and the Uncompahgre River.

AMPHIBOLE HORNBLENDE in the volcanic rocks included in the breccia along the Gunnison River. In acicular crystals in the porphyritic trachyte of the Sierra la Sal and Lone Cone.

CALCITE. In the cretaceous rocks of the Uncompahgre Valley, in red sandstones near Unaweep Cañon.

CHALCEDONY. South side of Gunnison River in trachyte.

COAL:

Lignite in the Dakota sandstones west of the Uncompagre River and in the cañon of the San Miguel River.

Bituminous coal (*Lignite*) in the Upper Cretaceous sandstones in the divide between the Uncompahgre River and Cebolla Creek.

Semi-anthracite in the cañon of Uncompahgre River below Uncompahgre Park.

FELDSPAR:

Orthoclase and undetermined varieties along the Gunnison River above the Grand Cañon, in Unaweep Cañon, and in granitic outcrops on the Uncompahgre Plateau.

Undetermined variety in porphyritic trachyte of the Sierra la Sal and Lone Cone.

Sanidine. In rhyolite and obsidian on south side of Gunnison River between White Earth and Cebolla Creeks.

GALENITE. In mineral veins at the head of Lake Fork of Gunnison River and near Ouray, at the head of the Uncompahgre River.

GOLD. In placer bars on the San Miguel River.

GYPSUM. In Upper Carboniferous rocks of the Dolores River and Salt Creek. In the Cretaceous shales of the Uncompagre River. In neither locality does it occur in large quantity. *Selenite* is abundant in many places.

HALITE (*salt*). Associated with gypsum and sulphur in sandstones of Upper Carboniferous or Lower Trias in Sinbad's Valley near the head of Salt Creek, a tributary of the Dolores River, near the Sierra la Sal.

HEMATITE (*micaceous*). In Unaweep Cañon.

HORNBLENDE. (See *Amphibole*.)

JASPER (*red varieties*). Along the Gunnison River in Dakota sandstones above mouth of Lake Fork.
LIGNITE. (See *Coal.*)
MALACHITE (*green carbonate of copper*). Staining iron ores in Unaweep Cañon, associated with pyrite.
MICA (*muscovite*). In schists and granites of the crest of the Uncompahgre Plateau, in Unaweep Cañon, and the granite exposures of the Uncompahgre Plateau north of Unaweep Cañon.
OBSIDIAN. In trachytes south of Gunnison River.
ORTHOCLASE. (See *Feldspar.*)
PYRITE. Associated with quartz and hematite in Unaweep Cañon.
QUARTZ. In granites and schists of the Gunnison River and Uncompahgre Plateau, and in the red sandstones bordering the Unaweep Cañon.
SALT. (See *Halite.*)
SANIDINE. (See *Feldspar.*)
SELENITE. (See *Gypsum.*)
TUFA (*calcareous*). At the springs in White Earth Valley, and in Uncompahgre Park.

REPORT OF F. M. ENDLICH, S. N. D., GEOLOGIST OF THE SOUTHEASTERN DIVISION, 1875.

LETTER TO DR. F. V. HAYDEN.

WASHINGTON, D. C., *November* 1, 1876.

SIR: I have the honor herewith to submit my report for 1875, as geologist of the Southeastern Division of the United States Geological and Geographical Survey of the Territories, under your charge. In accordance with instructions received, I took the field, starting from Denver June 7, 1875, and returned to that place after the completion of the work assigned to me, October 12. During that time an area of 12,500 square miles was surveyed by the party under Mr. A. D. Wilson's charge, to which I was attached as geologist. Toward the latter part of the field-season fog and deep snow greatly increased the difficulty of the work, and impeded rapid progress.

In the subjoined report you will find included a discussion on that region lying north of the Rio Grande below Antelope Park, and on the Huerfano Park. Both these sections had been examined, partially, in 1874, but no report was made upon them, as they would have constituted areas perfectly isolated from the remaining portion.

With a view to facilitate the more ready comprehension of descriptions, the district of 1875 has been separated, in this report, into sections determined by topographical limits. Five such sections have been made, and to each of them one chapter is devoted. The first chapter treats of the Sangre de Cristo Range and the Huerfano region; the second of San Luis Valley; the third of the southern extension of the Sawatch Range; the fourth of Rio San Juan and its drainage; and the fifth of the Post-Cretaceous formations of the Trinidad region, extending from there northward to the Spanish Peaks. A "conclusion" summarizes the results obtained during the season, and discusses the correlation of the formations then examined with those of adjoining districts.

Added to the report is an appendix containing a synopsis of the evidence of former glaciers in Southern Colorado and a list of minerals found in that State, as complete as possible up to date.

To Mr. A. D. Wilson, topographer directing, and to Mr. F. Rhoda, his assistant, I wish here to express my sincere thanks for their aid and co-operation during the summer.

To Mr. W. H. Holmes I am indebted for the preparation of illustrations, sections, and maps.

Hoping that this report may meet your requirements, I have, sir, the honor to remain, your obedient servant.

FREDERIC M. ENDLICH.

Dr. F. V. HAYDEN,
United States Geologist-in-charge.

GEOLOGICAL REPORT ON THE SOUTHEASTERN DISTRICT.

INTRODUCTION.

The district assigned to our party during the field-season for 1875 extended from longitude 104° 30′ west to longitude 108° west, was bordered on the south by north latitude 36° 45′, and on the north by north latitude 37° 50′. On the west side it connected with the work of 1874, and on the north with that of 1873. From June 7, we were in the field until October 12, and during that time the district apportioned to us was surveyed topographically and geologically, we having covered an area of 12,500 square miles.

Although the mountain groups were not so massive as during the preceding year, and there was a smaller number of very high peaks, yet the more diversified character of the entire region proved very satisfactory to the party exploring. Approaching from the great plains westward toward the mountains, the foot-hills are first encountered, differing in their general features from those farther north. Neither the rugged, precipitous ascents of the Colorado Springs region nor the classical "hog-backs" near Golden were represented. A long line of broken, plateau-like bluffs stretches for twenty-five miles westward until the Sangre de Cristo Range is reached. Monotonous in shape, monotonous in the ever-repeated change of sandstone with shale and shale with sandstone, they offered but few good points either for topographer or geologist. At one locality, however, this was altered, at the Spanish Peaks. These old landmarks, that perpetuate in their name the fame of the earliest explorers of Colorado under Coronado, lift their heavy forms high above all surrounding them. Although their peers in beauty and height are not far distant, yet they are sufficiently far to allow these volcanic monuments the most prominent place in the eye of one advancing toward them from the plains. Numerous settlements have been made along the edge of these foot-hills and within them, in the valleys of the streams they contain. Mexicans and Americans, by way of distinction, follow either agricultural pursuits or raise sheep. Still going westward, we leave the foot-hills, and are at the base of the Sangre de Cristo Range. Beginning at Poncho Pass, it runs east of south for more than 130 miles. Its high peaks, presenting the boldest outlines, look very forbidding when seen standing in relief against the sky. The evenness of the most elevated points, the symmetry of form, and the fields of snow that never disappear entirely, lend this range a charm that can never be forgotten by one who has ever seen it. Ascending the highest mountain of the range, Blanca Peak, we have a view that richly repays the fatigue and danger of the climb. Looking west, we see beyond the broad expanse of San Luis Valley the mountains of the Sawatch Range, farther on still the Uncompahgre group and the black, rugged peaks of the Quartzite Mountains. To the south, the level plain of San Luis gives us an idea of distance, and the two small round hills that later we meet as Mount San Antonio and Ute Peak look insignificant when viewed through the haze of fifty miles. A little east of south the numerous peaks of the Sangre de Cristo present themselves in a regular row, diverging, however, as the distance increases. Foot-hills and plains to the east are far below us, and the latter are finally lost, merging into the sky. Descending westward, we are in the San Luis Valley, with its sand and its sage-brush. Where water is plenty there the valley is agreeable. It is our plan to survey this when the weather is cooler, and we push on to the Sawatch Range. A high volcanic plateau we find, with isolated points that command the country. Miles upon miles are above timber-line, while the remainder is covered with a dense growth of fir and spruce. Snow greets us everywhere in dark and hidden corners, to which the sunlight in vain attempts to penetrate. Crossing from the waters of the Atlantic to those of the Pacific Ocean, by way of Weeminuche Pass, we see the west side of our plateau. Viewed from there, the steep slopes, cut by many a deep, precipitous cañon, present a picture of peaks innumerable, not much higher, often, than the main plateau. Yet, as we are several thousand feet below the plateau's level we look up to them, and hence their appearance as mountains. Along the northern drainage of the Rio San Juan there exists a beautiful country. Good land, abundance of wood, and an excellent supply of water we find in these upper valleys. We cross in succession one stream of this region after the other, still traveling on westward, until we have reached the Animas. From there we travel south and arrive at the Rio San Juan. Though much water starts to flow into this river, a large portion of it never reaches the stream. The sandstone bluffs, with their steep, sandy cañons, swallow much of the moisture that passes through them, and small streams cannot exist. Beautiful as the country is near the headwaters of the San Juan drainage, just so desolate is it in the immediate vicinity of that river itself. Dry, hot, and sandy is the region through which we travel eastward. After we had completed the work in the lower country we once more ascended the plateau and found the continuation of the volcanic area. Thence we passed through San Luis Valley, and crossing the Sangre de Cristo Range descended the foothills, where our work for the season ended.

As the character of the country varied so did the geology. It is a well-established fact that the orographic features of any given region furnish an indication of the lithological nature of the strata there found. In a certain measure, therefore, we are enabled to predict, from the trend and shape of the hills, the geological formation that we hope or expect to find. Knowing, for instance, that the sandstones of a locality are of Cretaceous age, we can deduce from the peculiar shape of bluffs or hills the conclusion that they *are* Cretaceous. During 1875 these characteristic features were especially noticeable. Metamorphic rocks form the "backbone" of the Sangre de Cristo, and there we found the highest and steepest mountains, while their base, more gently sloping, was composed of Carboniferous strata. Eastward from the range the isolated, prominent peaks, rising amid a sea of sandstone, betokened former volcanic activity. San Luis Valley, with its level surface, was a sure indication of drift, and the dome-shaped mountains at its southern end could be nothing but volcanic. The extensive plateau, rising at places into lonely peaks, was but a continuation of what we had seen during the two years preceding, of the enormous trachytic outflow. Beyond it the low valleys, the sandstone bluffs separated by steep cañons, and the gulches washed down into dark shales, denoted Cretaceous. Farther on, above these, the original mesas that have been cut in every direction, indicated the advent of a Post-Cretaceous period.

In order to facilitate the discussion of the district surveyed during

1875, the subjoined report has been divided into five chapters and an appendix. The first chapter treats of the Saugre de Cristo Range and the Huerfano region; the second of San Lúis Valley; the third of the Sawatch Range; the fourth of the country lying near the tributaries of the San Juan, and the fifth of the Raton Hills and their northern extension. In the appendix a synopsis of the evidences of the glacial period in Southern Colorado and a catalogue of minerals of Colorado are given, as complete as possible up to date. It has seemed best to separate the district, irrespective of drainage, as by this means a more satisfactory division could be made. The groups mentioned contain formations closely correlated, and in order to present a more general view of the entire subject, the most important facts will be reviewed in the "conclusion."

CHAPTER I.

SANGRE DE CRISTO RANGE AND THE HUERFANO REGION.

The work of 1875 here joins on to that of 1873, at Mosco Pass, and from there in a northeasterly direction along a line leading to station 83 of '73. At Mosco Pass we find on the eastern slope of the mountains the red Carboniferous sandstones* resting upon a red, metamorphic granite. This metamorphic group extends southward, culminating in the Sierra Blanca. East of it we find Carboniferous strata as the oldest, which in turn are followed by the Cretaceous extending to the border of the plains. Isolated patches of volcanic rocks, trachyte and basalt, are found at various places in the Huerfano drainage. Some of the most prominent among them are the Sheep Mountains. Farther south the Spanish peaks rise far above the Cretaceous beds, through which they have broken. Continuing southward in the Sangre de Cristo Range, we see that its "backbone" is formed by metamorphic granite, which, however, is frequently covered either by sedimentary or volcanic rocks. No younger formation than Carboniferous shows itself on the west side of the range, while on the east both Cretaceous and Tertiary may be found. South of Culebra Peak, station 116, the range splits, sending two divisions in a southerly direction.

DRAINAGE.

Huerfano Valley is well supplied with water. Through the central portion of it runs Huerfano River, in a general direction north of east. It is fed by streams flowing into it from the north, which carry a considerable quantity of water, and by smaller streams from the south heading in the detached volcanic mountains east of Sangre de Cristo Range. Directly north of Blanca Peak (station 8) is the head of the Huerfano itself. Rising in a valley surrounded on three sides by the steep walls of Sierra Blanca, the stream flows through a fertile little bottom, until, east of Mosco Pass, it emerges into the broad valley known as Huerfano Park. Settlements have sprung up along the river and sheepherds and farms denote the thrift of the settlers. West of the Huerfano drainage are numerous small mountain streams that rise in the high mountains, and, flowing but a short distance, are soon lost in the sand and drift of San Luis Valley. Fed by snow and ice, their water is fresh and cool, while the metamorphic rocks over which it flows preserve the pure taste. Rising near Sangre de Cristo Pass, southeast of Mosco, about 16 miles distant, is Sangre de Cristo Creek. Both from the north and south small tributaries swell the quantity of water. Among the former, Greyback Creek, heading near station 6 and flowing south, is the largest. Sangre de Cristo Creek flows southwest near Fort Garland, below which place it receives a large branch from the east.

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* Compare Report United States Geological and Geographical Survey 1873, p. 312.

RIO TRINCHERA.

Seven miles below the fort it forms a junction with Ute Creek, and from there, having a course 20° south of west, joins the Rio Grande about a mile above the junction of that river and Rio Conejos. The quantity of water it carries is sufficient to overcome the absorbing powers of San Luis drift during a large portion of the year. All that drainage heading between stations 119 and 122 (Trinchera Peak) on the west slope of the Sangre de Cristo, forms Rio Trinchera south of station 118. A number of creeks are again lost in the drift, so that the next stream of importance, farther south, is Rio Culebra. From station 122 to station 112 all the westward-flowing waters of the range belong to this river. Three main forks may be distinguished: the north one, heading at Trinchera Peak, flowing in a southwesterly direction and joining the next one near the Mexican settlement San Luis, which is situated immediately east of the San Pedro mesa: the middle one, heading at Culebra Peak (station 116), flowing north of west. This fork is called by the inhabitants the Rio Culebra, and it joins the south fork, Rio Seco, near its junction with the northern branch. Two tributaries between are named Rio Vallejo and Rio Gregorio, respectively.

At station 112, Rio Seco heads, first having a westerly course, then turning sharply to the north. It joins the other branches, as stated above. During its northerly flow it passes through that long (twelve miles) valley, that is separated from the San Luis Valley proper by the San Pedro mesa. In order to facilitate description I have given the long basaltic table that name, as I could learn of none existing, and shall distinguish, for the same reasons, the cultivated valley east of it as San Pedro Valley. Four Mexican settlements in the valley testify to its agricultural merits—San Francisco on Rio Gregorio; Chama and San Pedro on Rio Culebra, above the junction with Rio Vallejo; San Luis on the Culebra, near the northern entrance of the valley, and outside of it San Acacio. From this latter town the Culebra flows almost due west, and joins the Rio Grande about a mile south of station 105. Like the Sangre de Cristo it carries a goodly supply of water, and though much of it is lost by irrigation it brings water into the Rio Grande at almost all seasons of the year. But one more stream of importance do we find on the west side of the range—Rio Costilla. Heading about seven miles south of Costilla Peak (station 111), its course is toward the northwest, until when in the center of the sand-drift area of that southern portion of San Luis Valley, it makes an abrupt turn to the west, and, finding its way through Costilla Cañon, joins the Rio Grande at the base of Ute Peak (station 107). All the tributaries of this stream join it while still in the mountains, and, good as its supply of water here is, it is not adequate to the consumption by irrigation and absorption. During a large portion of the year Costilla Cañon is perfectly dry. As farther north, so here, too, a number of creeks south of the Costilla begin their run with evident ambition, but soon succumb to drift and sand. Rio Colorado, the most southerly one of the larger streams coming within our district, heads about eight miles east of station 108, but, flowing in a southwesterly direction, is soon beyond our jurisdiction.

Crossing the Range and traveling northward on its eastern side we find the drainage of several important streams. Not more than their headwaters come within the limits of this chapter, however, so the discussion of their entire courses shall be deferred until the proper place therefor is reached. First the Canadian River presents itself. All the drainage flowing eastward between Costilla Peak and station 113 belongs to that stream. Between station 113 and Trinchera Peak the waters of Rio Purgatorio head. Three main branches join near station 128, and form the river. The South Fork heads between station 113 and Culebra Peak, while the next six miles farther north contain the origin of the Middle Fork drainage, and the seven miles intervening between that and Trinchera Peak send their waters into the North Fork.*

Immediately north of Trinchera Peak heads Arapaho Creek. Its general course is a northeasterly one. From the mountains between stations 122 and 120 it receives many small tributaries; larger ones flow northward into it from the Spanish Peaks. Flowing from the west into it are the streams heading near and southwest of station 5. On the northeast side of East Spanish Peak heads Rio Santa Clara. It flows east of north and joins the Arapaho. After the junction the large river thus formed is called Rio Cucharas, which, flowing east of north, continues the course followed by Santa Clara, and joins the Huerfano. Rio Apishpa rises on the southern slope of the Spanish Peaks, and flows first east, then northeast. With this the main streams of the region discussed in chapter I are exhausted. Some of them are of considerable length, and all of them certainly of great importance to the agricultural pursuits carried on in their valleys. As a rule the soil of these valleys is good, and in case the farmer is enabled to procure an adequate supply of water for his purposes of irrigation, nothing, save such casualties to which all agriculturists are exposed, stands in the way of his success. Measurements approximating the lengths of these important streams are herewith appended, as they furnish a criterion for the question as to the relative quantities of water carried by each. The largest tributaries are also given for each one, and the sum firstly of these, secondly of the entire system of large water-courses, added:

Name of river.	Length of river in miles.	Length of main tributaries in miles, added.	Total length of main drainage in miles.
Huerfano	74	82	156
Sangre de Cristo	43	47	90
Rio Culebra	37	62	99
Rio Costilla	46	26	72
Rio Santa Clara	34	....	34
Arapaho Creek	41	63	104
Cucharas	22	....	22

LENGTH OF SOME TRIBUTARIES IN MILES.

	Name of tributary.	*Miles.*
Sangre de Cristo	Ute Creek	22
	Trinchera	21
Culebra	Rio Seco	17
Costilla	North Fork	16
Arapaho	Spanish Creek	21
Huerfano	Muddy	18

METAMORPHICS.

The area above described contains quite a considerable amount of metamorphic outcrops. There seems to be no doubt, from the numerous indications found, that metamorphosed rocks form the main bulk

* The region of the Purgatorio is treated of in chapter 5.

of the interior portion of the lower Sangre de Cristo Range, though at many places sedimentary beds of considerable thickness and volcanic flows have obscured any insight. As a rule, it may be said that the highest mountains of the range are formed by metamorphics, among which granites and gneissoid schists are the favorites. The Trinchera group, however, the highest peak of which is over 13,000 feet above sea-level, shows sedimentary beds to the very summit. Station 108, 12,467 feet, is the highest volcanic peak in the range. Going southward from Mosco Pass, the metamorphics follow the trend of the mountains. Gneiss and gneissoid schists, with black mica, dip steeply to the west on the west side, and are very much contorted on the east There a coarse-grained, light-red granite sets in, upon which a compass-station was located in 1874. From that point the same granite continues south toward station 6, which, at an elevation of 12,341 feet, is located on it. Flesh-colored orthoclase, grayish to white quartz, silvery muscovite, and small crystals of white oligoclase compose the rock. In Greyback Gulch, southeast of station 6, this granite is overlaid by red Carboniferous sandstone, but crops out on the ridge leading south towards station 7. Southwest of Station 6 is the Blanca group. Although this is but a part of the Sangre de Cristo Range proper, it stands out very prominently, by virtue of the low passes both north and south of it, and by virtue of the great altitude of its highest points. The mind of the inhabitants has seen fit, therefore, to distinguish this group by a special name, and it is known as the Sierra Blanca, or Garland Mountains. In order to retain the name, we have called the highest peak Blanca Peak. Metamorphic rock composes the entire group, consisting chiefly of hornblendic and micaceous schists, very firmly cemented by a white or grey quartz. Stratification of some regularity may be observed in the masses, and as the strata dip westward at an angle of about 60°, their position greatly aided the progress of erosion and attrition, and has produced the sharp ridges of that group. Ascending the one leading up from the southeast, the effect of this position is recognized very readily in a long ridge that may justly be compared to a knife edge on a gigantic scale. Station 8, the summit of Blanca Peak, is 14,464 feet high, 6,797 feet higher than Fort Garland. Toward the north the mountains fall off in a very steep precipice, at the foot of which is a lake from whence the headwaters of the Huerfano find their way. Southeast of the peak, at timber-line, are several small lakes, that at the time of our ascent, June 19, 1875, were still covered with ice. On all sides of the peak the surrounding metamorphic rocks are traversed by white veins of quartz, that show ramifications and other features incident to any metalliferous veins of ore-bearing regions. Chlorite takes the place at times of mica or hornblende in this rock, and thus produces either a protogine or a chloritic schist. Local replacements of this kind are very frequent, but probably could not be traced with sufficient accuracy to be of any value in determining the character of the material from which these metamorphics derived their origin. On the west and southwest sides the schist rocks are lost in the sand and drift of San Luis Valley. It is possible, though no positive proof was found, that small local glaciers may have aided in forming the deep cañons that open into the broad valley. They contain swift streams, of short course only, however, as they are very soon lost in the diluvial soil that they encounter. Near the base of the Sierra Blanca the hornblendic and micaceous schists disappear, and the granite from station 6 continues southward, crossing Sangre de Cristo Creek above station 7. From there the granite continues on southward, overlaid on the east by trachyte, and on the west by a small patch of the same material. Farther on, the heavy beds of red Carboniferous sandstone set in on both sides, so that in Indian Creek Pass, only a small outcrop of dark-red granite is to be found. This, too, is soon covered completely, and the summit of the pass shows nothing but the red sandstone. Again it appears on the main divide, leading from Trinchera Peak northward to station 119. The latter is located at the northern terminus of a bold ridge, at an elevation of 11,757 feet. A number of peaks, granitic, lying between it and Trinchera, rise to an altitude of over 12,000 feet. Continuing southward in a narrow strip, flanked both east and west by Carboniferous strata, the metamorphic rocks make a slight bend to the westward, leaving Trinchera and the succeeding highest points to the east. Sedimentary strata, standing nearly on end, lie tipped up against the granite, and these form the highest peaks of the range. So far as could be determined, the visible dip of the heavy granitic layers is a westerly one at this locality, as is also that of the superincumbent Carboniferous strata. Opposite stations 115 and 117, on the west side of the range, granite again protrudes from under the Carboniferous. Erosion probably has carried away the strata that were gradually thinning out as they neared the base of the mountains, thus exposing the metamorphic rocks to view. Culebra peak (station 116), 14,079 feet high, is within the metamorphic area, which, soon after having swerved to the west, returns to the center of the range. A general dip of 10° to 15° westward may here be observed in the granite. South of station 113, located at an elevation of 13,719 feet, the granite comes to a close. A high plateau is formed by an overflow of trachyte, which extends westward, and covers the granite toward the south. On the east side Carboniferous sandstone again overlies the metamorphic rocks. At this locality there are a number of species and varieties of rocks represented. Similar to the process of substitution of one mineral by another, as observed in the Blanca group, mica, hornblende, and chlorite occasionally exchange their relative functions, and the result produced thereby is a constant variation of the names that a lithologist would apply to the rock. Granite, however, is the basis of all these, and nearly all the varieties or even species are referable to it. True gneiss occurs in bands or large masses, changing into mica-schist and chloritic schist. Swinging westward, around the trachytic plateau, the metamorphic area continues south again. Stations 112 (12,840 feet) and 110 (12,684 feet) are both located within this extension. At this locality the range has separated, the one spur continuing on farther south, while the other follows a southwesterly course. On the latter the two last-named stations were made. To the east of station 112 the north branch of Rio Costilla takes its rise, in a valley that separates the two spurs of the range. Starting in trachyte it flows through granite for a large portion of the distance it travels before joining the smaller south fork. Neither spur of the range is very high here, so that a very good pass exists north of Costilla Peak. An old Indian trail leads over it, and with but comparatively a small amount of work it might be utilized as a good road. South of station 110 the granite, which here is of a coarse-grained variety, stained dark red on its surface by the oxidation of magnetite it contains, is again covered by a heavy mass of trachyte coming from the south. Costilla Peak (station 111, 12,634 feet above sea-level) is the last granitic promontory. Following down the valley of the Costilla, which several times closes into narrow granitic cañons, we reach the foot-hills falling off steeply into San Luis Valley. Their edge runs nearly due south, and their slopes mark the presence of a strip of metamorphic granite, while the summit of the range is composed of trachyte. Station 108 is located upon the latter, 12,467 feet high. No definite data were obtained referring to the dip of this granite, as it is very much obscured by cleavage. It seems, however, to dip westward. Many varieties were noticed here, also, an evidence in favor of the assumption that claims a common origin for the metamorphics of the Sangre de Cristo chain, and, so far as is possible to determine, a synchronous metamorphosis. Bands of typical gneiss alternate at places with micaceous or chloritic schists. Granite, from the fine-grained to the coarsest variety, is found, apparently without any definite system of arrangement. The coarse-grained is prevalent, containing often good-sized sheets of mica and large masses of quartz and feldspar (orthoclase). Quartz veins traverse the granite in several directions, of which, perhaps, the strike northeast to southwest may be regarded as the most frequent. Indications of ore were found in these veins, and will be mentioned at the proper place. With this the metamorphic area of the region which is discussed in this chapter is ended. A synopsis of the facts observed presents the conclusion that the metamorphics of the lower Sangre de Cristo owe their existence to an alteration of the

SILURIAN.

North of the Arkansas River the Silurian formation occurs.* From there it crosses the river toward the south, and is last seen as such near the northern end of the Sangre de Cristo Range. In its stratigraphical relations it is conformable with the overlying, younger formations, wherever it has been there observed. We have evidence, therefore, that it exists but a comparatively short distance from the range, covered by the Carboniferous; among the latter the strata of red sandstones that belong thereto. Going south into the range, we find that the sandstones still remain, form a large bulk of the mountains in fact, but the Silurian and the lowest Carboniferous have disappeared. At the same time, we observe that the metamorphic rocks of the range differ from those not much farther north, where they underlie the Silurian. So far as could be determined, the granites and schists of the Sangre de Cristo show stratoid relations conformable with those of the superincumbent sedimentary beds. They furthermore form the "core" of the mountain chain, holding the same relative position with reference to younger formations that Silurian or Devonian would hold. It seems possible, therefore, that during the progress of an extensive metamorphosis, the Silurian, and perhaps lowest Carboniferous strata, furnished the material for the existence of our present granites, gneisses, and schists at that locality. It is, so far as I know the region, impossible to prove any hypothesis of this kind, but, considering the analogous occurrence, the absence of all formations older than the Middle Carboniferous, and the evidence of the existence of this older formation only a short distance farther north, I think the assumption is entitled to further investigation. A similar case was observed during 1874,† but in that instance the solution was by far easier than in this one.

* Report United States Geological and Geographical Survey 1873, p. 308.
† Report United States Geological and Geographical Survey 1874, p. 190.

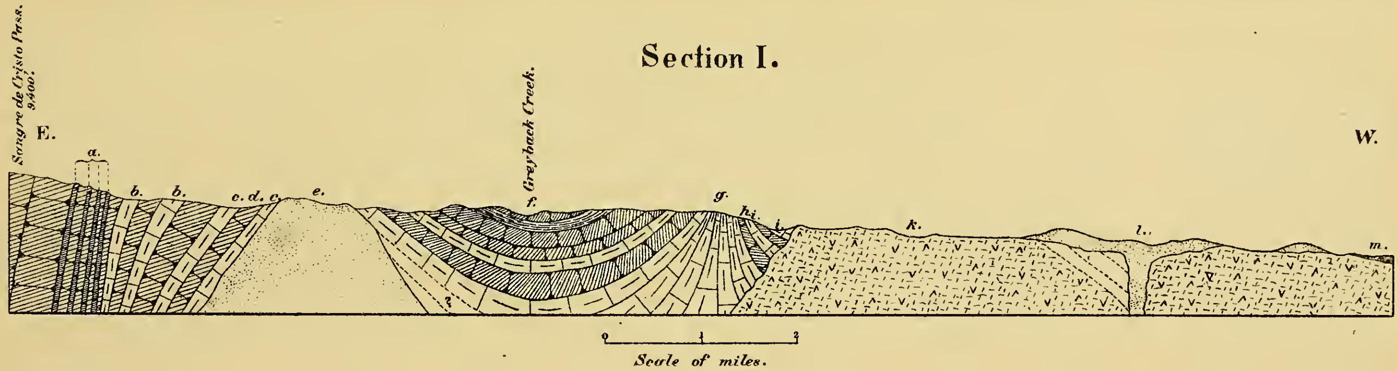
CARBONIFEROUS.

A group that I refer to the Lower Carboniferous occurs near Trinchera Peak. At the time we were examining that region, the ground was covered with more than a foot of snow, so the result of the investigations was not quite as satisfactory as might have been. It was found, however, that a greyish-brown, compact shale, sandy in part, was underlying the red Carboniferous sandstones conformably, and formed the summit of Trinchera as well as the highest peaks immediately south. Blue limestones occurred with it. So far as could be determined, the dip of these strata is to the east, at an angle of 60° to 70°. I consider this group, of which I have seen too little, however, to be positive, analogous to the well-established gypsiferous strata of other localities and the members below it. Its horizontal extent is small, but even from considerable distance the change in the formation can be noticed. This is the only outcrop of older Carboniferous formations that occurs throughout the district. Taking into consideration the extensive area surveyed, the numerous exposures of strata, and masses in cañons and on the slopes of hills, it is surprising that during 1874 and 1875, not more of the Palæozoic formations have been found. The only conclusion possible to arrive at is, that they do not exist in the regions examined. Whether the material that composed them has been metamorphosed, or whether they never were deposited there, are questions that will require a long time to solve. Certain it is, that the volcanic action having occurred in the two districts mentioned, is of enormous extent, but at the same time we have evidence that much of the metamorphosing process must have occurred at a comparatively old geological period, while, on the other hand, we have but little proof of volcanic or Plutonic eruption that may have occurred at the same time.

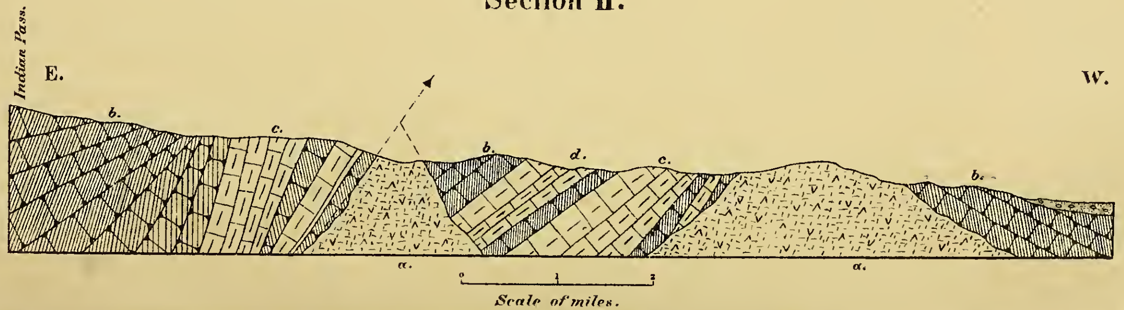
Red Carboniferous sandstone.—In the report of 1873, p. 349, the heavy beds of red sandstone north of Arkansas River have been referred to the Carboniferous. The same view has been held as regards the region near Rio Animas, explored in 1874. As will be observed, however, no positive palæontological evidence indicating beyond a doubt the age of this group was obtained during those two years, and the position of the same was mainly based upon stratigraphical evidence. In 1875 the necessary evidence was found, however, as will be seen in the subjoined pages, and it is without reserve, therefore, that this sandstone is placed in its present position. Had it been possible to make more detailed examinations at the localities that furnished this proof, no doubt a large number of interesting fossil species could have been collected. As it was, a sufficiency of material was obtained to warrant a positive assertion. Besides the observations made by myself, I have incidentally heard of others corroborating them. I regret that I have been unable to receive the material from others in such shape that it could herein be presented, so merely mention the fact. The distribution of this red Carboniferous or "Arkansas" sandstone is a very wide one. It forms a large portion of the Sangre de Cristo range, north of Mosco Pass, and continues from there nearly to the southern border of the 1875 district. Station 62 of 1874 is located upon this sandstone, and from there its eastern limit runs in a southwesterly direction toward the Blanca group, near the Sheep Mountains, upon one of which station 4 was made; it again spreads farther toward the east, appearing on the summit of Sangre de Cristo Pass. The larger portion of Veta Pass runs in it, and farther south Indian Creek Pass is in it entirely. Continuing southward it

Plate IX.

Section I.



Section II.



flanks the metamorphic center of the range on either side, dipping with the slope of the mountains. There it reaches a very considerable vertical development, which lets the foot-hills composed of it appear like small mountains. On the west side of the range we find it for the last time opposite station 113, but isolated patches occur nearly as far south as Costilla Peak. East of the range its horizontal distribution is greater. Extending toward the southeast from station 5 it underlies, although in an abnormal position, the volcanic rocks of the Spanish Peaks, confining itself farther on to the eastern slope of the range, however.

Commencing on the west side of the Sangre de Cristo Range, south of Mosco Pass, the first outcrop of this sandstone occurs on Ute Creek, near the base of the Blanca group. It is but an isolated patch, resting on the metamorphic rocks of these mountains. Northwest from that point, in Greyback Gulch, we first find it again, this time as a spur of the large mass that runs to the summit of the Sangre de Cristo Pass. Riding to this summit from the east side, we travel over Lower Cretaceous until the pass is reached. There suddenly the yellow color of the sandstones changes to deep red, and interstrata of argillaceous shale appear. The first view presenting itself, after crossing the summit, is that of vertical walls standing out prominently from the steep slope of the mountains on the north side. At first sight they appear like dikes. They are dark in color, and weathered partly in grotesque forms. Small cavities eroded into the rock are suggestive also of volcanic material, but upon examination these walls prove to be composed of sandstone. Descending farther along the road toward Fort Garland, the best exposures will be found on the north side. The vertical dip gradually changes into an easterly one, steep at first, but sloping more gently as we proceed. Trachyte, of almost white color, very compact, and closely resembling that of station 4, forms a basis for the strata to rest upon. This trachyte, a spur of the large mass immediately south, continues northward, forming the highest portion of a ridge leading up to station 6. Mention has been made of this fact, because immediately after passing through this volcanic rock we find ourselves again in the sandstone area, the strata of which this time, however, are dipping toward the west. We have, therefore, in this instance an anticlinal fold, the apex of which has either been broken by the eruptive material, or has been gradually eroded away. A small, synclinal fold now occurs in the sandstones and shales, in which the interstrata of limestone participate. Dipping steeply from both sides, a small trough is formed in the sandstone, the more westerly strata of which dip eastward at an angle of about 45°. Soon, however, (farther west,) the prevailing dip asserts itself, and it assumes the westerly direction, until the sandstones and limestones come in contact with the metamorphic granite. This continues for some distance; then the sandstone is covered by trachytic rock, which in turn finally, below station 7, disappears under the prevalent drift of San Luis Valley.

So as to give a more definite idea of the stratigraphical conditions observed on the north side along the road over Sangre de Cristo Pass, a section (Section I) is given. In it the various beds of sandstone, shaly sandstone, limestone, and the metomorphic and volcanic rocks are distinguished. Starting again from near the head of the pass we observe four heavy beds of a very compact sandstone (*a*), separated by others of less compact structure. These four are the ones described as having the dike-like appearance. From a vertical dip they gradually change to an easterly one, which is continued in the heavy underlying beds of limestone (*b*). Under these is a series of red sandstone strata. Very near the junction of the two, in the limestone, numerous specimens of *Productus semireticulatus* were found *in positu*. After the sandstones underlying follow two beds of limestone (*c*), separated by another sandstone (*d*). Immediately under the second limestone-bed, so far as could be observed, occurs the whitish trachyte (*e*) above mentioned. It seems probable that the eruption of this trachyte caused the formation of the anticlinal fold that can be observed, unless, indeed, the fold was created by other causes and the volcanic material merely took advantage thereof to occupy its present position. Having passed the trachyte, we find a repetition only in reversed order of the last named strata, dipping, this time, in conformity with the anticlinal fold in a westerly direction at an angle of about 20°. The sandstone strata (*f*), however, corresponding to *b* here suddenly curve upward and form a synclinal fold of small dimensions. It is to be assumed that this point is very near the original central line of the folding; therefore the strata corresponding to each other are but a very short horizontal distance apart. Sandstones form the center of the fold, while dark-red argillaceous shales adjoin them on the outside. In these shales specimens of *Sigillaria* were observed; they are pressed very flat, and owing to the nature of the rock they are found in, but poorly preserved. Instead of the strata now continuing the easterly dip they have gained through the synclinal fold, they turn to the west again as soon as the limestone series (*g*) is reached. This is of considerable thickness, analogous to that near the head of the pass. Three beds of sandstone then set in (*h*), dipping westward at an angle of about 30°, and separated by two beds of limestone (*i*). Immediately after the last bed of sandstone we come upon metamorphic granite (*k*), which probably during the Carboniferous period served as a shore for the rocks that now rest against it. It seems likely that this granite, too, has been disturbed from its original position, inasmuch as otherwise the deposition of sedimentary beds could scarcely have occurred in the way it is now observed. Trachyte (*l*), upon which station 7 is located, covers the granite and is followed by drift (*m*).

Making an attempt to reduce the plications here observed with many interruptions to one single fold, the identity of strata has to be considered. Could more time have been spared, more thorough results as regards detail might have been obtained. The section was made as carefully as may be possible without accurate horizontal measurements and the subsequent calculation of thickness of strata. On either side of the trachyte the strata are the same; it is a simple anticlinal fold, followed farther west by a synclinal one of small dimensions. Beyond this, however, we are somewhat at a loss how to place the heavy beds of limestone. So far as could be determined they are the same as the more easterly ones, but appear to be totally detached from them, and thrown into their present abnormal position. This, too, accounts for the peculiar relative position of the granite and the sedimentary beds to a certain extent.

South of Sangre de Cristo Pass is the Indian Creek Pass. It is but little used, although a wagon-road leads up to it. Here, again, on the north side of the road, is a good exposure of the rocks. Ascending from San Luis Valley, trachyte is first encountered, then metamorphic granite; joining on to this the sedimentaries begin. So far as could be judged, the junction is an abrupt one, the sandstone leaning against the granite with a very steep easterly dip. A continuous easterly dip may be observed throughout the succeeding strata, which consist of limestones and sandstones alternating. An abrupt stop of the strata occurs a short distance up the road, where they strike granite with their edges, but after that is passed they continue, dipping in the same direction at an angle of about 30°. Heavy beds of a blue to gray limestone here set in, separated by a bed of dark-red sandstone. In quality and texture the sandstones of this pass as well as of the one above discussed agree. They are generally of middle to coarse grain, cemented by an argillaceous material. Sometimes the cement is quartzitic. Shaly varieties and true shales are not wanting, but marls do not occur, so far as I have observed. As we proceed eastward, a curious curving of the strata takes place, no doubt in some connection with the anticlinal fold farther north. Though no true fold of that kind, the effect produced is virtually the same, and we find at one place the limestone strata, the last ones in the upper series, dipping at an angle of 90°. From there on, however, the stratification becomes more simple, the easterly dip gradually diminishes, until, at the summit of the Pass, it is not more than 10° to 12°. A section will explain more thoroughly what has here been said. (Section II.) We have in it but the three rocks, metamorphic, granite (*a*), red sandstone with its quartzose and shaly varieties (*b*), and limestone (*c*). The latter weathers into small angular fragments in part, in part it forms large bowlders that show, upon being exposed to atmospheric influences, the presence of silica, in the shape of either irregular nodules or small ramifying veins. The granite is red, coarse-grained, closely resembling in its lithological constitution that of station 6. It seems probable, that the very heavy mass of limestones (*d*) beyond the granitic outcrop may correspond to *g* of Section I, but it was impossible to trace the connection from a distance on account of the very dense timber covering the intervening space. It is in this limestone that the apparent anticlinal occurs, just before the heaviest beds of the sandstone set in. Owing to probably a slight admixture of manganese, a portion of the limestones that has for a long time been exposed shows a very dark color, strangely in contrast with the bright red of the succeeding sandstones. All through the limestones represented in the above section Carboniferous fossils were found, consisting chiefly of the species *Productus semireticulatus* and *Athyris subtilita*, *Spirifers*, &c. Not only do they occur in the heavy beds, but also in the thin interstrata between the sandstones. Taking into consideration this fact, together with the occurrences in Sangre de Cristo Pass, there is left no doubt in my mind as to the age of the sandstones, and the stand-point taken with reference thereto in 1873 appears to be fully justified. It is desirable that quarrying should be done in the sandstone itself, which, I presume, would lead to the discovery of Carboniferous plants. As it readily yields both to disintegration and erosion, the delicate impressions left by ferns, &c., may rapidly be effaced. Faint traces resembling plants, more particularly *Calamites* and *Sigillaria*, were observed, but were too doubtful to be admitted as positive evidence.

East of station 114, on the west side of the Sangre de Cristo Range, the red sandstone covers a considerable area. Numerous strata of blue limestone are inclosed between the sandstones. These former show fossils in abundance: *Productus*, *Orthis*, *Spirifer*, *Crinoids*, &c. No definite arrangement of the relative position of limestones could be determined, and it seems probable that they were deposited wherever the conditions for precipitation and conservation were most favorable.

From Indian Creek Pass, the elevation of which is 9,774 feet, the red sandstone continues southward in an unbroken line, flanking the granite of the range. Its strata dip due west, with some local variation, produced either by recent dislocations or such disturbances as may be due to physical changes in the underlying metamorphics. Near station 113 it stops, however, on the west side of the range, with the exception of a few patches north of Costilla Peak that reach from the east over on the west side of the divide. Throughout its entire occurrence thus far described, this red sandstone shows a singularly uniform character both in its stratification and its constitution. No lighter beds occur to vary it, as have been observed at other points, and its only changes appear to consist in the varying accumulation of argillaceous material, whereby differences are produced. The granite, which crops out west of it in a north and south-line about from station 122 to station 116, was probably at one time covered by it, but the fact that the strata exposed their edges on account of the dip greatly facilitated the process of erosion, and to-day the metamorphic rock is left entirely denuded at the immediate base of the mountains. This exhausts the occurrence of Carboniferous sandstone on the west side of the range.

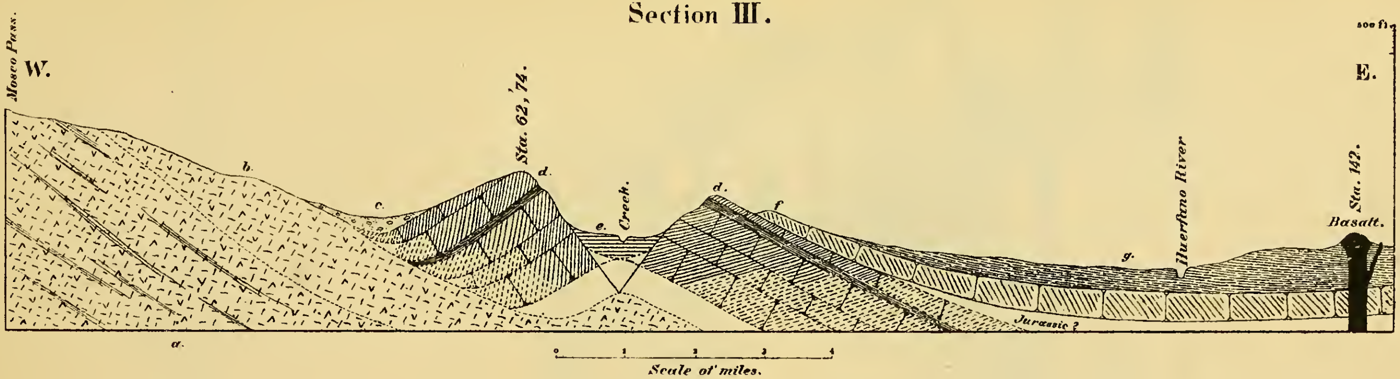
Of greater extent and more varied in occurrence is this same sandstone on the eastern side of the Sangre de Cristo Range.

Station 62 of 1874 is located on the red sandstone, near Muddy Creek. At that locality it dips toward the mountains at an angle of about 15°. This, however, is sometimes locally increased. South of the station there are a few low remnants of the same formation, that show a steep dip, reaching 60° toward the east, while opposite them toward the range the dip is westward. Between the two outcrops Cretaceous shales of No. 2 have been deposited nearly horizontally, thus showing a very striking unconformability. It is possible that these isolated points may be but fragments of the main mass farther west, or it may be that they denote an anticlinal fold. In view of the contortions and plications observable farther south, I am inclined to the latter opinion. Section III will illustrate the relative positions. As there are no exposures that admit of any idea as to how the strata continue to lower depths, only the appearance of the surface has been given. Metamorphic schists (*a*), partly gneissoid, partly micaceous, and partly hornblendic, are found in Mosco Pass, but give way to a red, coarse-grained granite (*b*) lower down. A deposit of drift (*c*) originating in the metamorphic area obscures the junction of the sandstone (*d*) with the granite. The former is stratified in heavy beds, coarse to middle grained, showing a variety of brown and red shades upon exposure. It dips westward at an angle of about 15° to 18°. Descending over the rise produced by the direction of the dip, which probably caused the lodgment of drift at the point indicated, we traverse a narrow valley containing horizontal beds of Cretaceous shales No. 2 (*e*). Immediately beyond that is one of the isolated hills of red sandstone, the strata composing which dip eastward at an angle of about 35°. So far as could be observed, they are identical with the western ones, but all or nearly all the beds of this sandstone are so much alike, that it becomes a matter of detailed research to decide any question of that kind. Only for a short horizontal distance do we find this outcrop; then it is again covered by Cretaceous beds belonging to Nos. 2 and 3 (*f and g*). Judging from the entire position of the outcrops with reference to each other, the acceptance of an anticlinal axis or a fault appears to be the more reasonable. It is strengthened furthermore by the approximately straight line which the general course of the outcrops shows.

A little east of south of station 62 of 1874, there occur a number of isolated outcrops of trachytic rocks, forming either long coffin-shaped hills, or rounded dome-like ones. A portion of the higher land near the headwaters of Huerfano drainage is also covered by the same material.

Plate X.

Section III.



Section IV.

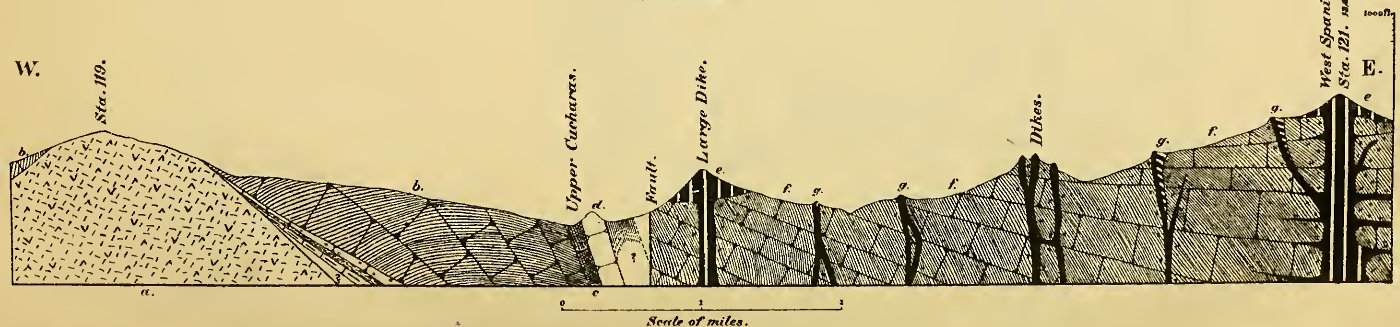


Plate XI.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

This trachyte covers to a great extent the Carboniferous beds, which appear wherever erosion or other causes have made it possible for them to do so. Northeast of station 5 is one of the isolated volcanic mountains, and there may be placed the eastern border of the red sandstone. It runs from there toward the Spanish Peaks, and is covered by the volcanic rock composing them. Along the east side of the Sangre de Cristo it continues, resting first on the metamorphic granite, then on the Lower Carboniferous of Trinchera Peak. All that region lying between Indian Creek Pass and the Spanish Peaks is covered by it, and there it has a steady easterly dip of 8° to 12°. Descending on one of the ridges from the pass towards the headwaters of Arapaho Creek, a rather curious case of erosion was noticed in the sandstone. Standing perfectly isolated, near the crest of the small ridge was a block of red sandstone, about 10 to 12 feet in height. Near the center of it a natural doorway was seen, almost high enough to admit of a man's passing through, while a little higher up was another smaller opening. Considering the thickness of the rock, it seemed curious at first by what agency those excavations could have been made, but upon closer observation a vertical crack was discovered, which split the entire bowlder. It was evident, therefore, that the water accumulating therein had gradually disintegrated the softer layers of sandstone, and, probably materially aided by frost, succeeded in gradually splintering off such portions as would most readily yield. The harder strata, the one dividing the two perforations, and the other forming the roof, had thus far resisted the influences that carried away other portions throughout the entire thickness of the bowlder. This process of excavation throws some additional light on the formation of sandstone caves, and of the "bridges," and "arches," that are so frequently met with in regions where sandstone abounds. A protecting cap for the cavity is, in an instance of this kind, an indispensable necessity. This was observed near station 120, which is located on the red sandstone of the ridge mentioned at an elevation of 9,560 feet.

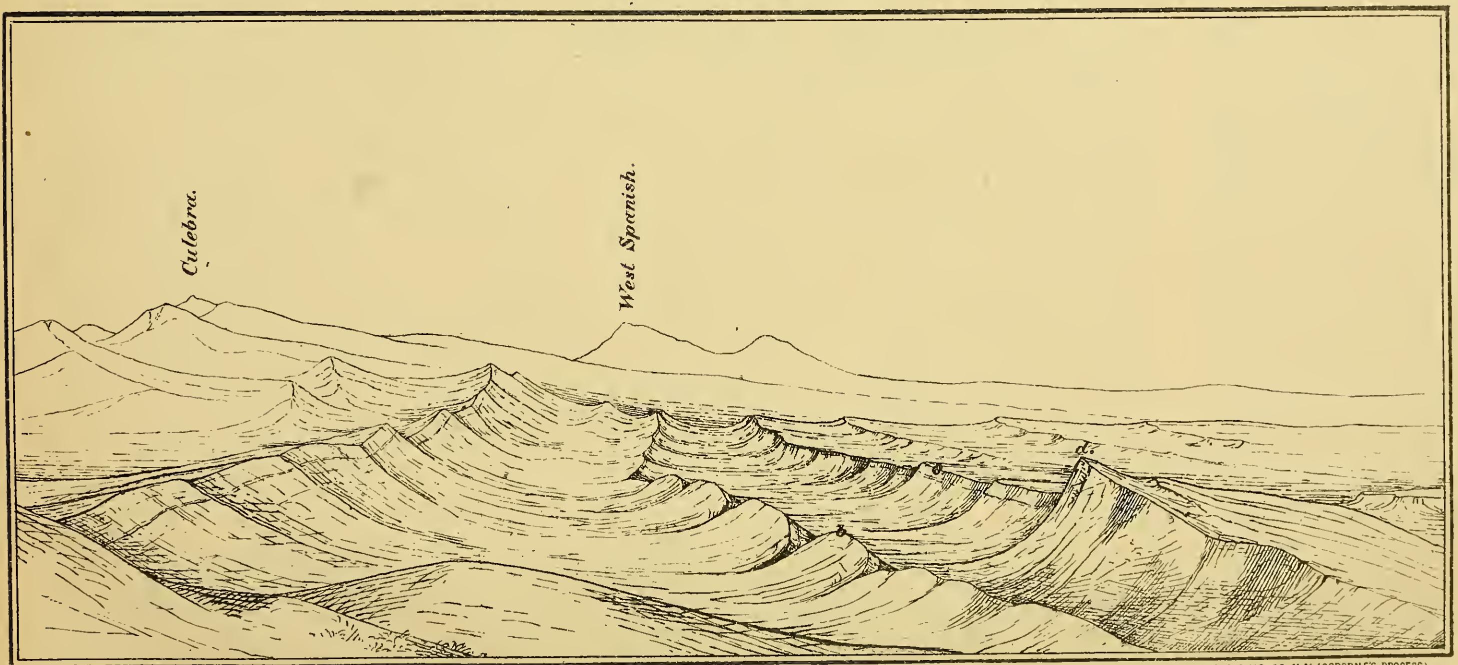
Descending into the valley we are confronted by a vertical wall of white sandstone. As we approach it, we find that the dip of the red sandstone becomes steeper and steeper, until it appears to e conformable with that of the white. Red shales compose the strata nearest to this sandstone, and they have permitted a narrow valley to be eroded parallel to their strike. Judging from lithological characters alone, I should unhesitatingly have pronounced this white sandstone to be Cretaceous and to belong to the lowest group. Upon examination, however, it was found that the main body of Spanish Peak West was composed of red Carboniferous sandstone. It therefore became a matter of extreme difficulty to decide, whether this was really Cretaceous, or merely an interstratum of white sandstone in the red. No fossils could be found. Continuing our explorations to the south and southeast, it was observed that the white sandstone continued in an almost straight, though at places broken, line on to Costilla Peak, a distance of about thirty-six miles. It was furthermore observed, that at its southern exposures it was accompanied by gray shales containing *Inocerami* and *Ostreæ*. In the neighborhood of Spanish Peak West (station 121), no other Cretaceous could be found, save the continuous area near station 123. It will be remembered that the Spanish Peaks are the only high mountains rising from the surrounding sedimentaries of that locality, and that they are partly (West Spanish) or wholly (East Spanish) volcanic. In view of these facts and in the absence of all fossils that might render a decision positive, I have concluded to regard this white sandstone as Cretaceous.

A section (Section IV) running from station 119 to station 121 will give an idea of the present position of the strata. Granite (*a*) forms the base for the red sandstone (*b*) to rest upon. This latter dips eastward at an angle of about 18° to 25°, but as we approach the valley the steepness of the dip increases, until it has become almost vertical. In the valley, among the readily decomposing red shales (*c*) it is very much obscured, and when next we have a good view of it, it is in the vertical wall of white sandstone (*d*). Nearest to this sandstone, on its east side, red shales and shaly sandstones again appear, dipping eastward at an angle of 70° to 80°. Soon a trachitic eruption has broken through them, forming a prominent hill (*e*). After that the red sandstones (*f*), for we find nothing but such now, begin to dip more gently, become horizontal eventually, and near the summit of Spanish Peak west, have a westerly dip of 6° to 8°. Numerous dikes (*g*) traverse the sandstone, and on the summit of the peak it is capped by trachyte, which stands in connection with a number of dikes apparently issuing from one main center. Assuming now that the red sandstone had its original dip to the east (8° to 15°), and that a portion of it was covered by Cretaceous sandstone, if we could get the force to uplift, east of the Cretaceous outcrop, the massive sandstone beds, curve them, and overturn them, so as to be apparently conformable with its secondary position, we would obtain the result observed at the present time. Whether the trachytic mass alone was accompanied by or the cause of that force, or whether it was aided by some other vertically-acting power which produced its most marked results at the point of least resistance, would then remain in question. As a fact it may be stated, that while West Spanish is composed mainly of sandstone, and only a small portion of the volcanic material, East Spanish is entirely volcanic.

In the field I held the view, explaining the enormous increase in thickness of the sandstones at Spanish Peaks, by the acceptation of an overturn of the strata. As has been mentioned above, the stratification near the narrow Cretaceous outcrop is very much obscured, and no absolutely definite knowledge could there be obtained. Since studying up the case, however, I have come to the conclusion that the disturbance there produced is not that of an overturn, but of a fault. This fault has occurred immediately east of the Cretaceous outcrop, has elevated the sandstones of the Spanish Peaks, and has given rise to changes in the inclination of their strata. Its vertical extent amounts to more than 2,000 feet. It is highly probable that the anticlinal fold observed near station 62 of 1874, may be in connection with this extensive fault. Considering the mass of volcanic material that has been ejected at Spanish Peaks, I conclude that the sandstone of the two peaks were raised from their normal position so as to assume that which they at present occupy. Injection of volcanic masses between the sandstone strata may account for the increased thickness of the latter. It is to be regretted that the key-point east of the Cretaceous outcrop was so much obscured by detritus and timber. During the disturbance of the strata there were, of course, innumerable cracks formed, which, owing, perhaps, to the great thickness of the sandstone, often run in very straight lines. The liquid or plastic volcanic material entered the fissures, and now forms the walls that often are over several hundred feet in height. In the portion of this chapter devoted to the volcanic rocks of the region, this will be more fully discussed.

A series of very interesting metamorphoses may be observed in the red sandstone while ascending station 121. Before leaving the unchanged sandstone, bowlders of quartzite and a very compact granite,

Plate XII.



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

fragments of argillite and micaceous schists, will be noticed. Not until after leaving timber-line, however, can the full extent of the metamorphosis be appreciated. Numerous dikes of a rhyolitic trachyte traverse the sandstone strata, and on either side of them the changes produced by heat under pressure are evident. Red shales are changed into maroon-colored, hard argillites, uncomfortable to walk on. The quartzitic sandstones have turned into red granular quartzites, while the argillaceous ones are now a typical granite. Schists are rare, but still occur, probably being the result of highly argillaceous sandstones. Following along the strata, beyond the influence of the volcanic heat, these same rocks return by gradation to their original character. At times very narrow dikes only, or ramifications of larger ones, can be found, and the extent of the material changed by them will be in proportion to their size. Nearing the summit, which is entirely volcanic, the metamorphosing influences are found to have had full sway. Hard fragments of the changed rocks have a ring almost like that of phonolite, weather in slabs, and show indications of columnar structure. On the ridge and on the sides of the mountain they stand out prominently, resisting more successfully than their unchanged surroundings the destroying action of atmospheric agents. There are few localities, probably, to be found, where this important branch of chemical geology is so thoroughly illustrated, and at the same time so accessible. It is to be regretted that during the time of our ascent snow covered a large portion of the mountain, and examinations could be made only with difficulty.

From the Spanish Peaks the red sandstone continues along the eastern side of the Sangre de Cristo Range, reaching just to the base of the mountains where the Cretaceous beds begin. In nothing does it vary from the occurrences farther north. Its thickness remains constant, about 2,000 feet, and its dip is to the eastward, perfectly regular. Station 124 is located on it near the middle fork of the Purgatory, at an elevation of 9,824 feet. North of station 111 (Costilla Peak) it is covered in part by trachyte, but only for a short distance. At this point a problem presents itself, similar to that near station 121. I have alluded to the long outcrop of the white sandstone, following a line about north to south, which is broken at times, for which, however, the connection can always readily be established. This sandstone continues south as far as the northern base of Costilla Peak. About ten miles north of the peak it stands perfectly vertical, and going farther south gradually turns to a western dip, while the tendency of its dip up to that point has been an easterly one. At the same time the strata of red sandstone, having a total thickness of about 1,800 to 2,000 feet there, follow the same course and dip to the westward, until near Costilla Peak they dip but about 35° from the horizontal. Near this peak the Carboniferous strata end abruptly against the granite, but the end of the white sandstone cannot be seen.

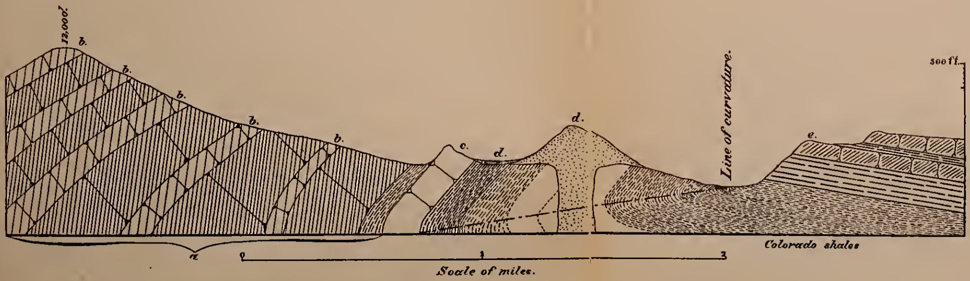
A sketch made from station 111, looking northward toward the Spanish Peaks, may give an idea of the general configuration of the country. On the west side a continuous ridge (*a*), composed of red sandstone, runs nearly north to south. The dip of this sandstone is to the westward. It slopes down, at first rather steeply, then more gently, until the second ridge (*b*) is formed by the white sandstone in question. Near the station this also has a westerly dip, but some distance off assumes the vertical and then steeply dips to the east. A narrow, long valley separates this ridge from the third one (*c*), which, however, is formed by sandstones by far younger than any of the preceding. A short distance from Costilla Peak there rises in the middle of this valley a comparatively high hill (*d*) composed of trachyte. On the western side its boundaries are parallel with the line of the second ridge, but on the southeast it has overflowed a portion of the younger strata. At first sight this illustration will suggest an anticlinal fold, but it is not one. Not a trace of the white sandstone can be found on the east side of the valley, while none of that observed there occurs on the west. This extraordinary arrangement of strata does not occur for any length of distance, because a little farther north both the Carboniferous and Cretaceous strata regain their original easterly dip. Taking a section (Section V) through the first ridge and the trachytic hill, we find the arrangement of the strata as follows: About 1,500 feet of the red sandstone (*a*) dip at an angle of 35° to the west. Five interstrata of whitish sandstone (*b*) were observed. They differ in nothing from the other, save in their color, which is not the pure or the yellowish white usually observed in Lower Cretaceous sandstones, but a more mottled reddish or brownish white. Exposed entirely on the west side we then find a sandstone (*c*), probably 200 to 350 feet in thickness. It is quartzitic in parts, of fine grain, lithologically totally distinct from the superincumbent ones. A large mass of small bowlders, gravel, and silt has been washed into the valley (*d*), from the red sandstones, so that any attempt at discovering the nature of underlying beds is rendered ineffectual. I did not succeed in finding there a single outcrop of strata *in positu*. It seems probable, however, that shales of some kind have permitted the formation of this valley, on account, first, of its peculiar shape and topographical features, and secondly, because such shales were discovered about 18 miles farther north in the continuation of the valley. The trachytic hill (*d*) stands out prominently at this point, sharp and well cut, though farther south it joins more closely the eastern bluff. Beyond it is the third ridge (*e*) composed of yellow sandstones and shales that will be treated of in chapter 5. Such is the appearance of a section at this point, without any reference to the causes that have produced the effect observed. Another section, (Section VI) made after having seen the entire valley, may give some idea of the dynamics involved in placing the strata into their present position. The third ridge (*ee*) is composed of sandstones and shales belonging to a Post-Cretaceous period, which dip eastward at an angle of 10° to 15°, underlying Cretaceous and Carboniferous beds, therefore, must have been moved at one time westward and overturned, in order to assume their present position. It will be noticed that this overturn extends but a short distance beyond the superficial appearance of the volcanic material, and that soon after that has disappeared a return to the normal dip takes place. It is an analogous case to that near the Spanish Peaks, where volcanics, too, play so important a part. Were it not for the fact that the white Cretaceous sandstone can readily be traced throughout the entire distance, the explanation of this phenomenon might prove to be very different. More will be said about the occurrence and surroundings of the latter in the discussion of the Cretaceous formation of the district to which this chapter is devoted.

Besides those given above, no outcrops of Carboniferous beds were observed in the district under consideration. It will be seen, that here, too, as farther north, they form a large portion of the Sangre de Cristo Range, and although not reaching very great elevations, with the exception of the Trinchera group, they are of great importance in the structure of the range. It will furthermore be observed that, in the vicinity of the greatest disturbances to which these strata have been subjected, we find the best passes across the mountains. At Sangre

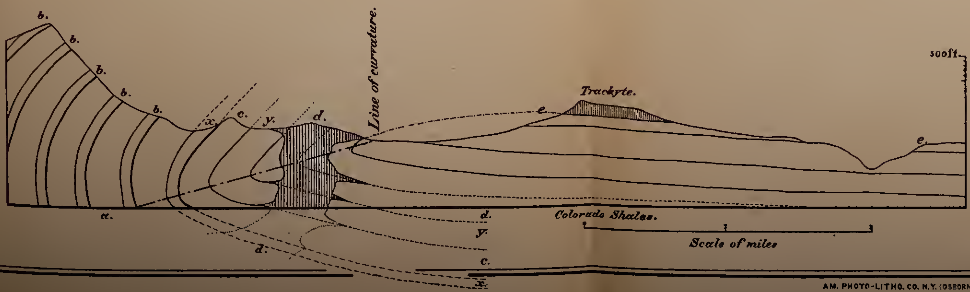
b.

Plate XIII.

Section V.



Section VI



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

de Cristo, at Veta and at Costilla passes, those beds have been folded and even overturned, and it is there that the lowest depressions were produced. None of the Upper Carboniferous limestones, that occur north of the Arkansas, have been found. It is possible that they may be covered entirely by the Cretaceous, but it does not seem probable that in such a case not even a single outcrop should have been observed.

JURA-TRIAS.

Nowhere were any Mesozoic beds of this group observed except at the southern end of the Greenhorn Mountains, which falls into our district. Station 63 of 1874 is located on a prominent hill composed of porphyritic trachyte near the base of the mountains, and this may be regarded as the central point near which the red Triassic beds are found. On the east side the development of these beds, both as regards the horizontal and vertical dimensions, is quite considerable. Piñons densely cover the low hills formed by them and greatly impede detailed examinations. It is evident, however, that the "red beds" occurring there are identical with those farther north. The bright-red color shown by sandstones, shales, and marls, the regular stratification, and the lithological constitution, all agree. Single strata of either white or yellowish sandstones give the bluffs and walls a banded appearance, strikingly in contrast with the more uniform color of the red Carboniferous sandstone. As heretofore no fossils were found, save some impressions resembling *Fucoids*. At the extreme southern point of the Greenhorn Range the red beds are entirely covered by the Lower Cretaceous, and do not again appear until due west of station 63 of 1874. There they are exposed in several cañons that cut deeply through the Cretaceous. Near the heads of the cañons the outcrops are found in the shape of almost vertical walls 200 to 400 feet in height, surrounded by timber, inclosing the swift streams that form numerous small cascades over the readily eroding sandstone. A few miles north of the station these outcrops cease, never at any time extending into the valley. On the east side of the Sangre de Cristo no evidence of Jura-Trias was found. It seems almost inexplicable why that should be so, but I doubt if the Triassic and Juriassic waters ever extended so far west in that region. Jurassic beds, consisting of the light shales and marls, occur east of station 63 of 1874, superincumbent upon the Triassic beds, and conformable with them. No fossils were found in them, but their position in the geological horizon of that region seems so well established, that their occurrence in definite connection with other formations may justify the assumption of their Jurassic age. None were found on the west slope of the Greenhorns. It is possible that they may occur in connection with the red beds mentioned, but the timber is so dense there, and the amount of redeposited material so large, that no positive information could be obtained upon the subject. Near the Sangre de Cristo no evidence of the existence of Jurassic beds could be observed.

CRETACEOUS.

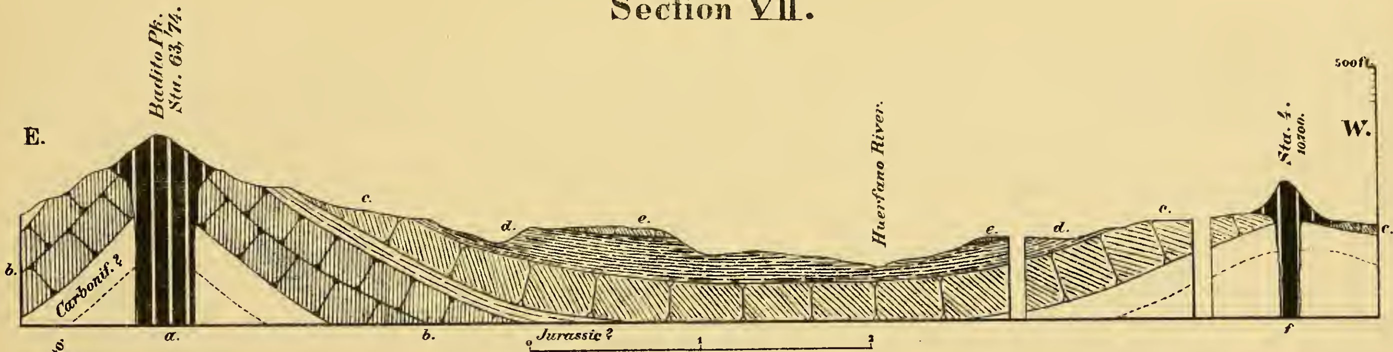
Quite a considerable portion of this district is covered by Cretaceous beds. Only the lower members are represented, however, not reaching higher than No. 3. The main area belonging to this formation is the Huerfano Valley, generally termed Huerfano Park. From the edge of the plains westward Cretaceous beds extend to the base of those volcanic mountains east of the Blanca group, underlying some of the trachytes that form the prominent peaks mentioned. Northward they extend along Williams Creek until lost under the drift of the southern portion of Wet Mountain Valley. Numerous volcanic dikes traverse both the sandstones and shales, and have produced many alterations in the physical appearance of the rocks with which they have come in contact. About east of the Spanish peaks the Cretaceous strata cease to be exposed, as they are covered by the younger Lignitic group, which extends far to the northward. West of Spanish Peaks No. 1 again appears, in an abnormal position, however, as has been shown above. From there the sandstones and shales both continue southward in a line parallel to the trend of the Sangre de Cristo Range. Along this exposure they afford features of much interest, though at the same time features that require careful study for correct interpretation. More particularly No. 2 is puzzling, as to its occurrence and stratigraphy.

Dakota Group.—(*Cretaceous No.* 1.)—This characteristic group is well represented. Beginning east and south of station 63 of 1874, it rests conformably upon the older Mesozoic beds. First the dip is toward the east 15° to 20°; then it veers around to the west, diminishing, however, in steepness as soon as it is due west. On either side of Williams Creek, the white and yellowish sandstones form the rim of a basin, as it were, to the younger Cretaceous beds deposited therein, dipping gently from both sides toward the center of this basin. Northwest and west they rest partly on the red Carboniferous sandstone, frequently the junction is so obscured by *débris*, or drift, as to leave its precise location in doubt. After passing station 62 of 1874, the sandstone, which here is yellow, makes a sweep to the southeast, including within its area the volcanic mountains of the Sheep Mountain group (stations 4 and 5). While riding up to the Sangre de Cristo Pass, along the wagon-road from the east, we pass over heavy beds of sandstone belonging to this group. From there it turns toward the eastern edge of the Spanish Peaks, and there disappears. Although it appears to crop out very distinctly in that region, overlying the red Carboniferous sandstone, its horizontal exposure is certainly very small, and obscured by the intense color produced by all washes and *débris* coming from the former.

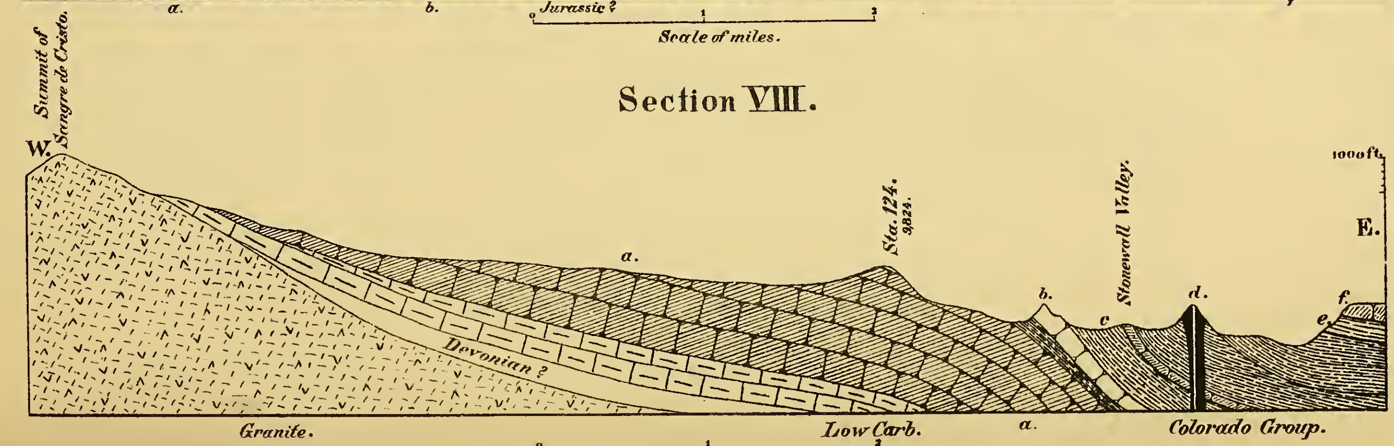
A section (Section VII) taken from station 63 of 1874 to station 4 may show the general stratigraphical arrangement, which is simple. The first-named station is located on porphyritic trachyte (*a*), which probably occurs there not as a continuation of the mass on the summit of Greenhorn Mountains, (stations 83 and 84 of 1873, but as an independent eruption. It has broken through the red Mesozoic sandstones (*b*), which surround it on three sides. They dip to the southwest at an angle of about 10° to 15°, and are overlaid conformably by the sandstones (*c*) of the Dakota group. Of these, the lower strata are white to light yellow, fine grained and hard, while the upper ones are softer, yellow, and decompose more readily. As they descend toward the valley, the angle of the dip gradually diminishes, so as to become almost imperceptible. Yellow and grayish shales (*d*) of No. 2 (Colorado group), containing the characteristic fossils of that horizon, are deposited on the sandstones, and are in turn covered by a yellow sandstone (*e*), which has mostly succumbed to erosion. Approaching toward station 4, which is located upon trachyte (*f*), we find that the dips are reversed. Instead of an inclination toward the west, we now have an easterly one. All the beds above given are recognizable here, and generally form either small bluffs or low benches, according to the lithological constitution of the rock composing the strata. This section gives a general idea of the condition in which we find Cretaceous No. 1 in Huerfano Valley and in the valleys of its main tributaries. Totally different from

Plate XIV.

Section VII.



Section VIII.



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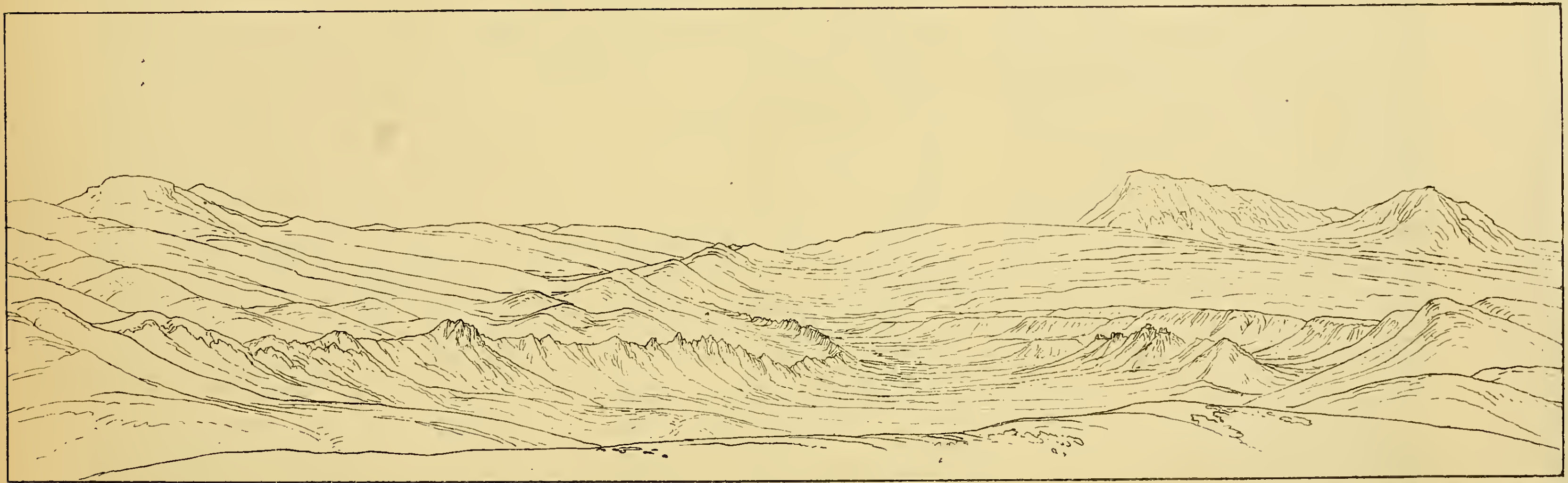


AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

Stone Wall Valley and Spanish Peaks.

Plate XV.

this is its occurrence west of the Spanish Peaks. Under the head of "*Carboniferous*," the position of the white sandstone there, as well as in the neighborhood of Costilla Peak, has already been discussed. It remains, therefore, only to trace the connection between the two, and show their correlation to superincumbent strata. For several miles near station 121 the white sandstone, standing on edge, is continuous; then breaks off, either by disconnection or by merely being hidden from sight on account of the dense timber prevalent in that region. Following in a southerly direction, however, parallel to the trend of the range, it appears again, dipping steeply toward the east, conformable with the underlying Carboniferous strata. Farther south it then continues, broken every now and then, but serving as a good horizon, by virtue of the bluffs it produces. Numerous volcanic dikes occur there, many of them running parallel to the sandstone outcrop, thus producing the effect of a single narrow ridge cut up into a number of small hog-backs. A little south of station 123 we enter Stonewall Valley. It is a narrow valley, running almost due north and south. Its western border is formed by the Sangre de Cristo range, its eastern by the regular line of bluffs belonging to the Lignitic group; a wall running along its entire length, almost without a break, formed by the white sandstone of No. 1, has given rise to the name. Viewing this valley from the south, it presents one of the most picturesque scenes imaginable. The high peaks of the Sangre de Cristo to the right, the bench of foot-hills, narrow and steep, produced by the Carboniferous strata, and the long-continued vertical wall of white sandstone that curves gracefully in the distance—all of these tend to complete the picture. To the left of the wall a fertile valley, rich in grass and well-watered, bears evidence of the appreciation settlers have for so secluded and choice a spot. Dikes of porphyritic trachyte, following the course of the wall, have raised a number of sharp, low bluffs, that relieve the regularity of the other features. A second smaller valley lies between them and the succeeding bluffs, that contrast in color and form with all that is presented to view. Yellow sandstones and shales form their steep faces, that are mostly covered with a plentiful growth of dwarf oak. In the back ground the towering forms of the Spanish Peaks, clad in that hazy color produced by distance, afford a grateful rest for the eye that has taken in the wonderful detail exhibited in the valley.

Station 124 was located on the prominent red sandstone ridge. A section (Section VIII) taken from there directly across the valley (west to east) may give a more definite idea of the arrangement of the strata. An easterly dip of about 30° is observable in the sandstones (*a*), but as we descend this increases. When the sandstone of the Dakota group (*b*) is reached we find it to stand almost vertical, dipping 80° eastward. On the latter side it is nearly entirely denuded, and presents the usual character of the sandstones belonging to this formation. Then follows the valley proper (*e*). Here we meet with the same difficulty that we have near Costilla Peak. The innumerable bowlders, the sand and fine *débris* from the adjoining mountains have collected in this valley and have been distributed over almost the entire area. It is only where the dikes occur that any satisfaction can be obtained whatever. So far as could be observed the angle of the dip decreases as we proceed eastward, and at the dike (*d*) cut by the section, it amounts to probably 40° to 45°. More difficult than this, however, is it to determine the nature of the strata through which the volcanic material has found its way. Altered by the heat and hidden by the *débris* from the dike itself, it seems certainly to have been a shale. Within the valley itself not a trace of any fossil was found, although at a few isolated spots small patches of the shales were exposed, only partly altered. Beyond the dike we find the same dipping at the base of the sandstone bluff at an angle of about 30° to 35°. Here we are once more in an easily-recognizable horizon. Shales (*e*) and sandstones (*f*) compose the bluff, the strata of which rest apparently unconformably upon the underlying dark-grey shales. In the same way as has been done, the wall or the stratum forming it can be traced southward until it disappears under the trachyte immediately north of Costilla Peak. It has been mentioned above that the easterly dip changes to a vertical position and then farther south gradually turns into a decidedly western one; so that the Carboniferous strata rest *upon* the Cretaceous. Wherever creeks, coming from the mountains, have cut through the Carboniferous and then the Cretaceous strata, as, for instance, the three main forks of the Purgatory, good sections can be obtained of all those beds that resist, to a certain extent, the eroding influence. The shales, however, have been cut out in deep troughs by the waters that were narrowed in their flow, and suddenly found themselves at liberty to expand. In the stead of a large portion of the material carried away, erratic bowlders, &c., were deposited, and thus all examination of the strata really existing at any given point is made very difficult.

Colorado group.—(*Cretaceous No.* 2.)—All the shales alluded to above as occurring in Stonewall Valley and both north and south of it, I suppose to belong to this group. Although I had occasion to traverse that particular region very carefully, I did not succeed in finding more than one locality where the question was answered beyond all doubt. Fortunately, this is in such close proximity to the questionable areas, that I have drawn my deductions, and have considered myself justified in so doing, mainly from the observations made there. It has been mentioned that the yellow sandstone bluffs at the eastern edge of the valley contain strata resting apparently unconformably upon those which are regarded as Cretaceous. Station 125 is located about a mile south of the South Purgatory, on one of the younger bluffs. While the strata, both of sandstone and shale, of the latter are characterized by light colors of great uniformity, I observed on the river itself, in its valley, a dark-grey shale, protected from erosion by several basaltic dikes. Upon examination this shale proved to have a dip of about 23° east, and to contain *Inoceramus* and *Ostrea complexa.* Its identity, therefore, was established. Further investigation showed that it was merely the continuation of the shales in the valley that had furnished such unsatisfactory exposures. It was apparently unconformable with the overlying rocks, but conformable with the gradually diminishing dip of the shales immediately west of it, and in direct connection with them. This is the only well-established occurrence of Cretaceous No. 2 that I can cite for the valley or its immediate vicinity. Observation, however, has shown that the character of this depression is very much in accordance with those generally formed in the readily yielding shales of this group, and in my own mind I have no doubt that the assumption of its belonging to that series is correct.

On the Huerfano the development of No. 2 is by far greater. Referring to section VII, two strata of the shales will be noticed—the one (*d*) of a yellowish to greenish color; the upper one (*d′*) reddish. Above them is a sandstone (*c*) containing fragments of *Inocerami* and *Ostreæ.* This portion of the Cretaceous was deposited without any intermission of time after the lower sandstones, because no erosion of the latter seems to have taken place. A large bay was formed by the waters depositing No. 2, which extended for a considerable distance up the Huerfano. At that time the Carboniferous strata had already been subjected to disturbances and to erosion, (compare section III,) so that at a number of places the shales are found to be bedded unconformably with the underlying red sandstones. This is but in accordance with observations made on the Pacific side of the Rocky Mountains,* where Carboniferous beds were apparently overlying Cretaceous. In that particular instance the strike and dip of the strata of both was the same, thus making the deception more perfect.

On the west side of the Sangre de Cristo Range no Cretaceous was observed along its entire length. It seems strange that this region should so completely have escaped all invasion during that period, but can readily be explained by the assumption that the points of inlet, which would be looked for at Pōncho and Veta Passes, and at the exit of the Rio Grande from San Luis Valley, were already at too high an elevation to be overflowed. With the exception of a curious drift conglomerate, deposited most likely by water and ice, I have observed in San Luis Valley no sedimentary formation younger than the Carboniferous. In chapter IV, while speaking of the Post-Cretaceous formation I shall have occasion to refer to some of its younger members, which do not occur in the district here treated of.

VOLCANIC FORMATIONS.

Although there are no extensive volcanic areas in this district, those we do find are of great interest, not so much locally, as on account of their peculiar geological genesis. So far as could be observed, nothing but trachyte, dolerite, and basalt occur among the volcanic rocks composing the various groups and dikes. Mention has already been made of the mountains near the eastern entrance of Sangre de Cristo Pass. On account of their color partly, partly on account of their shape, two of them have received the name of "Sheep Mountains," while the others, lower in elevation and less prominent in their forms, have not been named as yet. There are at that locality six volcanic areas, all belonging to one system, though separated at present by the effects of erosion. Lithologically they are similar or identical. Some basalt is found on the Lower Huerfano, forming small tables, the terminations of huge dikes. The Spanish Peaks, the volcanic portion of which covers but a small area, are very prominent and of importance in the volcanic system of the region. Near the headwaters of Rios Culebra and Costilla a large portion of the higher land is covered by trachyte, some of which extends down into the valleys. Besides these volcanic deposits there are innumerable dikes in the district, traversing mostly the Cretaceous, sometimes the Carboniferous formations.

A.—Volcanic areas.—As such I mean to designate the more massive portions of volcanic material, in contradistinction to the dikes proper. Station 4 is located at an elevation of 10,705 feet, on the summit of one of the more northerly mountains belonging to the Huerfano group, near the pass. Resting immediately upon the sandstones of the Dakota group, the strata—if we can speak of such—have a southwesterly dip. I do not regard the differences, partly in color, partly in structure, that can here be observed, either as strata in the true sense or as volcanic flows, but assume that, at the succeeding stages of cooling, the volcanic mass, in this instance, resolved itself into physically different rock, so that to-day, upon weathering, the effect observed is similar to that which would have been produced by stratification. The trachyte composing

* Report United States Geological and Geographical Survey 1874, page 218.

this mountain is about 1,200 feet in thickness, of a light-yellow to whitish color. Paste crypto-crystalline containing very bright, minute crystals of sanidite. Upon exposure it assumes a light-brown color, due to the presence of a very small percentage of magnetite, and breaks into thin fragments and slabs that have a semi-metallic ring. North of station 4 is another smaller hill, of almost the same shape and general appearance. Toward the west the volcanic mass has flown over the high portion of country, from which Sangre de Cristo Creek receives a considerable supply of water. At that point the trachyte covers the Carboniferous strata. A little east of south from station 4 is station 5, at an altitude of 11,512 feet, located also upon trachyte. It is identical with that of the former. Drawing a line from station 5 in the direction north 25° west, it will be found that the three mountains thus far mentioned stand in one straight row. Judging from this and from the dike-like character that almost all the eruptions in this region have, I should suppose that this was merely one immense dike, disrupted at the elevation of the present Cretaceous sandstones between them. It seems to have contained more volcanic matter than was required to fill the fissure, consequently overflowed both to the westward and eastward. As it is the case near station 4, so it is near station 5. Although the connection now is broken, and the Carboniferous strata covered by the two masses have appeared between them in Veta Pass, that large area immediately south of Sangre de Cristo Pass was in connection with the mountain of station 5. From the section through the pass (Section I) it is evident that there, too, the trachyte reaches to considerable depth, and is at the same time of the same lithological constitution as its two eastern neighbors. It seems probable, therefore, that a number of these huge dikes occur here, but on account of the lava having flowed from one to the other, their individual outlines have been lost. Station 7 is located on a trachyte, near the junction of Sangre de Cristo and Indian Creeks, 8,967 feet high. This appears to be an isolated outflow, separate from the eastern ones, but in connection with that a few miles north of it. In mineralogical and physical character this trachyte differs from the former. It is brown, almost lilac when fresh, contains small crystals of biotite and sanidite. A short distance below the station it can be observed overlying the metamorphic granite of that locality. It weathers, on account of its flows, by far more massively than the eastern, and presents more the character of that found on the west side of San Luis Valley. Only for a short distance can the flows be traced in any direction; then they thin out and disappear. It can be observed, as a rule, that the trachytes west of the Sangre de Cristo divide have a different character from those east of it, unless, as is the case farther south, the western ones have flowed over. It is furthermore noticeable that on the western side no dikes, neither the large ones, as the Sheep Mountains, nor the smaller ones, will be found, although but a few miles distant they occur in such great variety of form and composition and such exceptionally great numbers.

A most interesting group is that of the Spanish Peaks, (station 121.) Approaching them from the north, the two mountains are seen to rise far above the level of the surrounding country, and, standing isolated as they do, the effect of their height is still increased. The fertile valley of the Arapahoe is in the foreground, and from it rise abruptly the forms of these two giants. Innumerable walls, high and of great length, stretch from the valley up toward the summit of the peaks, while solitary volcanic buttes give evidence of others that have crumbled away. On the west side of the mountains narrow, sharp ridges, surmounted by the same walls that caused their present existence, lead up to the sharp summit of the higher peak. "Sentinels" of volcanic rock are stationed outside, rising in their isolated glory, as if to guard the access to the center whence they had their origin. An excavation resembling half a crater on the southwest slope of the mountain completes the deception already conveyed, that we here have a volcanic eruption that has left its evidence in the most approved form. East Spanish Peak, lower than the other, presents steeper outlines, more sharply cut slopes and ridges, and less of the characteristic dike-walls than its neighbor. Both are beautiful peaks, in form as well as in their geological features.

In speaking of the Carboniferous, it has been stated that the main body of the mountain is composed of red sandstone, that has been altered by heat, so as to produce a number of species of metamorphic rocks. Ascending the western peak from the south, we pass first over the red sandstones, until, near timber-line, we find the first evidence of larger masses of volcanic rock. Fragments of numerous varieties of trachyte and rhyolitic trachyte lay scattered around in great profusion. Vertical places are seen along the ridge we propose to climb, and we find upon reaching them that they are caused by the intersecting dikes. These are from 2 to 60 feet in thickness, and not unfrequently extend from near the summit down into the valley for several miles. All the strata in their immediate neighborhood have been baked, fritted, and completely changed. Near the top of the mountain the sedimentary beds have totally disappeared, and nothing remains but the trachyte, with its splendent brown mica, white oligoclase, and long needles of black hornblende. More than four feet of snow covered the summit at the time of our ascent (September 26, 1875) and it was more difficult than it otherwise would have been to trace the exact limits of the capping volcanic rock. Enough was seen, however, to show that this capping rests upon one of the changed sandstone strata, which at that elevation has a slight westerly dip. (Compare section IV.) Differing from station 121, which is 13,623 feet above sea-level, is the lower East Spanish Peak. This is composed entirely of trachytic rock, sending out also a number of radiating dikes, neither so many nor so long, however, as those of the western peak. With the explanation given in the discussion of the Carboniferous, relative to the upheaval of both these mountains and the formation of a fault, this is in accordance. It is evident that at the point of least resistance, *i. e.*, where the Carboniferous strata were thinning out, the quantity of volcanic material ejected should be larger, and at the same time the resisting medium, the sandstones, would furnish by far more cracks and fissures that could be filled by the injected lava. Dr. Hayden* regards these peaks as a "gigantic dike, with the strike about northeast and southwest." With this view I fully agree, adding that this main dike has clustered around it a very large number of accessories, emanating from the same source and formed synchronously with the elevation of the peaks. We did not visit the base of East Spanish, but I have no doubt that metamorphosis of the underlying strata could be observed here similar to that which has taken place on and near station 121.

Near the edge of the San Luis Valley, south of station 115, a belt of trachyte sets in, the continuation of the heavy outflow to the south. Station 114 is located on it at an elevation 9,807 feet. Low rounded hills covered with piñon and juniper, or presenting gentle grassy slopes, characterize the region. Deep gullies are worn into the volcanic

* Report United States Geological Survey 1867 to 1869, p. 153.

rocks, and they are well exposed. Metamorphic rocks underlie the trachyte here, which has a thickness of 300 to 500 feet. It is evident, both from this feature and from the identity of its lithological constitution, that this is but a flow from the south. On the west side drift of the San Pedro Valley covers the dipping strata or flows, and they are hidden from view. It could not be determined with certainty whether they appear at the base of the San Pedro Mesa, but this seems probable; it is also probable that their continuation is to be looked for in the bluffs northeast of station 105 in San Luis Valley. At the south end of the mesa the connection between the two former is established, and there the trachyte does appear, but it seems to dip under too far to show any broad area farther north. The connection between this and the southern mass has been severed by erosion, and Rio Costilla forms the boundary between them, running in metamorphic rocks at that place. Of the large volcanic area to the south, merely the northern end came within the boundary of our district. Along the western edge of the mountains metamorphic granite occurs from Rio Costilla southward. This reaches up to about timber line as a rule, though not always, and from there upward the trachyte sets in. It follows in its western border the edge of the valley, and produces a number of sharp; high peaks. Generally it remains on the highest portions, but west of station 110 crosses the Costilla, and forms a number of low hills with steep, bluffy sides. Here it is nearest to the station 114 group, being only four miles distant. The elevations of the two groups, this lowest one and the former also, agree, as well as their structure and texture. A few isolated outcrops, that may merely be fragments, are found higher up on the Costilla, but the main mass recedes southward. Immediately east of Costilla Peak, however, (station 111,) it projects to the north, forming the prominent hill (*d*) in section V. It seems highly probable that this is one of the points of minor outflow, as the character of the trachyte differs from that observed farther south. From there it extends eastward, covering some of the sandstone bluffs. Prior to the erosion which produced the present bluffs, it must have covered a by far greater area, as remnants of it are found at station 126, nine miles beyond its present extreme northern point. Steep walls and sharp ridges, similar to those of the Sawatch Range, indicate the presence of this volcanic rock. So far as could be determined from a distance, it extends much farther south, forming the mountains of the continuation of the Sangre de Cristo Range. At all points along the northern and western edge of this mass it was found to overlie metamorphic rocks, having adapted itself in its flow to the various features of erosion that existed at that time. Whenever a mountain was too high to be reached, or a ridge barred its progress, the trachyte has altered the direction of its course and sought more readily accessible localities. In the upper valley of the Costilla, aqueous erosion has no doubt removed a very great portion of the volcanic rock, and the river has deposited it either in the form of bowlders or sand at the base of the mountains in San Luis Valley. Columnar structure can be observed in some of the small outcrops in the valley, but not so frequently in the mass higher up. The trachyte bears evidence of having been very thoroughly fused, and is as a rule very hard, brittle, compact of texture, and has a semi-metallic ring when found in slabs. Station 108 is located on a sharp peak of this group, near the head of Rio Colorado, and is 12,467 feet above sea-level. It is on the western spur of the main range, which, farther north, separates into two branches. Here the trachyte is very characteristic, closely resembling that of the Sawatch Range; not that, however, found in the

Huerfano or in the Spanish group. As the average character the following description may serve: The rock has a dark grey color, produced by finely disseminated magnetite, and is microcrystalline. Thin seams of epidote occur in it. Crystals of sanidite are partly fresh, partly decomposed, in the latter case opaque. A green chloritic mineral occurs in minute crystals, dispersed throughout the entire mass.

The western spur of the range, the one upon which station 108 was made, I regard as the true continuation of the Sangre de Cristo, topographically considered. From a geological point of view the eastern one would probably be chosen, as it is here, that the formations composing the range farther north are fully represented. Red Carboniferous sandstone, which forms so important a feature on both sides of the range, is wanting on the western side, while it is found on the other, and there gives rise to the formation of mountains of considerable size. At Costilla Pass, the direct continuation of the range is broken, and, it seems to me, it must then be looked for in the western branch. Of the isolated patches north of the main area there is the one leading toward station 113. Trachyte there occupies a number of the higher points overlying granite or Carboniferous sandstone. Southwest of station 113 it forms a small plateau, above timber-line, and from there descends southward into the valley. It is not in direct connection with the trachyte of station 114, but approaches it within a few miles, and is, no doubt, the same flow. As the general dip of the metamorphics, so is the general dip of the volcanic rocks of this region a westerly one, except near station 111, where the flows extend eastward. In the southern group there is but little variety in the lithological character of the layers; they would belong, if compared, to No. 3, trachyte of the San Juan country.*

The average thickness here may be stated at 1,000 to 1,500 feet, although locally this estimate is greatly over and under reached. It would be of interest to make careful comparisons in detail of each successive flow or layer, and compare them with the analogous or parallel beds of the Sawatch Range. So far as could be seen in the comparatively hurried examination could that only be made, no positive identification of these strata with those farther west will be possible.

On the Huerfano, near Badito, station 141 is located on a Cretaceous bluff, covered by basalt. Its elevation is 6,952 feet. The regular bluff trends from northeast to southwest, has a comparatively flat top with some rising hills on its summit. Immediately south of it is another bluff of the same character. They are both in a line with stations 5 and 7, and probably belong to the same system of eruption, although the rock is younger. Northeast of station 5 is an isolated hill, almost dome-shaped, which I have named Muralla Peak, with a number of dikes leading toward it. Probably the main body of this hill is trachytic, as those farther west are, but the dikes are almost basaltic, and they seem to have been formed by the same material that covers the two bluffs in question, and probably at the same time. On the second bluff three conical rises may be observed, that apparently indicate the points of outflow. Water has carried on erosion very successfully in that region, and a large portion of it, that no doubt at one time was covered by volcanic strata, is now denuded and shows Cretaceous beds. Between the two bluffs the connection of the basalt is very slight, although they are but a very short distance apart. Small remnants of the more extensive basaltic areas occur in a few hills trending toward the larger volcanic group west. All of them either cover or penetrate Cretaceous beds.

*Report United States Geological Survey, 1874, p. 196.

South of station 84 of 1873, which is on the summit of the Greenhorn Mountains, a cone-shaped peak rises to an elevation of 8.897 feet. It is very prominent as seen from the surrounding lower country, and has been named Badito Peak. Upon this hill station 63 of 1874 was located. It is an isolated eruption of porphyritic trachyte, that broke through the red beds and the Lower Cretaceous sandstones, covering now but a small area. On the north the trachyte rests on metamorphic granite, which forms the bulk of the Greenhorn Mountains, while on its other sides it overlies Cretaceous No. 1. The rock composing the very pretty hill is a white to greyish trachyte, with a fine crystalline paste, crystals of sanidite, and oligoclase, and some small needles of black hornblende. It does not resemble the trachyte of the Greenhorn Mountains, but is more closely allied to that of the Huerfano group. Although the shape of the hill is the typical conical one of a volcano, no crater or even a vestige of any crater could be observed. It is a curious fact that, in spite of the very large amount of volcanic material that occurs in Southern Colorado, I have not been able to find a single mountain or hill of which I could say that it even only resembled an extinct crater. The eruptions have evidently not been accompanied by that demonstration of force which we observe in the volcanoes of the present day, but the existence of the dome-shaped and similar mountains that stand isolated is due merely to a slow process of eruption, comparable with boiling over. Many of them, of course, owe their shape to the gradual decomposition of the rocks on their sides. Rarely will a better instance demonstrating the former fact on a small scale be found than at station 63 of 1874. I might allude to Mount San Antonio and Ute Peak, in the southern portion of San Luis Valley; they, however, are of large extent, and have sent their flows for a long distance from them.

This is the last of the larger flows in the district discussed in this chapter. Essentially we have but three groups: the Huerfano group, comprising the mountains upon which stations 4, 5, 141, and 63 of 1874 are located; the Spanish Peak group; and the southern Sangre de Cristo or Venado group. The two former are intimately related, and are probably posterior to the third. Not from any deposition upon certain formations can this be judged, but mainly from the fact that in the former, rhyolitic trachytes and basalt occur, which are wanting in the latter. The relative age of volcanic rocks in our western country has been so well established, after much observation, that a mistake will scarcely be made by following the adopted succession. It will generally be found, too, that wherever this succession has been the guide for assertions, either contemporaneous or subsequent discoveries will corroborate them.

B.—Dikes.—A very large number of these occur throughout the district, but as it would be useless to enumerate all observed, only the most prominent or most interesting ones shall be mentioned. Station 142, 7,168 feet high, is located on a basaltic dike, that is one of a small complex. The general trend of the dikes at that locality is northeast to southwest, with several small ones crossing them at nearly right angles. Cretaceous shales of the Colorado group are the material through which the black basalt projects, and forms the steep walls that are almost inaccessible. The one upon which the station was located is very near the junction of Williams Creek and the Huerfano. Although scarcely more than 400 feet above the valley it affords an excellent point for an extensive view, a fact which had already been recognized by the Indians, inasmuch as we found the remnants of an old "look-out" on the highest

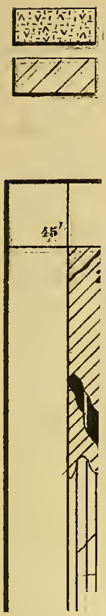
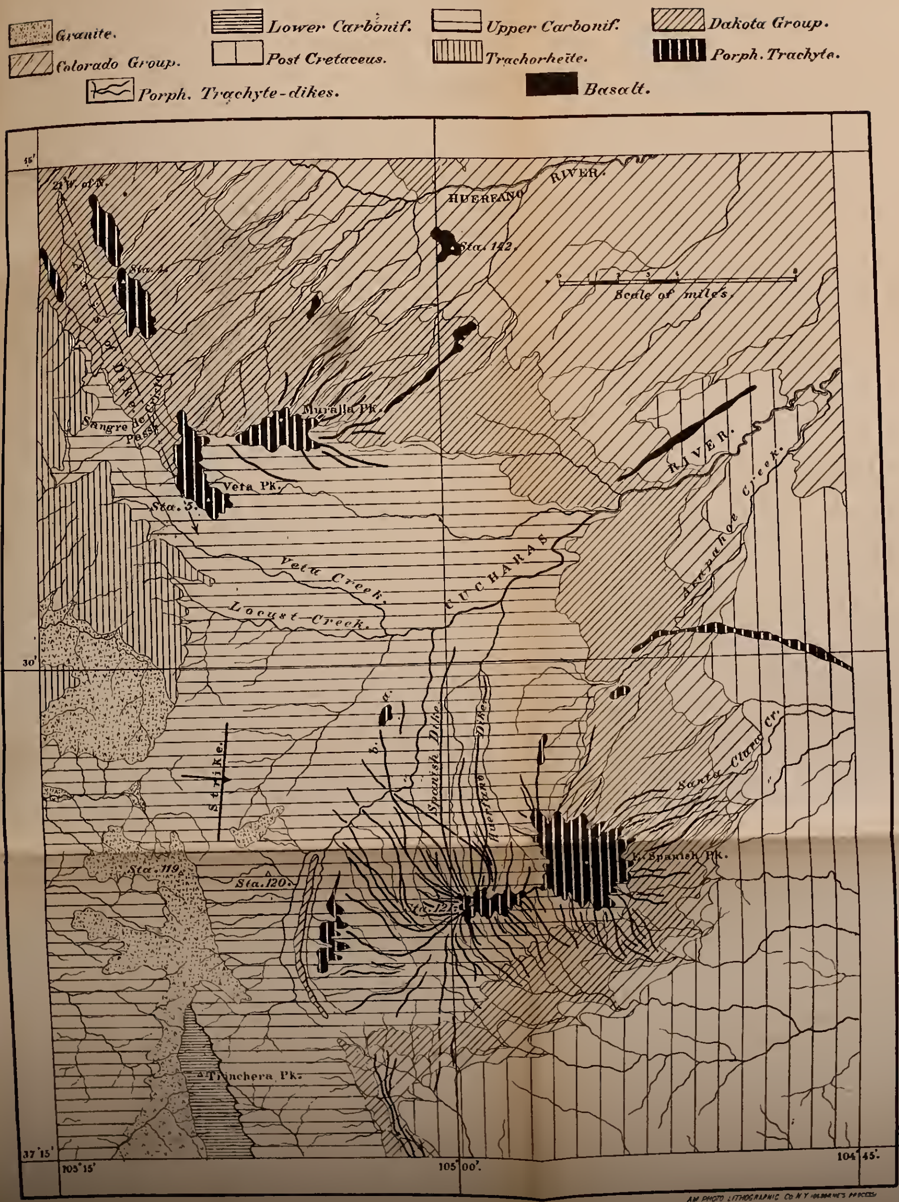

45'

Plate XVI.

Map of Spanish Peaks Region.



AM. PHOTO LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS)

point. No disturbance could be observed in the strata that were traversed by the volcanic material, a fact which has been noticed in almost every instance, and shall be discussed more at length below, when speaking of the dikes near the Spanish Peaks. Northeast of station 5 is the dome-shaped mountain that has been alluded to above, Muralla Peak. A number of creeks head there, belonging to the Huerfano drainage, and are separated from each other by narrow ridges, nearly all of which are surmounted by one of the wall-shaped dikes. The latter extend into the valley, at the base of the mountain, and some of them run along for several miles. They show the same physical characteristics as nearly all the others, and are composed of porphyritic trachyte. More than ten were located, issuing radially from near the center of the mountain. Regarding the three trachytic outcrops, upon two of which stations 4 and 5 (Veta Peak) are located as one huge dike in connection, probably, so far as regards formation, with the occurrence of the fault west of Spanish Peaks, we find it to be 14 miles in length, striking a little west of north. A long dike, very prominent in its form and course, occurs between the Santa Clara and Spanish Creek, north of station 139. Its course is about northwest, and the rock composing it is basalt. Numerous small dikes are to be found in the region from which these longer ones have been quoted, but they are obscured partly by the timber; partly they have crumbled down so as to be visible no longer unless upon special examination. They are of no importance, however, in considering the question both as to origin and cause of the dikes.

Emanating from and in the vicinity of the Spanish Peaks we find the greatest number of dikes in the district. More may be observed at station 121 than at the East Spanish. Radiating in every direction from the mountain, with its summit as a center, these dikes stretch for several miles into the valley of the Arapahoe. It is they that have caused the preservation of sedimentary strata in the shape of a mountain. Some of them show a remarkably straight course, others more wavering lines. A small map has been prepared showing their distribution, and to this I would refer. In consequence of the radiation, no prevailing direction can be assigned to the courses of the dikes; but it may be observed that the longest ones are at right angles to the strike of the two mountains themselves, while the others, though of considerable length, do not show that regularity either in course or form. This agrees with the theory explaining the position of the sandstones in the mountain. In case of any disturbance, such as has been assumed, the greatest strain would fall in such a way as to produce a breaking of the strata at right angles to their dip, and it is at right angles to this dip that we find the longest and most regular dikes. Some of them present an appearance that cannot but be compared to a wall, particularly so Huerfano dike, which is about 8 miles in length. Spanish dike is the longest one, measuring nearly 10 miles. Both are several hundred feet high and stand perfectly vertical. Transverse dikes also exist, crossing the others at acute angles. Ramifications take place in several instances, the branches retaining the same size, however, that is shown by the one from which they started. Wherever creeks were to be crossed by them, they are broken through, and in no instance have they caused any serious deflection of the water-courses. Small, local bends, of course, have been produced, but no entire alteration of the general direction. Altogether more than fifty of these dikes have been located near Spanish Peaks, but there are many more that were either hidden or too small to be noticed. Immediately west of the peaks is a prominent hill, trending north and south, which belongs to the dike system also. It must have been one of those instances where the lava overflowed and caused the formation of a capping of small extent on the strata through which it had been ejected. Several small outcrops of volcanic rocks occur in this vicinity that belong to the class of dikes. One butte in particular, a little west of station 121, near Arapahoe Creek, may here be mentioned. It (*a*) is probably in direct connection with the long dike (*b*) issuing from the mountain, but it is somewhat obscured, owing to the crumbling down of the prominent wall. The butte stands isolated, shows vertical walls on nearly every side, and the greyish-brown trachyte composing it shows indications of columnar structure. Although so many dikes originate from station 121, all of them passing through the red sandstone and metamorphosing it wherever the two were in contact, but few are found near East Spanish. There the strain upon the strata was by no means so great as it was a few miles farther west, and as a result they were not cracked and broken to the same extent. In view of so large a number of dikes and the probability of the strata parting while breaking, examinations were made to discover instances of intrusion. Only a few cases of this kind were observed, however, except higher up on West Spanish Peak. Several dikes, or rather one main dike continues from Spanish Peaks southward into Stonewall Valley. It is broken into many fragments by the passage of water at right angles to its strike. In each instance the protection afforded by the hard dike-rock to the surrounding softer material has resulted in the formation of hogback-shaped hills several hundred feet in height. Opposite station 123 several accessories either join or emanate from the main dike, but they are all by far smaller and do not produce the same hil.s as the former. Viewed from a distance, the effect is similar to that of a long-continued row of very regular hogbacks.

All of these dikes in question are composed of trachyte. Mostly it is of a light-colored variety, containing small crystals of sanidite and oligoclase in a microcrystalline or nearly amorphous, compact paste. Other varieties, with mica, hornblende, &c., are not wanting, however. The uniformity is such, though, that their correlation among each other is evident at a glance, were that not proved already by their occurrence and relative position. Owing to an admixture of magnetite decomposition has produced a variety of colors, among which green and reddish-brown are the predominating. Opposite station 123 the color of the trachyte is by far darker than farther north, and the oligoclase is not found. The former may be due to a greater percentage of magnetic iron. As a rule, however, the colors are light, and add to the prominency of the outstanding walls. In a number of instances a cast of the strata, through which the molten lava has passed, and where it cooled, can be observed on the dikes, more particularly on those that were injected into the fissures of the hard, red sandstone. Regarding the process through which the dikes have attained their present prominent appearance, it may be very easily explained. Assuming that the fissures were formed by some volcanic activity, and reached to sufficient depth to be in connection with the molten material below, it is evident that the pressure exerted upon this material, which was sufficient to produce a rupture, was sufficient also to force the liquefied rock upward into the fissures. That this process took place very nearly in the manner described is indicated by the fact that no disturbances of strata occur in the immediate vicinity of these small dikes, and that the strata on either side are mostly thoroughly baked and fritted. Exhibiting on their walls a cast of the strata, opposite which each particular portion of the dikes became rigid, is proof of the fact that the fissures were filled by either liquid or plastic material, as no other explanation than that of heat can be accepted for the formation of the rocks composing the dikes. Either the fissures were filled to the top, *i. e.* to surface of the ground or stratum, or the volcanic material passed beyond the top and spread itself in the direction that afforded the most ready access, of which latter case several instances have been mentioned above. Less frequent is the case where the volcanic material did not reach to the surface, but is now exposed in consequence of gradual denudation of the sedimentary beds. Gradual erosion and decomposition, though at the same time attacking the dike-rock, succeeded in wearing away more rapidly the strata adjoining the harder and more resisting trachyte or basalt. Thus, in the course of time, the strata were worn away for the vertical distance of several hundred feet sometimes, while the rock, formerly inclosed and hidden, gradually rose to view. Even to-day the transportation of the soil is going on at a more rapid ratio than the crumbling and wearing away of the high walls that have, as it were, grown out of the earth. In many instances the erosion of surrounding strata was so complete as to leave the trachytic walls standing perfectly free, without any foreign matter whatever. In others, however, as is the case in Stonewall Valley, the baking of the shale strata has rendered them sufficiently hard to withstand the influence of atmospheric and other agents more successfully, and we have, instead of a well-defined wall, one flanked on either side by a sloping mass of sedimentary beds. From the observations made it can only seem astonishing, when the very large quantities of material that were transported from their place of deposition is considered. It is true that many rocks will be rendered by far more liable to decomposition and disintegration by the process of baking or metamorphosis, but either very powerful agents must have been employed, or very long periods of time required to remove, *gradatim*, 300 to 400 feet of earth or rocks from so considerable an area.

In looking over the general strike of the dikes in this district, we will observe that there is not sufficient reason for assuming a preference for any one direction. Had the forces producing the disturbance near the Spanish Peaks acted uniformly along the entire eastern border of the Sangre de Cristo Range, we should probably have occasion to observe very regular and similar effects throughout the region. As it is, however, the causes for the formation of fissures to be filled are localized, and the effect will only extend itself to local occurrences. No generalizations, therefore, can be based upon the existence of these dikes, save the one that they were formed in consequence of volcanic seismic action. In the landscape they have a decidedly picturesque effect, producing not only the very sharp ridges on the mountains from which they start, and the hogbacks when not entirely denuded, but the characteristic walls that stretch for miles across a sometimes perfectly level country. The numerous little buttes, remnants or portions of such dikes, afford good landmarks in the lower country, and are welcome as stations to the topographer or geologist. Though of inconsiderable elevation, they command a sufficiently extensive view for such purposes. A number of them occur in the plains east of the Huerfano region, recognizable from a distance merely as small, black, stationary objects.

Regarding the age of the Spanish Peak outflows and the dike-system, sufficient data were obtained to throw light upon the question. As mentioned above, most of the dikes traverse Carboniferous strata on the northern and western sides of the mountains. East and south they penetrate the Cretaceous and Post-Cretaceous (lignitic) beds. Although the system of dikes does not continue into this latter group to any great extent, a number of dikes belonging to the same age as the others were found, showing also the same lithological character. It is evident, therefore, that the time for the eruption of all this volcanic material must be placed at a period subsequent to the deposition of the Lignitic group. This, so far as I am informed, will agree with the relative age accepted for analogous eruptions in other regions of Colorado. Dr. A. C. Peale will publish in a Bulletin for 1877 a thorough synopsis of all occurrences referable to this class of volcanic rocks, and in that publication will furnish a digest of all the principal features thus far observed in connection therewith.

DRIFT.

There are found in this district no very extensive drift areas, save that on the west side of Sangre de Cristo Range, south of Fort Garland. Adjoining the trachytes of the station 114 group, we find that the bluffs skirting the mountains are continued northward. In form and general character they resemble the volcanic bluffs, but upon examination prove to consist of drift of a peculiar nature. Stations 115, 117, and 118 were located on it. In my field-notes I have designated it as "compact drift," on account of its conglomeritic nature. Large and small bowlders and pebbles have been cemented loosely by quartz-sand, and clay, and form the bluffs that rise a thousand feet above the level of the valley. At the southern end of the outcrop of this curious material metamorphic and some trachytic rocks, originating in the Sangre de Cristo Range, compose the drift. It could not be determined which of the two predominated. Bowlders of all sizes, weighing from a ton down to the smallest pebbles, occur. All of them are well water-worn, but show striation only in very rare instances. Station 117, 9,583 feet above sea-level, shows these features very well. Gradual aqueous erosion has loosened a large quantity of the bowlders and pebbles, and has deposited them in the valleys of the adjoining streams, where they greatly impede the study of the strata underlying.

Immediately east of this north to south exposure of compact drift we find the red Carboniferous sandstones, which are in part covered by the former. The bluffs continue northward, until within about 6 miles of Fort Garland. Here the composition of the drift changes. Instead of only metamorphic rocks and trachytes being found among the erratic material, basalt and dolerite also occur. Station 118 is located on one of these hills, and it was a matter of some difficulty to get the animals up hill on account the innumerable bowlders, all round, that covered the side of the bluff. So far as could be determined, a thin layer of basalt about 150 feet in thickness covers a number of these small bluffs. It seems strange, at first sight, that basalt should cover drift that is composed, in part, of the same volcanic rock. Considering, however, over how very long a time the period allotted to each one of the volcanic formations must have extended, there is no reason why not a large mass of basalt or any other volcanic material should have become rigid, should have been eroded and even partly carried away before the next flow took place.*

* In some of the Liassic formations of Southern Germany it is not a very rare thing to find the petrified water-worn fragments of Ammonites, &c., imbedded in the limestones of the very strata of which they are considered to be characteristic in perfect specimens.

East of the drift of station 118 the metamorphic granite crops out parallel to the former. The Carboniferous strata have evidently been either worn away by some active process of erosion or have been broken off during their upheaval. Adjoining the compact drift on the west is the drift of San Luis Valley, containing near the edge specimens that have been carried thence from the bluffs in question, but they do not extend into the valley for any distance. It seems difficult to explain the origin of these drift-bluffs. Their considerable extent, their height, and their relative position indicate action of great force. No attempt at distinct stratification was observed, and from the nature of the heterogeneous arrangement of the bowlders it seems improbable that they should owe their existence to the agency of water only. The only explanation I can offer to account for their unique character (in that region) is that they are the result of deposition by moving ice-fields, by glaciers, together with water. If we study the character of the metamorphics from an orographical standpoint we will find that their outlines, the carving they exhibit near the western base of the mountains, indicate glacial erosion. I did not succeed in observing striation, or any definite proof for this assertion, but the habitus of that region is certainly glacial. Adding to this, I consider the disappearance of the Carboniferous strata near station 118 and the exposure of the granite as circumstantial evidence in favor of the acceptance of glaciers in accounting for the existence of the drift-bluffs. All the western glaciers in the district surveyed during 1875 are of basaltic or post-basaltic age, more frequently the latter, so that it would seem that after the enormous moraines in question had been deposited another flow took place here and covered a portion of them. I doubt not that these bluffs afford the key to the pre-glacial or earliest glacial history of San Luis Valley, but as very careful examinations and detail study would be required to arrive at any correct conclusions such as we were not able to make during our survey, I cannot make any positive assertions accompanied by the requisite proof. In the discussion of glacial phenomena this subject will be more fully treated of. I do not consider the assertion regarding glaciers as the moving agents proved, but it is an explanation that can be sustained by facts, which, though at present but imperfectly collected, may some day, after more elaborate examinations, prove to be conclusive. It is possible that the presence of this enormous secondary deposit may point to the inference that before the "lake period" a large portion of San Luis Valley may have been covered by a glacier—may, in fact, owe the details of its present topography at certain localities to such agency.

On the eastern side of the Sangre de Cristo Range, the drift-deposits are local and of small extent. All along the base of the mountains, in the valley leading from Costilla Peak northward toward the Spanish Peaks, the metamorphic rocks and Carboniferous sandstone bowlders have been carried down, covering the western edge of the valley completely. Flowing water and perhaps snow-slides have here been the moving agents, and in consequence the accumulation of the drift is not a regular one, but distributed according to capability of the streams. Along the western border of the Greenhorn Mountains we find the same thing occurring. There, too, metamorphic rocks and sandstones (Mesozoic) have been carried down and deposited parallel to the edge of the mountains and water-courses. This is a phenomenon so common at the base of the mountains in the entire region, that it scarcely deserves special mention. Only in so far is it of importance, as in some instance glaciers have had an influence on the deposition, and it is of importance to separate the two if possible. Following the main streams of the district we find the usual accompaniment of river drift and alluvial soil, much of which latter is turned to good account by the industrious hand of the settler.

MINERAL DEPOSITS.

At one time the "Sangre de Cristo mines" created quite a sensation among the prospecting and mining portion of the community. They are located in and near Greyback Gulch, the valley of the main northern tributary of Sangre de Cristo Creek, joining it in the pass. At the time of our visit, June 17, 1875, but little work was being carried on in the gulch, although deserted ditches, old sluice-boxes, and cradles spoke of former activity. Placer mining had yielded for a time satisfactory returns, but before long the locality was abandoned for others. Metamorphic drift coming from the mountains near station 6 fills the narrow valley and its branches, and it was from this that the precious metal was obtained. Want of water during some seasons of the year led to the construction of a long ditch, turning water from the Sangre de Cristo into the valley. These placers were discovered in 1862* but soon after abandoned, during the San Juan excitement produced by the ill-fated Baker. Lodes have been discovered in the metamorphics of the vicinity, but no active mining is carried on there at present. They are said to show very favorable indications, and the ore to yield assays that would warrant working them. The close vicinity of the San Juan mines has had the effect to draw prospecters and miners away from this region, and therefore the development that otherwise might have taken place was not reached.

While exploring the southern portion of the Sangre de Cristo Range, numerous veins crossing the dip of the metamorphic rocks were noticed. From surface indications—for no work has ever been done there—I should suspect the presence of considerable bodies of ore in the quartz veins. A lack of time did not permit of any detailed examinations, but the conclusion was reached that in case the existence of ore of a paying quality and quantity should be established in those veins their geological character will warrant their persistency to any depth that may be reached by mining operations. After reaching Trinidad I heard of a discovery made in the Sangre de Cristo Range, which was creating considerable excitement and was known as the "Trinidad Gold Mines." From one of the discoverers I learned that the location of the lodes was on the eastern slope of Culebra Peak. They run in the metamorphic rocks of that mountain and have merely been opened. "Red Mountain mining district" the locality has been named. Specimens of pyrite and chalcopyrite were brought from there. Should these mines eventually prove to be valuable, no doubt numerous other discoveries will be made farther south. The easy transportation to a base of coal-supplies (Trinidad), and the proximity to railroad connections, would, if ore exists in paying quantities, facilitate a rapid development of mining industry in the entire region.

Résumé of chapter I.—The area treated of in this chapter comprises about 1,500 square miles. With it the description of the Sangre de Cristo Range is completed. That was commenced in the report of 1873. Being able to survey adjoining districts each succeeding year has great advantages, inasmuch as both topographer and geologist are prepared for what they shall find, and both time and trouble will be saved thereby.

* Report United States Geological Survey 1867 to 1869, page 173.

Many of the formations usually met with in the Rocky Mountains are represented here, and have been discussed at their proper places. Metamorphics are found in the highest portions of the district, maintaining their general association with the most lofty peaks of the main Rocky Mountain chain. Of the sedimentary formations, the older ones have not appeared, probably having furnished the material for the numerous varieties of granite, gneiss, and schists that compose the "core" of the most prominent range of the district. Carboniferous is represented in its older and middle members. The opportune discovery of Carboniferous fossils in limestone strata inclosed between the massive red sandstones, at three localities, has definitely settled the question as to the age of the latter. They are sufficiently characteristic in their habitat to be distinguished from the younger Triassic beds, even should palaeontological evidence be wanting. Of older Mesozoic formations but little was found, and that merely the continuation of the areas flanking the Front Range on the east. Cretaceous, *i. e.*, the lower members thereof, is well developed. During the Cretaceous period the Sangre de Cristo Range served as a very effectual barrier, preventing the waters from entering the western country beyond, and we find therefore no evidence of it in San Luis Valley on either side, and do not again meet with the formation until we reach the western slope of the Sawatch Range and the Uncompahgre group. Tertiary does not reach our district as far as it has herein been described. South of the Spanish Peak country the Post-Cretaceous is admirably well developed. Volcanic rocks cover but a small area; are of considerable interest however in the northern and middle part of the district, where their peculiar character and favorable occurrence invites study and comparison.

CHAPTER II.

SAN LUIS VALLEY.

During the years 1873 and 1874, our division of the United States Geological Survey examined and mapped the northern portion of San Luis Valley. Though much information was elicited during the progress of our work, it soon became apparent that but little could be done toward a final solution of this problem until the southern end of the valley had been explored. Numerous questions enter into consideration regarding the genesis and early condition of this depression. The work referred to above was accomplished during 1875, and we are now able to discuss the valley and its immediate surroundings as a whole. In order to present the facts that have been gathered in a clearer and more connected manner, I shall discuss the northern as well as the southern parts, at the risk, even, of repeating what may have been said with regard to the former in previous reports. Apart from the purely scientific interest inherent in the geological history of San Luis Valley, the results we have obtained have a practical bearing upon the conversion of waste land into productive soil. In order to speak positively in reference to this point, in order to demonstrate the extent of improvements thus to be made, a survey upon a larger scale than ours would be required, and it is with this prefacing remark that any suggestions are made.

Crossing Poncho Pass from the north, we enter Homan's Park, the northern end of San Luis Valley. Low, rolling bluffs present a more broken appearance of the country, which fully justifies the separation by a distinguishing name. On either side mountains of considerable altitude inclose the park. A terminal range of the Sawatch Mountains is on the west; the Sangre de Cristo Range on the east. Through the park runs San Luis Creek in a southerly direction. A short distance below the junction of this and Kerber Creek the valley proper commences. A vast expanse of level country stretches out to the southward, widening in that direction. Sand and alkali abound. All along the eastern border of the valley the Sangre de Cristo Range follows its course, culminating frequently in peaks that reach over 14,000 feet elevation. Toward the main passes that cut this range, in the vicinity of Fort Garland the valley widens considerably, and retains for some distance farther south a width of about forty miles on average. On the west the long-continued Sawatch Range, with its high volcanic regions, serves as a boundary for the valley. It falls off more steeply farther north than in the southern portion, for reasons below to be given. In the vicinity of Rios Conejos and Culebra bluffs rise in the valley to a relative altitude of 1,400 feet, which break the continuous uniformity of its level. Farther south still, the plain gradually grows more narrow, the mountains on both east and west sides approach each other, and at about north latitude 36° 45′, or fifteen miles below the southern boundary of Colorado, the valley may be considered as having come to an end.

In spite of the high surrounding mountains, San Luis Valley is not well watered. As above mentioned, San Luis Creek flows through Homan's Park, but is soon lost in the sand and gravel of the succeeding plain, except during the "rainy season." Numerous rapid mountain-streams rise in the Sangre de Cristo Range, flow but a short distance beyond the base of the mountains, and then share a like fate. A phenomenon can there—as well as at a number of other places—be observed, namely, the disappearance of streams in the morning that may have furnished an ample supply of water at any given point during the evening preceding. This is due to the cessation of the melting of snow that is contained in many crevices in the mountains whereby the creeks are fed in the day-time. Farther south, about 30 miles northwest of Fort Garland, are the San Luis Lakes, two ponds of considerable extent, but little depth, abounding with water-fowl of many species. At their shores a plentiful deposit of alkali testifies to the character of the water they contain. Going farther south, on the east side, we find streams of more importance. The range there becomes wider, and larger volumes of water flow into the valley. Ute Creek, Rio Trinchera, Rio Culebra, Rio Costilla, and Rio Colorado are of good size, and all of them carry, for a portion of the year at least, water into the Rio Grande.

On the west side of the valley we observe fewer small creeks, but more that retain their water, either during the entire or a large part of the year. Saguache Creek is the largest of the more northerly ones, flowing into San Luis Creek. South of that some small creeks leave the mountains, but find an untimely end in the sand. About north latitude, 37° 43′, the Rio Grande del Norte enters the valley, flowing first in an easterly direction, and then, after a run of about 45 miles, turning south. Piedra Pintada, Alamosa, and Conejos are tributaries of the Rio Grande, coming from the high volcanic region west of the valley. Spanish settlements occur all along these latter, as well as on those more southerly rivers on the opposite side. A feature of interest may be noticed in the courses of the Alamosa and Conejos more particularly, that seems surprising when the apparent plain through which they flow is taken into consideration. Of both these rivers, the course is at first very nearly due east, but when they have approached the Rio Grande within about 10 miles, they make a sudden turn to the northeast, and only enter that river after having flown for some distance in that direction. With this the drainage of the San Luis Valley is exhausted, and I shall proceed to the consideration of the geological formations surrounding it before entering into the discussion of such features as are shown by the valley itself. It is necessary to arrive at a full understanding of all points involved before giving those facts that have led to conclusions below to be elucidated.

Starting again on the east side from the north, we follow the course of the Sangre de Cristo Range, about 15° east of south. Metamorphic rocks compose the northern end, which are soon overlaid, however, by sedimentary strata of Carboniferous age. Near Mosco Pass these strata cover but a small area, and again metamorphic groups make their appearance. Sierra Blanca group shows these almost exclusively. In the Sangre de Cristo Pass, east of Fort Garland, Carboniferous is found and continues southward, with some interruptions, caused either by superincumbent volcanic rocks or a protrusion of the underlying metamorphic material. South of Rio Costilla trachytic rocks become predominating, and form the highest portions of the range, while metamorphic granite occupies the slopes descending into San Luis Valley. North of this river a basaltic bluff (San Pedro mesa) about 14 miles in length forms a barrier between a long narrow valley (San Pedro Valley) running along the base of the range and the eastern edge of San Luis Valley proper. This basalt is but a continuation or *vice versa* of the group in the valley upon which stations 103 to 105 are located. I mention this point here, as it will subsequently be found to be of importance. Heavy beds of coarse gravel occur north of Rio Culebra, belonging properly to the valley, but in consequece of their thickness and subsequent erosion, appearing like the last foot-hills of the range. Along the western border of the valley the mountains are but a continuation of the great volcanic area which has been discussed in part in United States Geological Survey, (Report 1874, page 103.) Trachyte and trachytic conglomerate compose the greater portion by far, and basalt, when found, is merely observed in the character of a superincumbent statum or strata. These latter become of considerable importance south of Rio Alamosa, inasmuch as they produce a gentle easterly slope of the foot-hills and descend into the valley, forming, for many miles, its level plain. Mountains and hills in the southern portion thereof are composed of the same material, and for a long distance the unbroken cover of basalt effectually prevents any insight into the structure beneath.

Comparing both absolute and relative elevations of the ranges and peaks on both sides of San Luis Valley we find that those on the eastern side are the higher ones. On average the high peaks of the Sangre de Cristo Range may be said to reach an altitude of 13,000 to 14,000 feet, and quite a number of them exceed the latter figure. Comparing this with those mountains of the west side, that are situated at about an equal distance from the edge of the valley, we observe that the eastern mountains are from 3,000 to 4,000 feet higher, on average. While the data of elevation obtained throughout the valley itself cannot but be too meager to be considered satisfactory, we are enabled to say, that its western side, near the mountains, is higher than the corresponding one on the east. These facts become important in the question of the transportation of geological material within the boundaries of the valley, and are therefore here briefly alluded to. It seems natural, of course, that we should find collected in San Luis Valley specimens representing all the formations above given as forming the mountainous regions surrounding it. Drainage heading in any one stratum might carry bowlders and pebbles into the valley, thus leaving us a safe guide whereby to recognize the former courses of rivers and streams. Attrition, however, has reduced the size of these bowlders and pebbles to such small dimensions that but little if any satisfaction can be gained therefrom. So far as I have been able to see, it is only the distribution of one specific kind of sand or gravel over any given locality that is of importance in unravelling the geological history of this vast valley. In the subsequent pages this view will be maintained, and the reasons given more fully therefor, besides the deductions arrived at from the observation of such specific distribution.

North of the Rio Grande, San Luis Valley presents an unbroken plain, slightly depressed in the center, rising more on the west than on the east side. Sand covers the entire expanse. Near San Luis Lakes the progress of vegetation, together with the action of moisture, has been productive of soil. Should a similar process be applicable to other portions, the same desirable result would probably accrue. Approaching the western border of the valley bowlders of volcanic rocks—mainly trachyte and some basalt—may be observed, but they extend only a short distance downward from the foot-hills. Analogous to this we find on the east side specimens representing the formations of the Sangre de Cristo Range, but they, too, cease as soon as the valley is fairly reached. At the western entrance of Mosco Pass there is a large accumulation of fine sand in the shape of "dunes."* Upon examination it was found that this sand owed its existence to the western range, fully fifty miles distant. It is accounted for, however, by the fact of the sand having been blown there, thus covering the drift that would naturally be expected to present itself, in that case drift from the Sangre de Cristo. These "dunes" seem to be of comparatively recent date, geologically speaking, and belong to the Post-Glacial age. North of the Rio Grande no evidence was found, indicating positively the former presence of glaciers, though it seems to me possible that such evidence may still be discovered. Taking sand from the central portion of the valley, it was seen that it is composed in part by the feldspars (the only mineral there which can lead to a decision) of the volcanic region of the west, as well as from the metamorphic rocks on the east side. Sanidite, orthoclase, and oligoclase were found in such quantities that it would be impossible to determine which of the two groups furnished the greater portion of the material. One orographic feature observed very frequently north of Del Norte deserves mention. The western mountain country has broken into "bluff country," and continues as such eastward to the edge of San Luis Valley. The last outposts of the foot-hills appear, viewed from above, very much like islands in a sea of sand and pebbles. I state this to illustrate the evidently very even distribution of these latter materials, as regards relative elevation. Piñons covering the knolls, but wanting below them, tend to increase the similarity of the picture.

Far more varied and interesting do we find the character of the valley south and west of the Rio Grande. For about fifteen miles south of del Norte the features of the valley-border change but little. The same bluffs are there, showing the same island-like appearance. Station 14, there located, shows a capping of basalt. Though not more than 40 feet in thickness at some places, it was found to be of the same character, lithologically, as that farther south, which occurs in such large quantities. A short distance north of Rio Alamosa the continuous area of basalt sets in, and is found southward on the west side of the valley as far as our explorations were extended (north latitude 36° 45′). From that first point just mentioned basalt caps the trachorheïtes of the main range, and sloping eastward gently, forms the bottom of that portion of San Luis Valley. On the higher portions of the foot-hills it is found merely as a capping, while the streams flowing eastward have their beds in trachyte or trachytic conglomerate. Isolated points beyond the foot-hills testify to subsequent eruptions of the same material, and afford good locations for topographical stations. It may be observed that at these points the regular stratification, so noticeable elsewhere, can no longer be traced. Although it seems that the flows from such eruptions have extended but a short distance, their existence can easily be recognized, not only from the lithological constitution of their material, but also from the evidently secondary positions they occupy with reference to the underlying basalt. Crossing the Rios La Jara, Conejos, and San Antonio we find that but very little soil covers the volcanic rock. Although this feature is frequently regarded as indicative of late geological age, I cannot entirely accept this view. We know of no more powerful

* Report United States Geological and Geographical Survey, 1875, page 333.

agent in the decomposition and disintegration of rocks than the aid of growing vegetation. The action in this instance is not merely a physical but also a chemical one, and although atmospheric influence is not to be undervalued, I have come to the conclusion that the comparatively "fresh" appearance at this locality is due mainly to the absence of densely distributed vegetation. Besides the fact that rocks constituted as basalt is, form soil but very slowly, it is not to be overlooked that the scarcity of water will retard the growth of plants very much, so that the rock has a double chance of retaining its original physical and chemical character. Having crossed Rio San Antonio, we stand at the base of Mount San Antonio, 10,883 feet above sea-level. A dome-shaped peak rises 2,000 feet above the valley and is composed entirely of basalt and melaphyr.

This peak is one of the main points of outflow, and has sent its lava in regular flows in every direction, more particularly toward the west and south, however. Having alluded to this we come to the consideration of an important point. Does the basalt capping the trachytes of the foothills on the west side of San Luis come from the west or east? My opinion inclines toward the latter view. Although the entire slope of this basalt is *from* west to east, at an angle of 2° to 8°, I have reasons to assert that an uplift—very gradual—took place a little west of the central line of that plateau range, and that the present position of the volcanic strata is accounted for thereby. (See chapter III.) So far as could be observed, there is either none or very little difference both in constitution and mode of occurrence in the basalts existing along the western border of San Luis Valley. An exception, however, is found at the isolated hills denoting a local outflow, which among themselves are very similar. South of Mount San Antonio are a number of low basaltic bluffs, which I did not visit personally, but from their position regard them as remnants of subsequent flows from the original point of eruption. Their present shape may be owing partly to rupture, partly to erosion.

Entering San Luis Valley from the western mountains, the streams run through almost inaccessible, narrow cañons in the basalt. Farther up-stream, near their headwaters, in the trachyte, they show the same phenomenon, although the causes are different. As is shown in chapter III, evidences were found at the headwaters of Rio Conejos and its tributaries of very extensive glaciers. These latter moved along the sloping plane of the elevated plateau until they reached, farther eastward, the readily yielding trachytic conglomerate, and there cut in deeply. Although it is possible that these glaciers extended down-stream for some distance, I have found no proof of their having reached the valley proper. No erratic bowlders of trachyte, no morainal deposits, and no striation of rocks appear in the valley itself. Entering one of the basaltic cañons, that of Rio San Antonio for instance, it will be seen that the basalt is deposited in regular layers, from 4 to 20 feet in thickness. Vertical walls inclose either the creek-bed or the narrow valley, reaching more than 100 feet in height. The creek itself flows over basaltic bowlders, that do not seem to be *in positu*, but to have fallen from the sides. Comparing the single layers of the two cañon-walls, they will be found to correspond perfectly. It seems to me, therefore, that in the absence of any extensive aqueous erosion, considering the narrow width of the cañon, and the constancy of stratigraphical relations, these cañons were formed by rupture. As the most effective and plausible cause producing this effect, I regard volcanic earthquakes. It seems no more than reasonable to suppose, in view of the experience of our present age, that volcanic eruptions of such magnitude as those we here observe must have been preceded, accompanied, and followed by volcanic earthquakes. And again, the observations during the present century have shown us results therefrom that compare admirably with those noticed in San Luis Valley. I regard it as ill-advised to explain the presence of the cañons or "cracks" in any other way, though the theory of contraction upon cooling of the material might produce analogous results. Some of the river-bottoms are much broader than that of the San Antonio, broad enough to contain human habitations and small "farms." This is probably due in part to the gradual erosion of the vertical walls, which, slowly receding, increased the distance between each other, and furnished material for the formation of silt and soil.

Quite a considerable area is covered by this basalt; northward it extends to Rio Alamosa, reaching that river opposite station 101. From there its boundary runs in a southeasterly direction, crossing Rio Conejos about 25 miles above its junction with the Grande. Ten miles north of Ute Peak (station 107) it crosses the Rio Grande, and from there continues southward, including Ute Peak and the lower hills near the Rio Colorado. Between Rio Conejos, after it has changed its course into a northeasterly one, and the Rio Grande, there are a number of table shaped bluffs, rising to a relative elevation of 1,400 feet (9,200 feet above sea-level). They are composed of black, vesicular basalt, the strata of which show a general westerly dip of a few degrees. A number of small knolls are located nearer the Conejos, separated from each other by an accumulation of diluvial or alluvial deposits. Near the Rio Grande, however, basalt is no longer the only material building up the bluffs. Trachyte forms the lower portion, while the former shows itself as a capping of the higher portions. Station 105 is located on one of these trachytic hills, west of the river, about 400 feet above it. At this point the trachyte crosses the Rio Grande, extending itself in a row of bluffs for about eight miles to the northeast. Here, too, the highest portions are capped by basalt, black and vesicular. Trachyte, from station 105, shows a partly crystalline, partly amorphous paste, which contains small crystals of a black biotite, crystals of a colorless sanidite, reaching a length of 5 millimeters, and dark-green portions, probably chloritic. Its color is a dark, dull greyish-brown, becoming a little lighter upon weathering than on the fresh fracture. It is a very compact rock, producing, almost, the impression as if cooled under heavy pressure.

Following from there down the Rio Grande, we pass for about 10 miles through fine drift-sand, containing occasionally a small patch of pebbles, but as soon as the basalt is reached the river cañons, and its bottom is no longer accessible to either man or beast. The same can be said of Rio Costilla, which empties into Rio Grande opposite the north side of Ute Peak. Again, the same characteristics that have been given when speaking of the San Antonio hold good. Great regularity of the cañon-walls, identity of the strata opposite each other, no evidence of the cañon's having been produced by erosion, and no certainty as to whether the rivers flow over basalt *in positu*. Ute Peak, similar in shape to Mount San Antonio, rises 2,200 feet above the valley to an altitude of 9,664 feet. It is composed entirely of basalt, which shows varieties similar to those from San Antonio, the black vesicular one predominating. Following from Ute Peak southward along the edge of the basalt, we find it bordered by drift-sand, partly of metamorphic, but mainly of volcanic origin. Commencing a little north of Rio Colorado, and traveling northward along the eastern edge of San Luis Valley, it will be observed that metamorphic granite and some schist rocks compose the base of the foot-hills, very nearly as far up as to the point where Rio Costilla leaves the mountains. Having crossed this river, the San Pedro Mesa, a basaltic table, which has been mentioned above, is reached. East of it is an equally long, narrow valley, having a drift-bottom, and containing several Mexican settlements. This table continues, striking nearly north until it reaches Rio Culebra, a large branch of which follows along the inclosed valley. At the entrances of most of the streams into the valley may be found large deposits of bowlders and pebbles, located in such a way as to obstruct the direct passage of the water, thus forcing it to turn either to the right or to the left. Rocks composing the foot-hills are most frequently met with in this drift.

Having given an idea of the distribution of the volcanic formations in San Luis Valley, it becomes incumbent to consider their correlation. Trachyte is the older of the two volcanic rocks under discussion. It is possible that the trachytic group, through the center of which the Rio Grande finds its way, may be but a remnant of the great mass 30 to 40 miles farther west. It seems difficult, however, in case this view should be maintained, to account for the disappearance of all that enormous mass of material that must have formed the connection between the two. East of the group there is the trachytic mass of station 114 continuing in the San Pedro mesa, where it underlies basalt. It seems highly probable, therefore, that at one time the two were in connection. I regard this outcrop as the continuation of the eastern trachytic area, the connection between the two having been broken. From the points mentioned, the flows extended principally in a southwesterly direction. It is, to a certain extent, different with the basalt. We have two mountains, San Antonio and Ute, situated but a short distance from each other, both presenting a very similar appearance, and both composed of the same volcanic material. We have, furthermore, the uniform flow of basaltic lava west and northwest of these two mountains, and have isolated patches of it to the north and northeast. Probably a considerable area is covered by it farther south, but our explorations did not take us there. Comparing the altitudes of San Antonio, Ute, and the basaltic plateau of station 104, we find the difference between Antonio and Ute, 1,219 feet, and between Ute and station 104, 516 feet, the last named being about 1,500 feet above the valley there. Assuming that we regard Ute and Antonio as the two main points of outflow for that immediate region, we have a thickness of 1,500 feet of volcanic rocks to account for in the neighborhood of Ute. In speaking of the 104 plateau above, the general westerly dip has to be noticed, while the basalt, forming the western side of the valley, dips a little north of east. Adding to this former dip the fact that the eastern boundary of the basalt closely follows a straight line nearly south of station 104; adding, furthermore, that with the exception of the basalt between Rios Costilla and Culebra, none was found, I have arrived at the conclusion that, at the time of the basaltic eruption, the westerly dip of the older volcanics in question did already exist, and that its existence caused an almost complete cessation of the flow toward the east. The one exception to it is San Pedro mesa, which was probably formed by an arm of the flowing lava extending from the southwest. Neither San Antonio nor Ute show any craters on their summits, in evidence that the eruption was a massive one. To this species we are by far more accustomed in Southern Colorado than to any other.

The influence of the dip of the basalt can be readily observed in the course of the Rio Conejos. Flowing first in an easterly direction, after leaving the mountains, the river suddenly bends to the northeast and joins the Grande north of the trachytic and basaltic group. Being forced to abandon its flow toward the east by the dip of the volcanic strata, and being prevented from turning south by the northeasterly dip of the basalt through which it had flown down, the only course remaining open was that to the northeast. A glance at the map will show the curious course of the river, while but eight miles distant from it the Rio Grande flows in precisely the opposite direction. A cañon in which the Rio Grande flows has been alluded to above, and the same origin has been claimed for it as for that of the San Antonio. Judging from the direction of the cracks and cañons in the basalt, it may be inferred that the seismic action originated in the immediate vicinity of Ute Peak. Evidences of former river-courses are to be found near the Rio Grande and near the Culebra. This led to a more careful investigation of the previous condition of that as well as the remaining portions of San Luis Valley. Although the results obtained might have been presented in more detail and with more accuracy had time permitted, I trust that at some future time we may be able to verify them by means of surveys on such a scale as to leave no room for doubt.

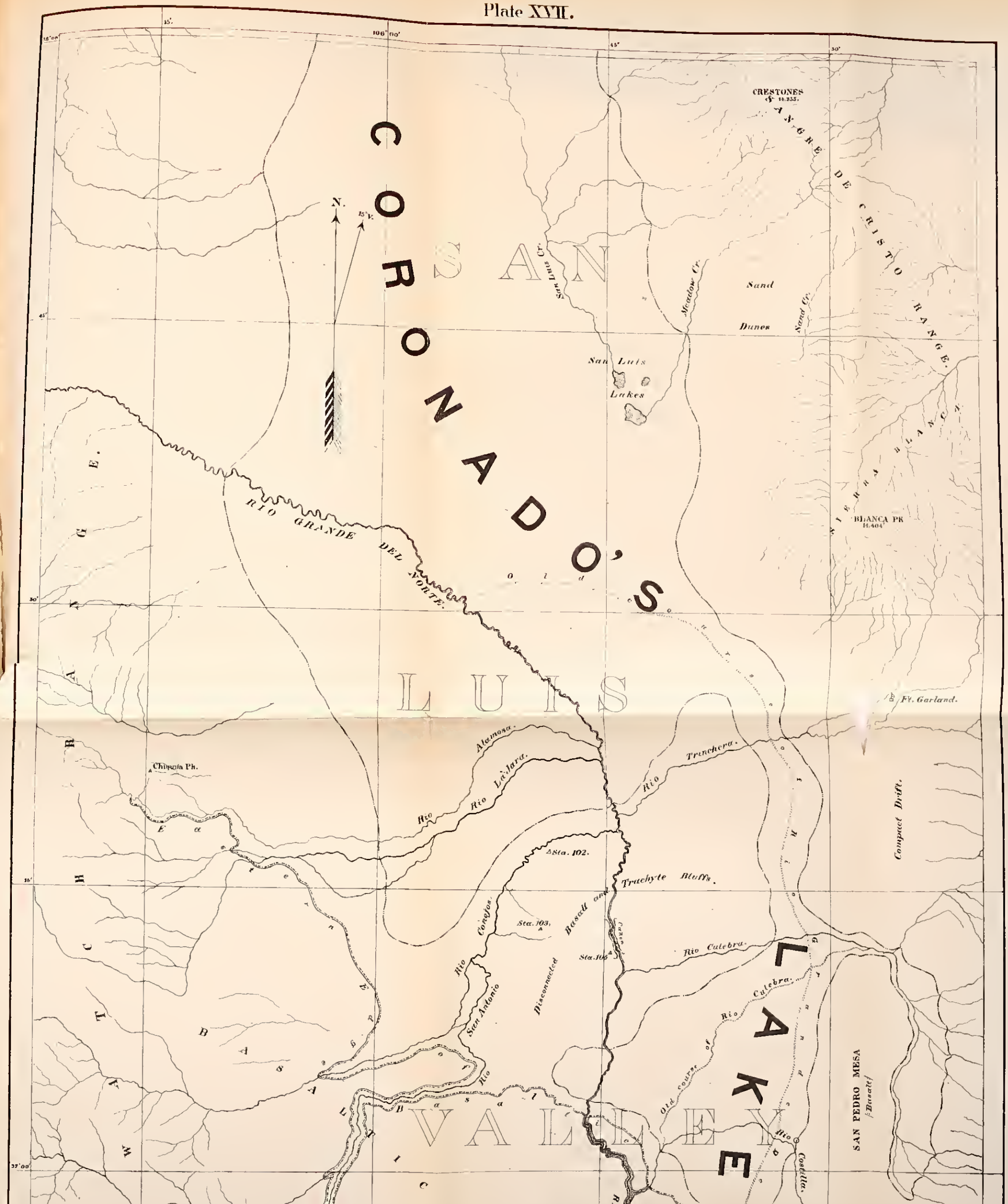
Regarding the physical condition of the surface of San Luis Valley, it can appropriately be divided into three groups: 1, the fine sand-drift; 2, the local drift along the edges of the valley; and, 3, that area upon which basalt is exposed. Of the first group we find two large areas; the *northern* one commencing north of San Luis lakes, extending both east and west, to within a short distance of the inclosing ranges, and finding its southern terminus a short distance below the junction of the Conejos with the Rio Grande. From there it extends eastward and connects, about fourteen miles west of station 105, with the *southern* sand-drift region. This fills the flat valley lying between the San Pedro mesa and the plateau of station 104. It ends about eight miles below Ute Peak. Of the second group but little needs be said, as it is determined by the number and rapidity of mountain-streams that may be found all along the edge of the valley. Basalt, as already stated, has produced but little soil in the valley, save in the immediate neighborhood of streams. It is covered by sand at all those points where the two meet.

Judging from the evident deflection of rivers, the failure of mountain-streams to carry specimens of the rocks through which they pass into the valley for any distance, the deposition in banks of the material that many streams bring with them, and the cañoned outlet of the Rio Grande, I have come to the conclusion that at one time San Luis Valley was covered by two large lakes, the northern and the southern. These I have named, in order to facilitate discussion, Coronado's Lakes. Of these the former covered about 1,400 square miles; the latter 300 square miles. I have alluded to the cañon near station 105, cut through the trachyte. It is about three miles in length, and its general direction is perfectly straight. In case that narrow passage, which I assume to have been opened by seismic force, should be closed to-day, the result would be an accumulation of water in the northern half of San Luis Valley, the formation of a lake. This lake would reach a certain depth of water, consequently increase in area until the slight rise southwest of Fort Garland would be overcome, and it would then flow over into the southern region of the sand-drift, the lowest portion of the valley there. No outlet would be formed on the western side of San Luis Valley, on account of the rise produced by the dipping (northeast) of the basalt strata. It seems to me that the presence of the sand-drift areas at the very localities where at present lakes could be produced argues strongly for the correctness of the view that such lakes have existed there in former times. At the time of the existence of these lakes the inflowing streams that often carry considerable quantities of water lost their impetus upon reaching the placid sheet, and thus were unable to transport for any distance the rocky material they had so far brought with them. Instead of flowing out of San Luis Valley through the cañon, the Rio Grande found its exit about eight miles farther east, through the opening which leads down to the Rio Grande Valley. It may seem curious that no heavy deposits of alkali or old "shore-lines" mark the presence of these ancient lakes. If, however, the assumption that the Grande found a sudden egress through the deep fissure produced by a volcanic earthquake is true, there is no reason why the waters should not have flown off by far too rapidly to permit of the formation of either. Rio Culebra, after the emersion of the land, followed a southwesterly course, and, joining with the Costilla near the entrance of the cañon, flowed into the Rio Grande. Subsequently this was changed, and the Culebra now flows nearly due west, entering the Rio Grande just below station 105, about 14 miles farther north. An accompanying map will demonstrate the former condition of San Luis Valley and the changes that have there taken place by far better than could be done by description alone. Were it possible to make a survey during which all the contours were accurately measured, I doubt not that the old boundaries of the lakes could be by far better determined than it has been possible to do at present.

Upon the consideration of the Glacial period in this section of Southern Colorado the presence of these lakes has a direct bearing. In case they still existed at that time, and there is no reason why they should not, the increased evaporation, the dependent, greater precipitation, and a decreased mean annual temperature, would all act as favorable agents to the formation and perpetuation of fields of ice. I do not mean to say that this particular presence of lakes was the sole cause of the existence of glaciers not very distant, but I do mean to say that it aided their growth and progress. On the other hand, in case these lakes were drained, glaciers, but a short distance off, would have lost a considerable supply of moisture, and probably the mean annual temperature of immediate surroundings would have increased perceptibly. Certain it is that the time of the existence and disappearance of the San Luis Valley lakes must fall mainly into the Post-Basaltic period, and I think that naming a time near the close of the glacial epoch in Southern Colorado will be very near the actual time of the formation of the basaltic fissure through which the two lakes were drained. In Appendix A, the former glaciers of Southern Colorado and the time of their existence are more fully discussed.

While exploring San Luis Valley north of north latitude 37° 30′, it was impossible to come to any satisfactory conclusions with regard to its condition in former geological periods, and it was not until the southeastern corner was reached that the sand and rocks could interpret their meaning intelligibly. Analogous cases to the one just considered we have in Nevada and Southern California, besides their being observed in other countries outside of our own. It is to be regretted that no animal remains could be found in the sand, that would have settled the question more positively, but it is highly probable that the lakes were alkaline, although fed by many fresh mountain-streams. The altitudes given on the map will convey some idea of the uniformity of elevation which may be observed throughout San Luis Valley.

Plate XVII.



AM. PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNES PROCESS)

Meager as they are, they tend to show the effect of either one or the other kind of causes operating throughout the valley. Of interest is the very gradual and even descent as shown in that region where the basaltic strata dip from the southwest.

Professor Stevenson * says: "The general characteristics of San Luis Valley show beyond a doubt that this whole region, as far south as the New Mexico border, and as far north as the head of San Luis River, was at one time occupied by a great fresh-water lake covering an area of several thousand square miles and fed by streams coming from the mountain glaciers." Essentially this statement agrees with my own observations, but it is a rather general one. As regards extent I cannot perfectly agree with Professor Stevenson, but have laid down the boundaries of my lake area so as to make it smaller than it would appear from his publication. Precisely upon what the assumptions justifying the supposition of an ancient lake are based, is not stated, save that "general characteristics" be regarded as such. So far as I am able to determine, the physical character of the drift and its very uniform distribution over certain areas, each area containing drift of specific nature, furnishes the only criterion for decision. Professor Stevenson mentions "terraces" as existing in San Luis Valley, but I am unable to agree with him on that point. It is true that slight undulations occur, but they have neither the character of terraces of erosion, nor that of terraces deposited by receding water.

On the east side of San Luis Valley we find a very interesting group of drift, that has already been mentioned in chapter I. It is the drift that I have designated as "compact." Bluffs of considerable relative elevation are composed of numerous bowlders of all sizes. Sand or clay cements them, either loosely or more firmly. Two of our stations were located upon these bluffs. Nearly all the drift in the valleys immediately adjoining owes its origin to a comparatively rapid denudation of these hills. No doubt this formation could—if studied sufficiently in detail—furnish a clew as to the early formation of San Luis Valley, and, with a view to this object, the drift in question will be more fully discussed in Appendix A, when treating of the glacial phenomena in Southern Colorado.

Along the streams in San Luis Valley, agricultural pursuits are engaged in by Americans and Mexicans, the latter more particularly in the southern portion. Owing to the dry nature of the soil, irrigation is required, and thereby many acres have been reclaimed. Near the base of station 104 plateau, a number of very fine springs are found, and meadows receive their water from them. The general elevation of the valley is such that most of the cereals, potatoes, and corn will yield good crops. What the result of forming a small lake near the center of the valley might be, can be deduced from the trials and experiments made elsewhere. As soon as moisture enters the soil, and the most superficial sand is either removed or mixed with the underlying stratum, there is no reason why not rich crops should reward the farmer. Wherever farming is carried on in the valley with any system and industry, and where there is no lack of water, the results are satisfactory. The supply that can be obtained from the streams there is adequate to but a very small portion of the entire valley. More water is consumed here than perhaps at many other places, for irrigating purposes, on account of the character of the soil, which necessitates great waste.

* Report of the Geographical and Geological Explorations West of the One Hundredth Meridian, vol. iii, 1875, p. 462.

CHAPTER III.

THE SAWATCH RANGE.

In this chapter the Sawatch Range shall be considered. Topographically this may be considered as a portion of the San Juan Mountains. It will include all the headwaters of the rivers Pinos, Piedra, San Juan, Blanco, Navajo, and Chama. The division of the entire district has been made in this way for the sake of convenience. We have for consideration this range, which mainly consists of one geological formation and on its western slopes the upper valleys of the rivers mentioned composed of sedimentary beds. Thus both description and classification will be facilitated and a more uniform field will be left for the discussion of the San Juan River region in Chapter IV. Although this chapter will cover quite a considerable area, the formations found represented herein are very simple in their character, presenting but few points of special interest, and the stratigraphy of the sedimentary beds shows scarcely any variation. We are, in this region, gradually approaching the great stretches of similar or identical formations that characterize the southwestern portion of the United States. As has correctly been said, "America is the country of big trees and of widely extended geological formations." A few points of special interest were observed, but the general interest lies, in this district, in the correlation of the groups with contiguous ones.

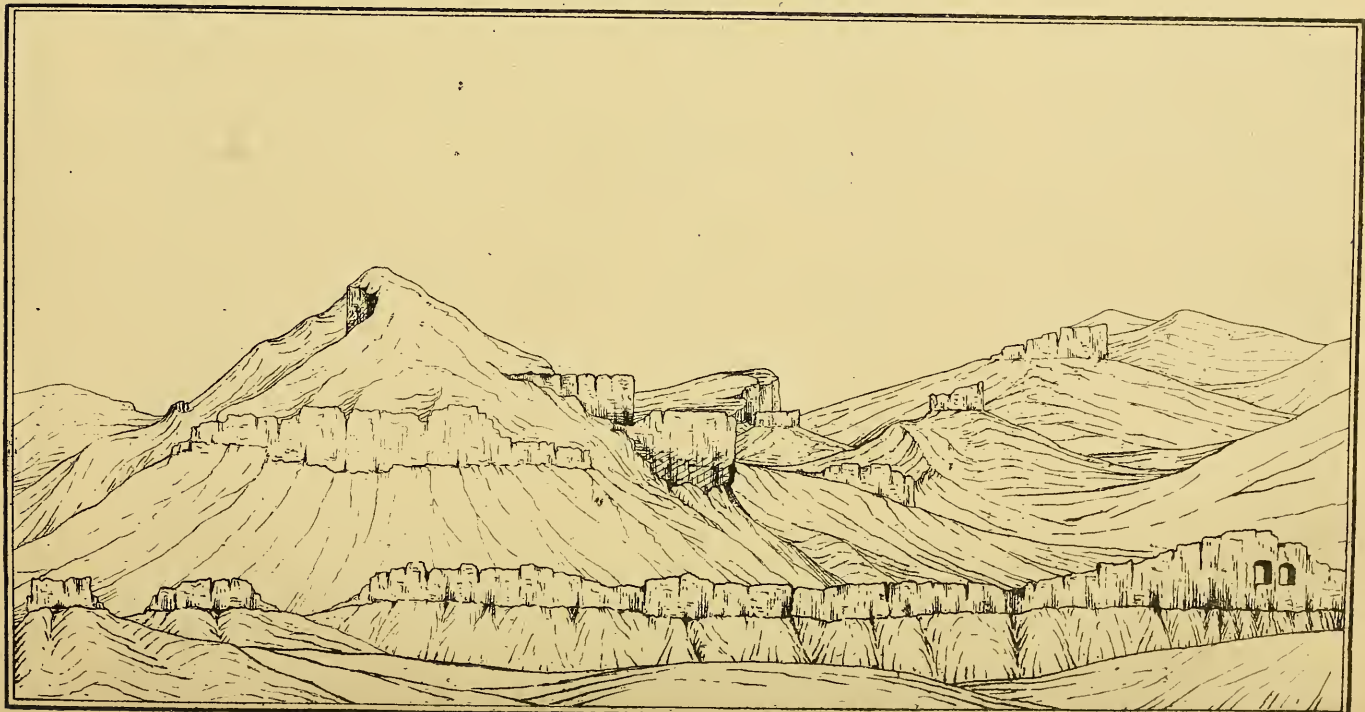
On the west side of San Luis Valley rises the Sawatch Range, or rather its southern continuation. North of Del Norte, the mountains show steep slopes and reach high altitudes, while some distance south of that town the upward slope is by far more gradual. Bluffs with vertical faces form the transition between the high mountains and the valley on the north side, but on the south the valley itself seems gradually to slope upward until the high peaks in the background are reached. Traveling up the Rio Grande everything we see around us is volcanic to the very head of the river, excepting one small sedimentary area below Bristol Head. Bluff after bluff we pass, while the mountains remain in the distance. Broad valleys are found along the river, and again cañons, passable only for pack-animals. Steep walls on either side inclose the swift stream that receives a constant supply of fresh, clear water from the adjacent mountains. Settlements have been made in a number of the valleys through which the river winds its serpentine course, and stores have been established for the accommodation of the numerous prospectors and miners entering the well-known mining districts of the San Juan country by that route. A good wagon-road leads beyond Pole Creek, leaving the river only where it is demanded by the serious obstacle of a cañon. Piñons and cedars cover the low bluffs near San Luis Valley, but farther up the river dense timber is found on the surrounding hills and mountains. Aspen, spruce, and fir, contrasting in their colors, lend life and variety to the dark-colored rocks exposed on bluffs and mountain sides. Above the great bend in the Rio Grande, just south of Bristol Head, Antelope Park is located. This little valley contains a small settlement known as San Juan City, and presents a pleasing change from the high walls that inclose the river directly above. In the report of 1874 the region from here upward has been discussed, so that the portion remaining for this chapter is below the park in question, and all that region south of the Rio Grande. Although the Sawatch Mountains here present more the appearance of a very large plateau, studded with isolated peaks, its gradual narrowing toward the south preserves for it the character of a range. On the west side it falls off very steeply into the beautiful valleys of those rivers that form the main drainage of the San Juan. Rocky slopes, with deeply-cut cañons separating them, present a bold front when viewed from the west, and give from there the impression of an exceedingly rugged range of high mountains instead of a plateau.

By the Sawatch Range the continental divide is formed, running here in a direction approximating northwest to southeast. Owing to the plateau-like character, the divide makes many small turns and curves, which would be avoided had we before us a continuous sharp range with a well-defined crest. As usual, a number of stations were located on peaks occurring along the line of the water-shed, because there generally we find prominent points that command good views of the surrounding country. Stations 35, 28, 21, 20, 19, 87, 84, 81, 63, and 62 are all on the divide, beginning in their enumeration from the north. On the summit of the plateau swamps abound above timber-line, owing their existence to the unbroken continuation of the underlying strata. They greatly impede progress for animals and men, but form a delightful abode for the millions of mosquitoes that were there encountered. Grassy slopes are frequently met with; also those broad expanses of rock-fragments that German geologists so characteristically term "*Felsenmeer*" (ocean of rocks). From these latter the peaks rise, presenting, however, less steep outlines than those formed by the same volcanic material farther west in the district of 1874. Steep edges of the plateau afford good stations, as they permit extensive views into the country lying below them. They are frequent in occurrence, owing their existence either to erosion and subsequent "drops," or to the latter alone. With the exception of some small outcrops of metamorphic rocks in the south, the entire Sawatch Range, so far as belonging in this chapter, contains nothing but volcanic formations, and their boundaries define those of the range. In the latter head a number of large streams, flowing partly into the Rio Grande, partly into the San Juan, the Pacific drainage. Beginning in the south on the eastern side of the range we find Rio San Antonio, which, flowing in a direction north of east, joins Rio Conejos. This latter heads near station 19, flows first northeast, then makes a sudden turn to the south, reverting again to its original course after reaching San Luis Valley, in which it joins the Rio Grande near station 102. Rio Alamosa also starts near station 19, and flows into the Rio Grande. Rio San Francisco heads at station 18, and, after a northeasterly course, reaches the Rio Grande below Del Norte. All these streams leave the mountains and flow for a distance through San Luis Valley, while the remainder of the Rio Grande drainage remains within the borders of the mountainous country. The main branch of the river is the South Fork, heading near station 20, and joining the river about sixteen miles in a straight line above Del Norte. Hot Springs Creek starts from station 28, and, flowing about north, empties into the Rio Grande at Wagon-wheel Gap. South River joins it opposite station 27.

Besides these more prominent streams, there are a large number of smaller creeks that carry their water into the river both from the north and south. Local names have been given to some of them by the settlers, denoting their appreciation of zoölogical science. Trout, deer, elk, grouse, gopher, owl, and other animals have been brought into requisition to supply appellations for creeks that are important only perhaps as landmarks, indicating the boundaries of landed property. Traveling up one of the small tributaries we cross Weeminuche Pass, 10,670 feet above sea-level, and find ourselves on Pacific drainage, at the headwaters of Rio Piedra tributaries, on a creek that we have named Weeminuche Creek. From there, in a southeasterly direction, to Pagosa Peak (station 38), the streams issuing in deep cañons from the range, belong to the drainage of the Piedra. Beautifully clear waters, cold from the melting snow of the high pleateau, all join near station 40 and form the swift Piedra, that carries its water for 40 miles farther southward into the San Juan at station 67. Rio Nutria, one of its main branches, heads just south of the Pagosa Peak. From this mountain southward, all the streams flow into the San Juan after but a short run. The San Juan itself heads near station 19, and making one of the curves that are so characteristic of volcanic countries of this character, leaves the mountains about 12 miles southeast of Pagosa Peak. Its main tributaries are Rio Blanco and Rio Navajo. Of these the former heads near station 19, enters the lower country opposite station 77, and joins the San Juan at station 74. Its name is appropriately given, for the whitish shales and marly clays it passes through impart to the water a color that somewhat resembles that which an admixture of white paint would produce. Rio Navajo is longer than Blanco, and carries more water. It rises northwest of station 87, in the mountains, and flowing first in a southerly direction through a narrow valley, suddenly, upon emerging from the mountains, makes a sharp turn of 90° to the west. After following a general westerly course, with several bends north and south, it enters the San Juan near station 72. Its southern drainage is quite extensive, though many of the creeks do not reach the Navajo during the dry season. Recrossing the continental divide near station 62, we are once more on the Atlantic side, and find here the drainage of the Rio Chama. This stream heads immediately south of station 84, and flows through a narrow, glacial valley into the open country due south. In this latter is the settlement of Tierra Amarilla, with its three towns, Ojos, Puenta, and Nutritas. Near the latter Rio Brazos, coming eastward out of the mountains, flows into the Chama. Both streams carry a considerable amount of water, and are utilized for purposes of irrigation. The settlement there is a thriving one, composed entirely of Mexicans, while a few Americans own the stores and hold the Indian agency there established. Agricultural pursuits and the raising of sheep and cattle speak well for the generally indolent character of that class of settlers.

Immediately at the base of the mountains, all these streams just mentioned enter rich valleys. Tall pine timber covers the low ridges, separating them, while meadows covered with excellent grass are found near the water. The elevation is such as to produce a delightful climate, made all the more so on account of the sheltered position of these valleys. On the Piedra, particularly, the country seems to offer every possible inducement to settlers, with the one exception, the presence of Indians. They still hold the land, and full well knowing its value, they jealously guard against the advent of strangers, convinced that the ingress of but a few, even, would soon be followed by an irresistible immigration. To use the picturesque language of one of our western companions, this region is the "Land of the Gods." Similar to this in character are the

Plate XVIII.



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

upper valleys of the streams farther south, after they have left the mountains. Almost the entire valleys in question are located in Lower Cretaceous beds. In order to facilitate description, the rivers of the various regions of the range will be discussed and the variations in formations or local phenomena of importance or interest be mentioned.

A.—Rio Grande drainage.

Ascending this river from its entrance into San Luis Valley at Del Norte and Loma, we find trachytic formations on either side. North of the river the bluffs gradually decrease in height as they approach the valley. Trachyte, or a conglomerate composed of trachytic material, forms them. A decided dip eastward of 3° to 6° is noticeable in the strata or flows, and on that side the bluffs slope into the intervening valleys and into San Luis gently, without many breaks. Facing them from the west, however, this is changed. A sketch made from station 11, looking east, is here given, which illustrates the character of the bluffs. On the west side steep, vertical walls of the brown trachyte are presented near the summits of the hills, some of them showing precipices a thousand feet in height. These walls, inaccessible from the west, except where a break may occur, often stretch for considerable distance in the direction north to south. Small caves and arches are formed by erosion and decomposition in them, and the *débris* from their faces covers the narrow valleys in between. Covered by piñons and cedars, they sometimes still show grassy slopes that prove to be an acceptable pasture for the sheep-herds of the neighboring settlers. Owing to the loose nature of the soil and gravel in the valleys, water is at certain seasons of the year rarely to be found. Springs occur near the bases of some of the bluffs, but run only a short distance. Combined with the easterly dip is one toward the south, produced by a concave curvature of the volcanic strata. This latter is at right-angles to the course of the river; its strike therefore is parallel with it. Correspondingly we find a northerly dip south of the Rio Grande. Thus a shallow synclinal fold is formed, in the axis of which the river finds its course. This accounts for the almost straight line followed by it for nearly fifteen miles. Comparing the trachytic strata of this vicinity with those farther west in the mountains, it will be found that they correspond with No. 3, though they appear to have lost in thickness. Station 11 is 10,460 feet high, while Del Norte, nearly due south of it, is about 8,000 feet above sea-level. Farther toward the northwest the mountains get higher, so that station 26 is located at an elevation of 13,711 feet. Here the character of the volcanic rocks corresponds closely to that observed in the 1874 district.

Following up the river we pass station 56 of 1874, which is located on an isolated outcrop of blue Carboniferous sandstone. So far as could be determined, there are several disconnected outcrops of the same rock on either side of the Rio Grande. They have probably been brought "to day" by denudation. Trachyte surrounds them on all sides, and covers their extension toward the south. It was expected that their continuation would be found on the western edge of the volcanic area, but this was not verified. Although the outcrops are very small, occurring merely along the lower ridge, running parallel with the river, they are sufficiently characteristic to admit of recognition. This is the only instance where, in the volcanic district of 1875, unchanged sedimentary beds were found protruding through the superincumbent trachytic beds. It argues, inasmuch as the case is so isolated, for the assumption that the general configuration of country was already a varied one at the time of the trachytic eruptions. In 1874 an analogous case was observed at the head Cunningham Gulch, where limestones, probably of Devonian age, occurred in a single outcrop, overlying metamorphic schists, covered by trachyte No. 4. No fossils were found on station 56 of 1874; but the characteristic chalcedonic concretions occurred that indicate locally the age of the stratum. At the eastern end of the great Horseshoe Bend in the Rio Grande is Wagon-wheel Gap, generally only called the Gap. This is a vertical rent in the trachyte, that there formed a narrow ridge, running north and south. Formerly, before this passage was effected, the river flowed around the place, making a curve to the southward, and probably formed a lake west of it. Vertical walls, about 800 feet in height, now inclose the Rio Grande, which so nearly fills the gap produced, that room is left on either side of it only for a wagon-road. The north wall is the higher one of the two, measuring about 1,200 feet. From there the mountain or former ridge slopes upward, until it culminates in the summit upon which station 25 was located, at an elevation of 10,279 feet, 2,000 feet above the river. The trachyte here belongs to No. 2 upper, and shows on either side columnar structure, which no doubt facilitated the rupture, that cannot otherwise have been formed than by violent demonstration of force. Whether this force was seismic, however, or whether more gradually-acting agents were employed, I am unable to decide. Indians utilized the southern hill as a point of "lookout." A long, low wall runs along its entire northern edge, and round towers, two to five feet high, are placed along it at different intervals. Walls on the south afforded protection against any one advancing up the gentle slope from that direction.

The fortifications are well conceived, and the locality chosen with judgment. Numerous fragments of chalcedony and jasper, occurring in the trachyte of No. 2, furnished material for the manufacture of arrow and spear heads, a number of which were found in the old stronghold. Mr. Wilson found one arrow-head of obsidian, which certainly was never obtained from any locality in Colorado, but must have come from New Mexico, or even farther south. Joining the Rio Grande, immediately below the gap is Hot Springs Creek, which heads on the northeast side of station 28. This name has been given to the stream from the occurrence of several hot springs there, within a mile of its junction with the river. Three springs are there, all situated but a short distance from the creek, one on the west, two on the east side. One of them, the largest, has been led into a bathing-house, and the water there shows a temperature of 105° F. The observations as to temperature were made July 4, 1875, 7 p. m. A short distance above the house is the spring itself. It is contained in a natural basin, oval in shape, measuring 11 feet by 7, along its two axes. Here the temperature of the water is 131° F. Bubbling up from the center, carbonic-acid gas and sulphureted hydrogen escape in great volume, while the mineral constituents, carbonates of lime, soda, and potash, are either deposited on the bottom, or aid in building up the rim of the basin that confines the spring. Some iron is also in solution. At the base of a low bluff the upper spring issues, showing a temperature of 122° F. and containing the same minerals in solution. Its clear water invites to tasting, but the alkalinity it possesses in a high degree soon destroys its application as a continual beverage. The third spring, between the two, measured 107° F. It is surrounded by a considerable deposit of carbonate and bicarbonate of soda, and the taste of the water is that of a nearly saturated solution. These springs have attained a local reputation for the cures effected by their use, in aggravated cases of rheumatism and kindred diseases. The healthy mountain-air, the free and easy life, together with the use of these hot waters thoroughly impregnated with mineral matter, would no doubt have a very beneficial influence upon some invalids whose ailments an in-door life and the use of drugs might fail to conquer so speedily. At the time of our visit, quite a number of people were there, seeking relief from various diseases they suffered from, and all of them expressed their admiration of the sanitary qualities developed by the water of the springs. Preparations were being made to utilize the two upper springs, besides the lower one.

Dr. Oscar Loew, mineralogist and chemist to the 100th meridian survey, has published* three analyses of these springs, which are appended. The temperatures which were there observed are generally higher than those I have taken. A comparison gives the following result:

No. 1.	No. 2.	No. 3.	
150° F.	Cold.	140° F.	(Loew.)
131° F.	107° F.	122° F.	(Endlich.)

Analysis of No. 1:

Sodium carbonate	69.42
Lithium carbonate	Trace.
Calcium carbonate	13.08
Magnesium carbonate	10.91
Potassium sulphate	Trace.
Sodium sulphate	23.73
Sodium chloride	29.25
Silicic acid	5.73
Organic matter	Trace.
Sulphureted hydrogen	Trace.
Total	152.12

This, as well as the following analyses, is calculated so as to give the mineral constituents in one hundred thousand parts of water.

Analysis of No. 2:

Sodium carbonate	Trace.
Lithium carbonate	Trace.
Calcium carbonate	31.00
Magnesium carbonate	5.10
Potassium sulphate	Trace.
Sodium sulphate	10.50
Sodium chloride	11.72
Silicic acid	1.07
Organic matter	Trace.
Sulphureted hydrogen	12.00
Total	71.39

Analysis of No. 3:

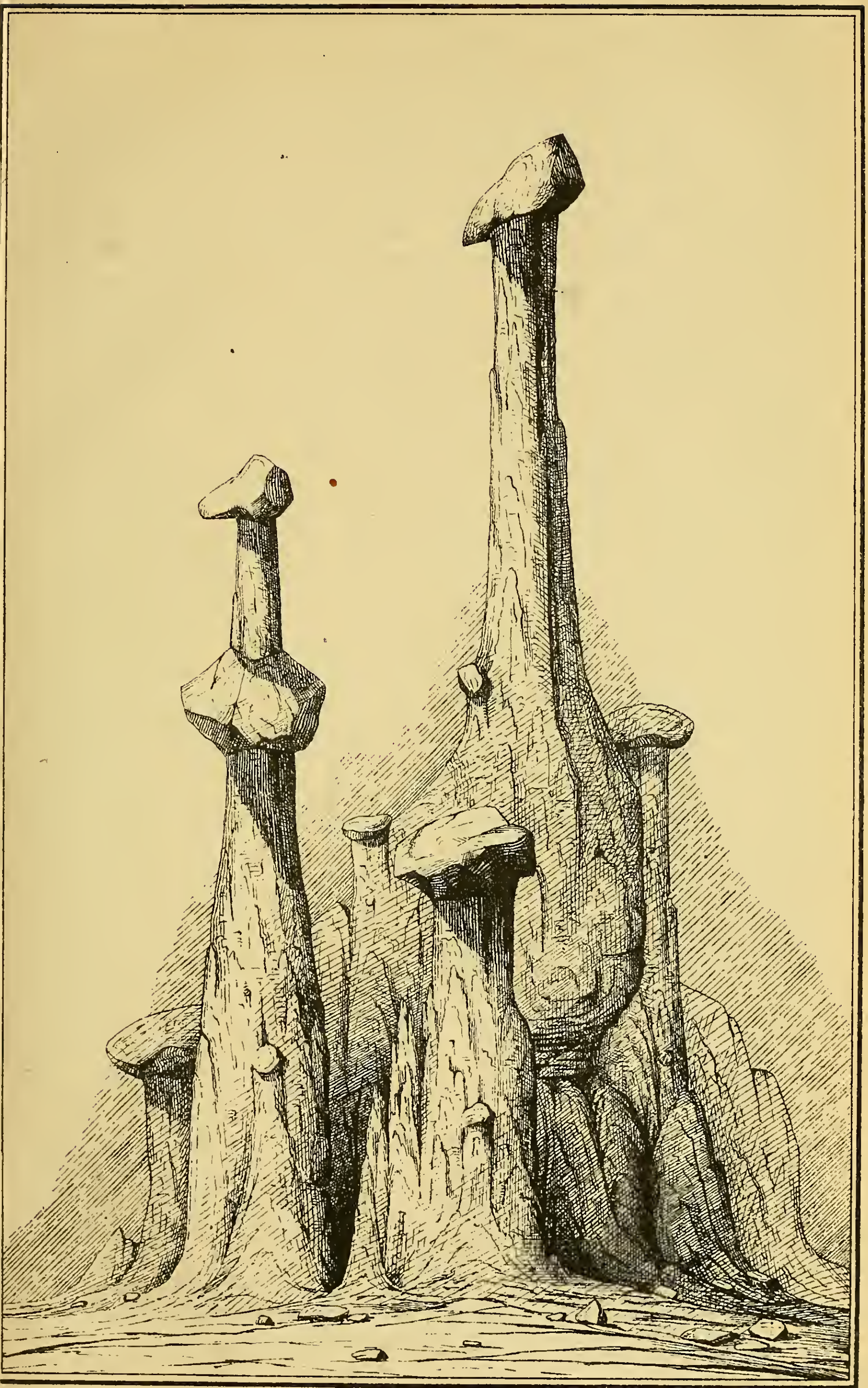
Sodium carbonate	144.50
Lithium carbonate	Trace.
Calcium carbonate / Magnesium carbonate	22.42
Potassium sulphate	Trace.
Sodium sulphate	13.76
Sodium chloride	33.34
Silicic acid	4.75
Organic matter	
Sulphureted hydrogen	
Total	218.77

* Report Exploration and Survey West of One Hundredth Meridian, 1875, p. 623.

Trachyte flanks both sides of the river above the gap, stretching down in long, low ridges from the mountains. South of Bristol Head,* station 27 is located on an isolated hill, at an elevation of 9,278 feet. Opposite this station South River flows into the Rio Grande. On the former a group of very great interest was discovered, a group of monuments. For about 3 miles along the east side of South River, hundreds of "monuments" occur, imparting to the wooded slope that is studded with them a weird and picturesque appearance. A long ridge separates this stream from the parallel creek east of it. On the west side this ridge falls off perpendicularly, with narrow, rocky walls leading off from the precipice at right angles. It is on these walls and in the interstices between them that the curious products of erosion are found. Rising from a massive base, the spire-shaped columns, profusely ornamented by accessory towerlets, reach a height of 400 feet. Several of them cluster together below, and, separating as they increase in height, form groups that for unique appearance will scarcely find their equal. Dark spruce timber, trees of great size, seem but like dwarfs by the side of these mighty columns. The entire surface of the walls is corrugated, ornamented with diminutive monuments, while the edges and the top are literally covered with the graceful forms. For 3 miles in length and about half a mile in width the surface is covered with the monuments. Through openings in the timber the groups appear, like so many statues placed there by the skillful hand of nature, while again they reach far above the tops of the highest trees. Owing to the comparative regularity of the arrangement of the walls, certain zones are more richly supplied with the monuments than others. Looking down from above into the deep chasms between the walls, the slender columns capped with the projecting top, occurring of all possible sizes, present a view at once impressive as a whole and singularly beautiful in detail. Trachytic conglomerate, that shows indubitable evidence of having been deposited by water, furnishes the material for the formation of the monuments. On average, the thickness of this stratum, that also occurs at numerous other localities, is about 600 feet. In consequence of erosion, the walls jutting out from the precipice do not show the entire thickness of the stratum, but are only about 500 feet high. Rising from the very base of the walls, the highest monuments reach about 400 feet, but the average height may be quoted at about 60 to 80 feet. The conglomerate is composed of large and small trachytic bowlders that are but loosely cemented by volcanic sand, which is redeposited by water. At no point was it observed that the cementing medium produced a harder rock than at the place where the largest number of monuments are found. In contradistinction to the formation of the monuments in the Garden of the Gods, those of this locality are primarily formed almost entirely by aqueous erosion. Numerous observations, showing the form in every stage of development, have demonstrated the process of generation. Assuming before us the vertical or nearly vertical wall of trachytic conglomerate, we find that innumerable large and small bowlders project from its surface. Water slowly moving down along the wall finds a temporary resting place upon reaching one of these bowlders, and then flows down on one or the other, or both sides of it. Owing to the very readily disintegrating character of the conglomerate, the cementing grains of sand and the small amount of clay intermixed are readily washed away, and gradually a vertical groove appears on either side of the bowlder. This groove is, in the course of time, worn deeper and deeper, the bowlder

* Comp. Report United States Geological Survey, 1874, p. 199.

Plate XIX.



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

projects more and more, until its rear end, formerly buried in the wall, is reached. Then we have the beginning of the monument. All that portion directly under the protecting cap has remained intact, and now stands out prominently as a cylindrical column, bearing a rock of often very irregular shape on its upper end. After that stage of development has been reached, erosion by sand, frost, and other agents assert their influence in shaping the monument to the typical form. The highest portion of the cylinder gradually becomes thinner, while the lower one, on account of its greater bulk and more recent separation from the original place of deposition, retains to a great extent its thickness. Bottle-shaped columns are the eventual result, capped by an erratic bowlder, which projects on all sides over the narrow "neck" sustaining it. If erosion progresses further, particularly that produced by sand, the neck again is the portion most violently and successfully attacked. It grows still thinner until it has assumed the shape of a cone. Then the stone capping it can no longer retain its delicately-balanced position and falls. Thus the needles are formed. To these latter is allotted, but a short existence. Exposed entirely to the eroding agents, the cone grows more and more obtuse, its height less, and, crumbling down piece after piece, before long its place is only marked by a low mound of disintegrated conglomerate. Storms and rain carry off the smaller particles and the sand, so that all we find to-day to mark the places where perhaps hundreds of the monuments stood at one time is a layer of trachytic bowlders that locally accumulate where once they were imbedded within or placed on top of the monuments.* A very beautiful trachyte composes the greater portion of these bowlders. It is of a variety that occurs at a number of localities in the district of 1874. Instead of segregated minerals contained in a paste, it consists mainly of a crystalline aggregate. Sanidite crystals, colorless, yellowish, and pink, together with black hornblende crystals, black mica, and white or yellowish oligoclase, make up the trachyte. A small quantity of a reddish paste occurs sometimes, but rarely. Frequently a light-green semi-opal forms a sort of cement, and then produces a harder variety of the rock. Some of the sanidite crystals show adularization. Partly material made up of this trachyte, partly that from other varieties, compose the cementing sand. Much of the clay that enters into the composition of the latter has been washed out from the surface of the walls and monuments, and has collected as a yellow deposit in the small streams and creeks leading to South River. On the west side of this stream the same formation occurs, but the monuments are only found scattered here and there, by no means in the same groups as on the east side. Particularly beautiful in their scenic effect, as well as in their form, are those monuments occurring on the sloping edges and tops of the walls above mentioned. Wherever the marks of stratification are noticeable, the shape of the monuments is different. They seem to be laterally compressed, instead of showing a symmetrical development on all sides.

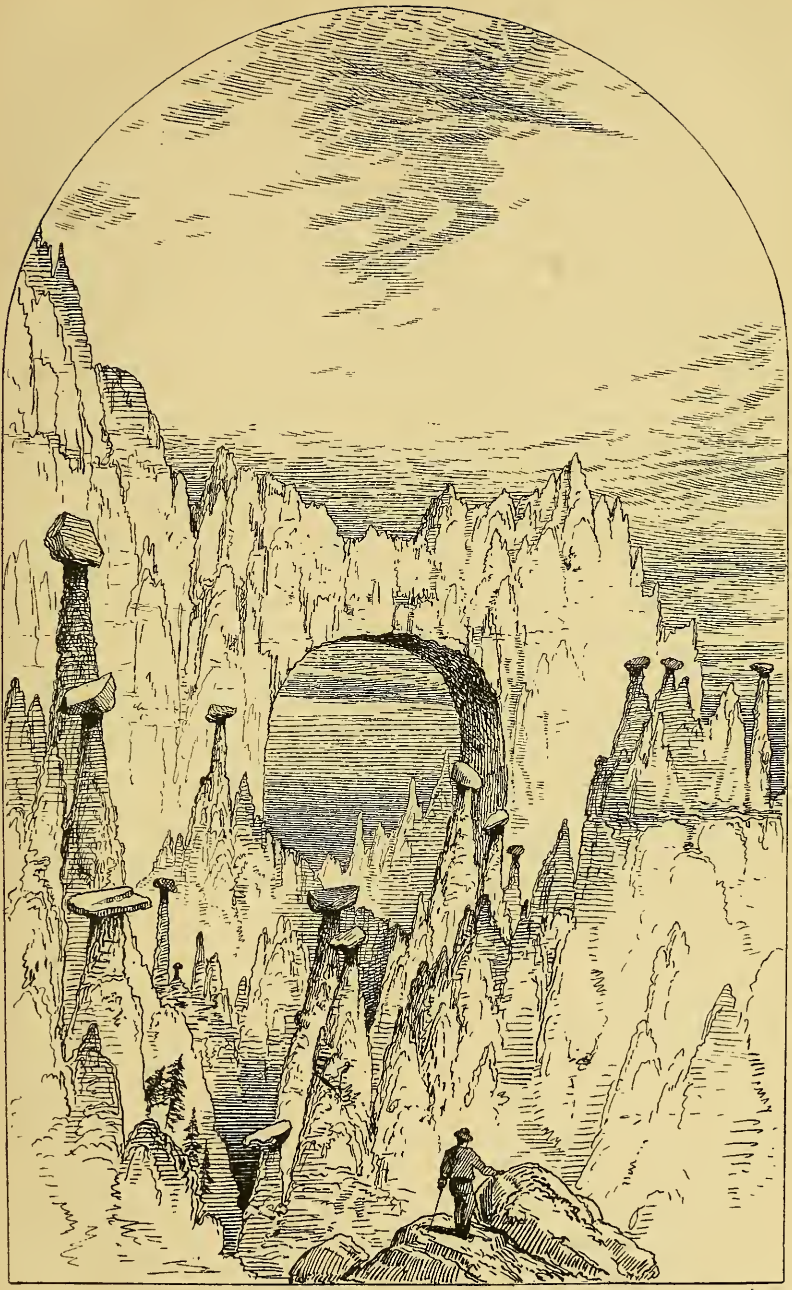
A curious incident in the formation of one of the monuments was there observed and is illustrated by the annexed cut. The highest one measures about 35 feet. Gradual erosion reduced the diameter of the column of the smaller one until eventually the rock in the upper third of the monument was reached and a second one was formed under it. Accidentally the bowlder in question had its position in a vertical line under the first, so that its present poise is possible. Among the hundreds that were seen there this is the only instance of the kind observed. A small group is represented by the cut, showing monuments in several

* Comp. Report on Geology of Northern California and Oregon, J. S. Newberry, 1857, p. 46.

stages of development. It is a copy of one of the innumerable groups studding the tops of the walls. There of course the height of the columns is not so considerable as of those starting near their bases. From the numerous needles and remnants of needles on the walls, it may be inferred that there the existence of the monuments is by far shorter than below, where they are less exposed to the wind and to the consequently more severe erosion both by sand and water. It requires but little force, directly applied, to overthrow a monument there 1 or 2 feet in diameter.

Another feature adding to the interest of this locality is found in the natural arches formed in the narrow vertical walls. Speaking of the walls as narrow, it may be stated that this is meant comparatively. They are from 30 to 160 feet in width above, but compared with their length and height even this produces the impression of very narrow width. Altogether we found eleven of these arches, nearly all of which were remarkable for their great regularity of outline. The one represented by the illustration is perhaps the most regular, and sufficiently low down in the wall to be surrounded by monuments. As Mr. F. Rhoda of our party was the first one to find an arch, I have named this one Rhoda's Arch. It is about 150 feet wide and 180 feet high, very symmetrical in outline, leaning slightly toward the east however. A number of high monuments, the highest reaching over 200 feet, are in the foreground, where the interspersed spruce trees look very diminutive, compared with the towering forms of the monuments. As regards the formation of these arches, an idea suggested itself in consequence of studying the conglomerate. It was found that at many places the sand more loosely cemented the bowlders than was generally the case, and there niches were worn into the walls by the action of erosion. Should the process that produced these niches be continued, the result will be a perforation of the wall—the formation of an arch. It is readily conceivable how the process of erosion would progress more rapidly after the first decided start had been made, and the arches in their present form would require much less time to be completed than the niche which was their beginning. Many niches were found, but they are, as a rule, so absolutely inaccessible, that the investigations as to the nature of the conglomerate in which they occurred was necessarily limited to a few instances only. Although we frequently met with the same conglomerate during the summer, we never found another locality where these monuments had been formed. Why the valley of South River should be thus favored is not very apparent. The eastern ridge, upon the west slope of which they are found, is narrow, densely timbered, and shows no evidence of having turned large quantities of water in the direction of the monuments. From the south water might have flowed freely, but the transverse position of the walls excludes the probability of water coming from that direction having had any considerable influence in the eroding of the unique forms. The explanation is probably to be sought in the physical constitution of the conglomerate, which is so peculiarly adapted to the formation of monuments of that character. In time—though it may take ages—the capped columns will be transformed into needles, they in turn will disappear, to leave nothing but a small remnant of *débris;* all the beauty of that rarely-visited spot will then have vanished.

Above station 27 on the Rio Grande Antelope Park begins. Bordered on the north by the long bluff that runs parallel to the precipitous edge of the plateau upon which Bristol Head is located, the valley stretches along in a westerly direction. On the south the steeper slopes



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

Rhoda's Arch

Plate XX

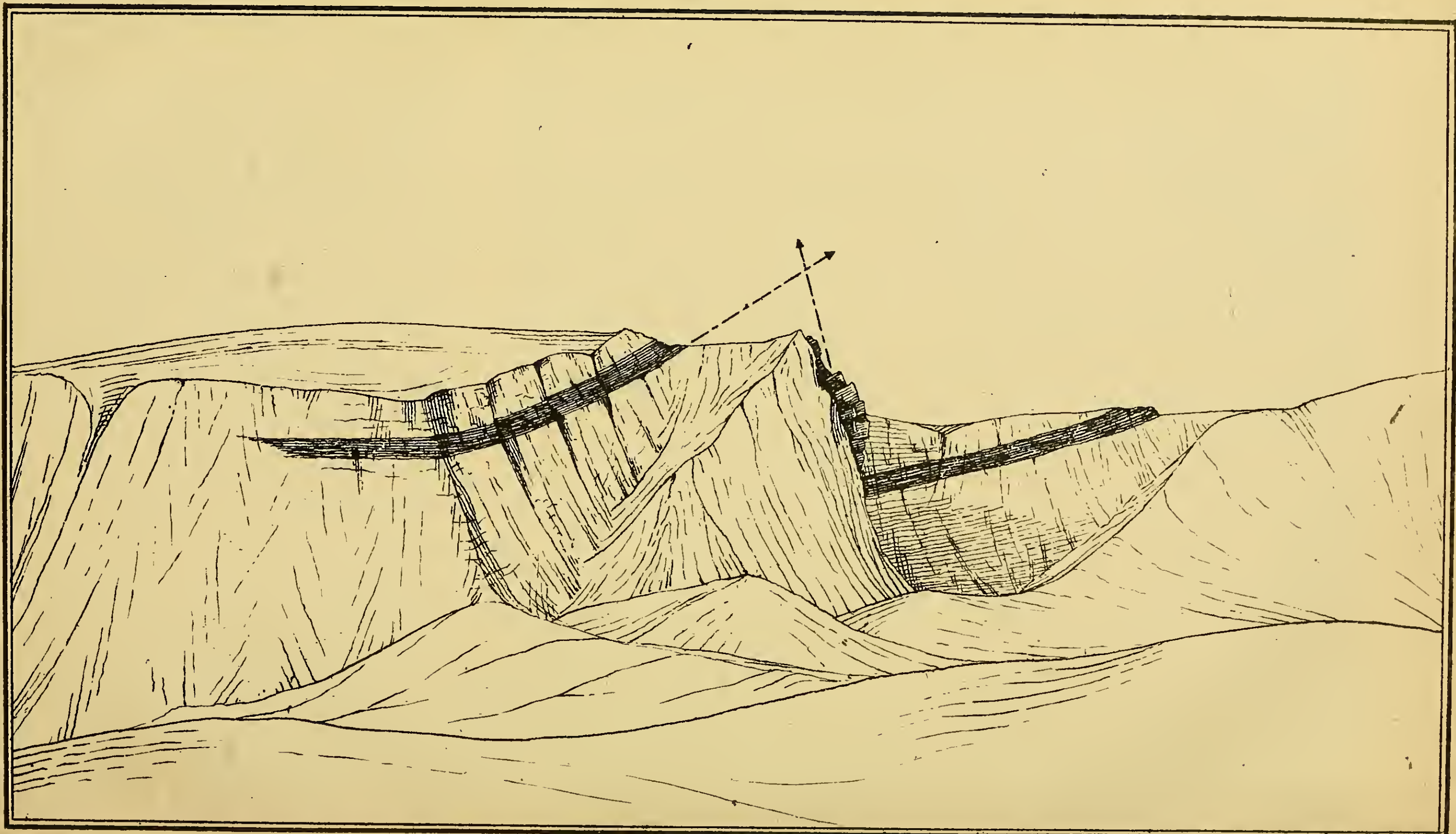
of the trachytic strata form its confines. In the lower portion of the valley the old courses of the Rio Grande can readily be traced. At present it winds its course very near the northern edge, but formerly it flowed on the other side. Courses that belong to three different periods can be recognized. Either there is but a shallow, continuous depression to mark one of them, or a series of swampy places, connected with each other, or the old remnants of the banks, denoted by rows of pebbles and bowlders, and accumulations of sand. We have here an excellent illustration of what I have been accustomed to term the "parallel shifting of rivers." The general course of the Rio Grande in Antelope Park is a little south of east, corresponding to the long dimension of the valley itself. It is not meant that each turn of the winding river is moved parallel to itself, but that in the course of time the deposition of river-drift at the points of weakest current will produce a change of the velocity and volume of the current, thereby, too, changing the places of deposition. In this manner, and owing to these changes that will invariably occur in a valley of any breadth, the river will eventually have covered the entire width of the depression, so far as steep slopes on either side may permit it to travel parallel to its own general course. This accounts for the fact that often valleys of considerable breadth, but having a level surface, are found to be covered entirely with river-drift. In a case of that kind it is tempting to assume an enormous amount of water as having passed over that locality at some remote period. From the courses taken by the Rio Grande in former times, it is evident that the river covered, in time, the entire valley, constantly changing, as it did; and it is natural, therefore, that we find the drift, both of the river proper and that brought to it by its tributaries, distributed over the entire surface. This fact becomes all the more striking as some of the streams entering the Rio Grande farther west head in the metamorphic area of the Quartzite Mountains, and we find here the characteristic quartzites and schists that can have had their origin nowhere but in the mountains cited. They are spread all over that portion of Antelope Park, together with the volcanic bowlders from the immediate vicinity, and from the neighborhood of the headwaters of the river. It was noticed that drift, identical with that of the Rio Grande, covered a considerable portion of the bluff upon which stations 33 and 34 were located, about 900 feet above the present level of the water. It seems almost impossible to account for the presence of this drift. It is well known that any drainage coming from the north could not have brought quartzites and schists to those places, as none occurs within reach of the waters flowing from that direction. How the river could have reached to an elevation 900 feet higher than its present level is not readily understood. On the southern side of the valley the trachytic strata were observed to dip 4° to 8° toward it. The strata of this bluff dip toward it 8° to 16°. Whether the river at one time flowed at a much higher elevation than at present, depositing its drift where it is now found, in apparently so abnormal a position, and whether through a subsidence indicated by the synclinal dip of the strata its present course was established, I am unable to prove. Transportation by glaciers suggested itself, but no positive evidence of moving ice whatever was found in that region. This is one of those numerous puzzling questions that cannot be answered without a very minute knowledge of both the geognosy and orography of the entire section of country involved. I merely make mention here of the fact, as I have several more localities farther south to discuss, where analogous occurrences were observed. Between Crooked Creek and the Rio Grande, above Antelope Park, are a series of bluffs, upon one of which station 53 of 1874 was located, at an elevation of 10,303 feet. With great certainty the strata of trachyte No. 2 and No. 3 can be separated here. They are very nearly horizontal, having but a slight dip to the eastward. There is no doubt that the bluffs, now separated by cañons, were at one time a continuous plain, over which the Rio Grande *may* have found its course. In that case the deposition of erratic material near stations 33 and 34 would be fully explained, but there is no sufficient proof at hand to substantiate the supposition, although it is the only one affording a semblance of probability. The cañon opposite station 53 of 1874, through which the river flows, is one of separation, not of erosion, as is amply shown by the character of its walls, by its course, and by its topographical features generally. As such is the case, the chasm produced would have afforded a convenient outlet for the river into the lower country east of Antelope Park, and abandoning the elevated position heretofore occupied, the Rio Grande would have sunk its level nearly a thousand feet. Just above the cañon the creek flowing north from Weeminuche Pass enters the river, and there the work of 1875 joins with that of 1874.

All the drainage flowing into the Rio Grande from the south, runs entirely in trachyte, until we reach those streams that flow for some distance through San Luis Valley before joining the river. Of the former, the south Rio Grande is the most prominent. It heads south of station 18, flows first west of north, then takes a turn toward the east. Trachyte No. 3, and high up in the mountains No. 4, occur within the limits of its drainage. In lithological character the strata here are identical with their western continuations in the Uncompahgre group. No. 4 is not developed to so great a thickness as there, and in consequence the peaks do not reach the high elevations that we find farther west. Station 21, near the headwaters of this stream, on the continental divide, has an elevation of 13,323 feet, and station 28, at the head of Hot Springs Creek, is 13,160 feet high. This may be regarded as an average for the higher peaks of the plateau-range upon which they occur. More elevated mountains are not wanting in the range, but they are not numerous. Stratigraphically the conditions are very simple, a gentle, general easterly dip being the only variation from the horizontal noticeable, with the exception of some slight local faults or of "drops." From station 20, (11,892 feet,) one of the former was noticed in a bluff to the northeast. On the face of the plateau-like bluff a dark stratum of trachyte is exposed, which has been displaced for the vertical distance of about 200 feet. The line of the fault breakage is marked very prominently by the *débris* of the dark bed. Most of the ridges in this locality partake of the characters of plateaus, separated by deep cañons.

Below the South Rio Grande, the next stream of importance is the San Francisco. It flows mainly through trachytic strata, but enters San Luis Valley near Del Norte. Near its headwaters stations 17 and 18 are located, the latter 12,768 feet above sea-level. They are within the Summit mining district, the discovery of which created considerable excitement several years ago. In this district we find the "*red stratum*"* developed, that is an important feature in the mining regions of the San Juan country. Here, as there, the color is produced by the decomposition of very minute pyrite crystals, with which the trachyte is thoroughly impregnated. Inasmuch as it denotes the presence of a mineral that very frequently is auriferous, the appearance of this characteristic

* Report United States Geological Survey 1874, p. 197.

Plate XXI.



may serve as a guide to prospectors and miners. Its colors vary here, as farther west. Starting from white they pass through yellow and orange to a brilliant red, deepening at places into a dark brown and maroon. It is not in this stratum that always the paying lodes are found, but it is evidently in intimate connection with the lode-bearing formations. West of the headwaters of the San Francisco, stations 15 and 16 are located, at elevations of 12,515 feet and 13,176 feet. The latter is a high, rounded hill covered with short grass. Over it leads the wagon-road to the Summit district. Both are trachytic. On station 15 the trachyte weathers in thin slabs. It is of a brown color, containing sanidite, hornblende, biotite, and some oligoclase. When sufficiently thin, the slabs produce a submetallic sound upon being struck. Descending with the stream we find ourselves in the low bluffs, characteristic of the western border of the San Luis Valley. Their strata show a general dip to the eastward, which here is changed by a slight one to the north. On one of the rounded bluffs station 14 (9,629 feet) was located. Its summit is formed by a capping of black vesicular basalt, containing small fragments of a very yellow olivine. On account of the commanding view, this point had been utilized as a "lookout" by the Indians, and we found the low circle of stones intended to shield the sentinel from observation.

Near the San Francisco heads Rio Alamosa. From the northward to the entrance of the Alamosa into San Luis valley the eastern border of the Sawatch Range has been formed by trachytic bluffs. Here, however, this changes. Station 101 is located at an elevation of 9,627 feet, and forms a prominent hill on the west side of the valley immediately north of the Alamosa. This is composed of trachyte, but south of it the more recent basalt sets in. So far as could be determined, the latter is unconformable with the former at this point. The Alamosa heads at station 19, a prominent rough mountain in the trachytic area, rising to an elevation of 13,323 feet. A part of the Alamosa drainage heads in the Summit district, and some of the mines there are located within its limits. Reaching the valley, the river flows first through a small outcrop of the trachytic conglomerate, and then enters a broad cañon walled in on either side by basalt, but having a flat bottom that is utilized for agricultural purposes by Mexican settlers. Rio la Jara joins the Alamosa in San Luis Valley. The basalt of this, as well as of the border of the mountains farther south, covers in an almost continuous layer the prevalent trachyte of the region. It shows, near its western, highest edge, an easterly dip of about 7°, which gradually diminishes as it approaches the plain, and eventually enters it. There it forms the bottom of the valley for some distance, until it is covered by the drift. Wherever branches of the stream come from the mountains, they have cut through the basalt into the trachyte or trachytic conglomerate, so that the first will then only be found as a capping, covering the bluffs that have been produced by erosion of the continuous eastward-sloping bench. Identical with the occurrence of the basalt here is that on the drainage of Rio Conejos, farther south. It heads along the continental divide in numerous small branches, west of station 86, which we named Conejos Peak. This mountain is 13,183 feet above sea-level, affords an excellent landmark, and is entirely surrounded by drainage belonging to the river of the same name. Receiving its largest tributary, Rio San Antonio, from the southwest, the Conejos finds its course through the widespread basalt immediately after leaving the mountains. The most westerly appearance of the basalt is observed on station 88, (12,181 feet,) where it occurs as the capping of a trachytic plateau of small extent, trending north and south. From there eastward the country is more broken, showing, however, in its character, that the contours produced are but the result of the cutting of an extensive plateau that formerly existed there. Again we meet the basalt, overlying trachyte on a small plateau, 10,631 feet above sea-level, upon which station 90 is located. As at station 88, so we find here an easterly dip of the volcanic strata, both of the trachyte and of the basalt. Looking southward from that station, we can observe the well-defined western edge of the plateau, striking about north to south, sloping eastward at an angle of 6° to 8°. This expresses the dip of the volcanic beds. Upon the edge of the plateau, south of Rio San Antonio, station 96 was made, at an elevation of 10,294 feet. From here we may regard the basaltic outcrop as continuous. It is cut by every stream leading from the mountains into the valley beyond, but all the bluffs remaining are covered with the basalt. The entire area belongs to one flow, stratigraphically as well as lithologically. Throughout its entire extent the even dip eastward is preserved, diminishing gradually as we approach the broad expanse of San Luis Valley. An idea of the arrangement may be obtained from Section IX. Distribution and character of the basalt, after it has entered the valley, is discussed in Chapter II. A comparison of a few basalts collected from various stations throughout the region under consideration, will show the general uniformity of their character, as well as the constancy of the variations occurring.

1. Station 91. Basalt.

Paste, microcrystalline, color middle to dark grey; weathers dark-brown. Contains small spherical cavities, which appear glazed. Brown decomposed inclosures of olivine have a splendent luster. Magnetite is segregated in small, octahedral crystals. Is altogether very homogeneous, heavy and hard.

2. Station 96. Basalt.

a. Paste, microcrystalline, color dark-grey, weathering brown. Olivine in exceedingly minute particles. Spherical vesicles, containing small crystals of zeolites. Magnetite not visible.

b. Paste, crystalline, color reddish-brown, weathering lighter. Crystals of black biotite occur sparingly. Olivine, decomposed, dark, splendent brown. Irregular vesicles distributed throughout the entire mass, some of them containing zeolites. Decomposition of magnetite produces the brown color.

3. Station 97. Basalt.

a. Paste cryptocrystalline, color dark-gray to black. Slightly vesicular, vesicles either spheroid or drawn out. In some of them deposits of zeolites. Olivine the only segregated mineral distinguishable.

b. Essentially the same as above, but highly vesicular. Vesicles frequently round, while on the same bowlder in another zone they are drawn out. No mineral distinguishable but olivine, which is partly decomposed.

c. Paste microcrystalline, color pitch-black, with fatty luster. Very compact. Vesicles too minute to be visible. No segregated minerals. Resembles the typical melaphyrs of Europe. Large percentage of magnetite. This variety is subject to, mainly, three modifications.

d. Physical characters as above, excepting the presence of vesicles; these are very flat, drawn out to the length of half an inch. Between the larger ones are very minute ones. The rock breaks into shaly fragments, owing to the fact that the vesicles have been compressed in one direction. This latter feature still more modified in—

e. Where the compression goes so far as to produce a decided lamination. On the surface of fracture, which latter occurs only in the direction of the longitudinal axes of the vesicles, it has an appearance similar to that of the surface of a palm-leaf. The vesicles no longer remain as such, and are only indicated by the *quasi* cleavage-planes of the rock.

f. Shows no segregated minerals whatever, and is as porous as a sponge. The vesicles are small, averaging 1mm in diameter.

g. Paste microcrystalline, its structure much obscured by decomposition. Compact, no vesicles. Color, mottled red-brown and black. Small particles of olivine are distinguishable, although decomposed. This is essentially the variety *c*, without vesicles and a changed color, the result of higher oxidation of the magnetite.

h. Same as *g* in paste. Color, reddish drab. Minute, irregular cavities, produced by decomposition of certain mineral constituents. Olivine inclosures reaching a diameter of 2mm. This is a still further progressed product of decomposition.

i. Very much like *f.* Color, greyish brown, thoroughly vesicular. Not only are the small vesicles found as in *f*, but large ones occur, showing a glazed surface. All of them have been more or less drawn out. In its texture it closely resembles pumice.

Station 104. Basalt.

a. Paste, microcrystalline; color, black. Minute crystals of feldspar and finely distributed olivine give the rock a glassy luster. Innumerable small vesicles. Some larger ones are scattered throughout. The latter are filled with either crystalline, crystallized, or amorphous carbonate of lime. I do not regard these amygdules as accidental inclosures,* but consider their formation to be a secondary one. Probably it is the result of the decomposition of minerals containing lime, which latter was held in solution by water containing carbonic-acid gas, and deposited by it in the vesicles upon the loss of this gas. Were the amygdules accidental inclosures of limestone, their form would not be regular (spheroid) nor would they consist of calcite, but of marble. Experiments have shown that pure limestone changes into marble, not crystallized calcite, upon being subjected to heat with exclusion of air.

Station 99. Basalt.

a. Paste, greyish black when fresh, reddish brown when decomposed; crystalline. Crystals of black biotite in minute crystals. Olivine brown. Minute vesicles and scattering larger ones, both irregular.

Recurring again to the headwaters of Rio Conejos, we find that this stream rises entirely in a trachytic area. Stations 84 and 87 are located at the heads of Conejos waters, on the continental divide; the latter at an elevation of 12,261 feet. Here we find evidence of a very extensive glacier, which at one time covered the entire plateau there, and branching off from the high summit spread itself in several courses both toward the east and south. Deep cañons have been cut into the volcanic material, some of which are almost inaccessible. A hard bed of trachyte forms the highest portions of the plateau trending north to south, and overlies the readily-eroded trachytic conglomerates. Striation and polishing of the former furnishes indisputable proof of the action of moving ice, while the cañons cut into the conglomerate, narrow and deep, denote the courses taken by the ice and water after

* Comp. O. Loew. Exploration and Survey West of One Hundredth Meridian, 1875, vol iii, p. 642.

leaving the eastward-sloping plateau. Higher peaks, as those upon which the above-cited stations were located, have escaped the denuding influence of the glacier, save at their bases, but east and west of them, the entire region was covered with the moving ice-fields. In accordance with the physical character of the conglomerate underlying the trachyte, it has readily yielded to the carving action of the water and ice, and precipitous walls, starting at the point where the protecting trachyte has been worn away, and inclosing on either side the cañon, give testimony of the long-continued erosive activity of the glaciers. It seems probable, though it could not be proved without examination that would consume more time than we could spare, that some of the glaciers extended down to the edge of San Luis Valley. The shape and character of the cañons, more particularly, and the transportation of material, would argue for this assumption. No moraines that could be considered characteristic or typical were found outside of the mountains, but the uniform habitat of the cañons throughout their entire length, permit a view of that kind to appear probable. In Appendix A, the glaciers of Southern Colorado are discussed more at length. In harmony with the general dip of the volcanic strata of the eastern slope of the Sawatch Range, we find here, too, an inclination toward the East. It becomes very evident in the conglomerates. At the heads of the glacial cañons their thickness is from 800 to 1,000 feet, showing slight local variations, dependent upon the facilities for deposition. Twenty miles farther east, just at the exit of the Conejos from the mountains, the upper stratum of the conglomerate appears in the bed of the river and the low banks immediately adjoining. Comparing the elevations here, and at the beginning of the basaltic cap vertically above it, we find that the entire trachytic series participates in this dip, as well as the superincumbent basalt. Although the conglomerate in these cañons is essentially the same as that on South River, we find no evidence of the picturesque monuments that there are so well developed. Cavities and caves occur, together with column-shaped rocks, the products of erosion by water, both frozen and flowing. In a rock of the constitution like this conglomerate, frost is one of the most powerful eroding agents. Water permeates the entire mass, and upon being expanded by freezing, finds but little resistance in the loose sandy agglomeration. Thus, in a comparatively short time, the detail features of a cañon-wall or precipice can be altered beyond recognition. Though striking forms, produced in this manner, are not wanting in the conglomerate of the cañons, they cannot compare with those south of the Rio Grande. In a region so high as this one is, the frosts continue into that period that we call summer, and begin again in August; it is therefore not surprising that we should find all evidences of striation or grooving, as produced by glaciers, obliterated here, where undoubtedly large masses of ice at one time descended in that form of a glacier that is appropriately termed "*Sturzgletscher*" in German. It is simply analogous to a waterfall; instead of water we have ice.

At the southern end of the Sawatch Range, so far as it is in our district, a change of formations takes place. Although trachyte remains the principal rock, so far as area is concerned, it was found that metamorphic beds crop out from underneath it. At places, the volcanic beds, without any appreciable change in their general elevation, become thinner. This is due to the fact that, at the time of the immense volcanic eruptions that have covered the region, the configuration of the country was already a very much broken one. We find in this region that mountains of metamorphic rocks must have existed, which were either but partially covered by the volcanic beds, or were covered with so thin a layer that this readily yielded to erosion and was carried off, thus exposing the older formations. Near station 95 the trachytic area shows its smallest width along the entire range (so far as treated of in this chapter), and it is here that the metamorphic formations appear. Several small outcrops were observed farther north, in deep cañons, where the superincumbent volcanics had been removed. This was aided, in two instances at least, by the agency of glaciers. Evidences of the latter were observed near station 94, at the western edge of the metamorphic outcrop, but, so far as could be determined, they were of small extent only. Drift found 20 to 30 miles farther west, on the summits of Tertiary bluffs, could have originated nowhere but at this locality. It is difficult to decide, however, whether it was transported to those places by the agency of water or ice.

Station 95 is located on a north to south granitic ridge, at an elevation of 10,373 feet. It is the first of the continuous metamorphic outcrop that extends from there westward. Throughout the region the remnants of trachyte superincumbent have the usual easterly dip of 6° to 8°, but the metamorphics show an entirely different one. Following down the Rio Brazos, we remain in coarse-grained, light-red granite, until, southeast of station 94, we reach the older, lower strata and find them to consist of quartzite. Here the Brazos runs through a deep, impassable cañon, walled in on either side by vertical, quartzitic strata. Station 94 is located upon these, just north of the river, at an altitude of 10,603 feet. Here the quartzite occurs in a number of varieties. From the pure white, granular quartzite it changes into grey, while other strata show slight admixtures of mica. Local accumulations of the latter take place in certain strata, producing a micaceous schist. Between stations 94 and 93 the junction of the superincumbent trachyte and the metamorphic quartzite is sharply defined. South of these stations (beyond the limits of our district) trachyte again sets in, covering, as farther north, the metamorphic strata. Near station 94 the evidences of glacial action were observed. They consist in the rounding off and polishing of quartzitic beds *in positu*. Small lakes and ponds have been formed in the shallow excavations produced in part by the moving ice. Apparently the ice moved downward into the present narrow cañon of the Brazos, but it is highly improbable that ice could have cut that narrow gorge for a depth of more than 2,000 feet. The latter appears to be a cañon of separation, through which the river found its course after it had been formed. Should the glaciers have existed farther south and have been of very great extent, their presence would go far toward explaining the occurrence of drift 20 miles west that has been mentioned above. Viewed from the west, from the low valley of the Tierra Amarilla settlement, the Brazos Cañon has an imposing effect. Dark vertical walls, not unlike in general appearance to those of the Yosemite Valley, inclose the rushing stream that with steep fall enters the valley at the base of the high walls inclosing it. Station 94 rises high above the depression below, and in its outlines already denotes the fact of it being composed of a material different from the surrounding volcanics. It would be of interest to follow the continuation of the metamorphic outcrop southward, as there more definite features might be observed.

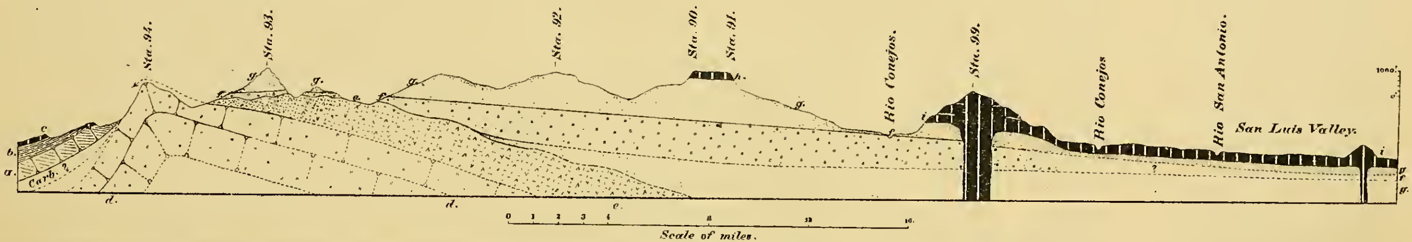
A section (Section IX) taken from station 94 to station 99, at the western edge of San Luis Valley, runs about northeast. Slight variations have been made from the straight line, in order to introduce those features that are most characteristic to the region. On the western slope, from station 94 downward, we find the Cretaceous beds belonging to the Dakota (*a*) and the Colorado groups (*b*) covered by a thin stratum of basalt (*c*); then follows the quartzite (*d*), showing an anticlinal fold, under the highest point of the mountain composed of it. Granite (*e*) coarse-grained, with flesh-colored orthoclase and white, silvery muscovite, appears on the upper stratå of the quartzite. Both of these show well-defined, regular stratification. On the west side the dip of the quartzite is very steep, amounting to nearly 80°, but it becomes more gentle east of the anticlinal axis. Conformable with it there is the dip of the granite, reaching about 22°. This dip is continued, with slight local changes, throughout the granitic area exposed, and is particularly noticeable in the ridge upon which station 95 is located. Unconformable with the metamorphic strata, though also dipping east, are the beds of trachytic conglomerate (*f*). They show an inclination of 6° to 8° eastward, which remains constant throughout almost the entire distance that they show any exposures. A shallow convex fold occurs northeast of station 93, which is located at an altitude of 11,214 feet on the compact trachyte (*g*) covering the conglomerate. Trachyte continues, worn away at some places so as to appear thinner, but retaining the regular succession of its flows and its constant easterly dip. It is covered by the basalt (*h*) of station 90, which reaches a thickness of 200 to 250 feet. From the small plateau formed by the protecting cap of basalt the trachyte is broken away again, as we descend, and the conglomerate for the last time makes its appearance on the banks of the Conejos. With trachyte underlying, we then find the long stretch of basalt (*i*) in San Luis Valley, a continuation of that at station 90. Local eruptions of small extent, such as station 99, have produced hills outside of the mountains proper, but they are limited in number. Although even here, at the very edge of the great valley, the easterly dip can still be observed, it has now decreased to 3° and 4°. On account of the evenness of the flow, the uninterrupted expanse of basalt, we find a very level plain formed in this region. It extends for some distance along the western side of San Luis Valley, and is quite unique in its character. Evidently the volcanic material at the time of its eruption must have been in a very viscous state, which accounts for its present regularity. It is highly probable that at one time the basalt of San Luis Valley and that sloping down westward from station 94 and then continued in the valley below, were one mass, and that it was also in connection with the basalt of station 88. Lithologically there is no distinction to be made, and the arrangement of this volcanic rock, topographically considered, speaks for the former connection.

One main stream still remains before we reach the San Juan drainage. Rio Chama heads near station 84, and flows almost due south. Its main tributary is Rio Brazos, from the east, which joins it at the town of Nutritas. The Chama heads within the glacial area that has been mentioned as existing at the headwaters of the Conejos. From station 84 the glacier bent around in a westerly curve, and entered, falling steeply, the cañon of the Chama. This is not as narrow as those of the Conejos, although its walls are composed of the same rocks. Near the head of the valley metamorphic schists have been exposed in consequence of the removal of the superincumbent trachytes and conglomerates. The exposure is small only, and the schists show both striation and polishing. From there downward the glacier has deposited large moraines, clay, bowlders, pebbles, and sand; everything is thoroughly mixed in, piled up in small hills along the course it pursued. At the upper end of the valley the appearance of the surface is what might be termed "hummocky." Lower down the moraines become more regular; are placed either par-

Plate XXII.

Section IX

from Station 94. to San Luis Valley.



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

allel to (lateral) the trend of the valley or across it (terminal). The present creek-bed indicates the course taken by the ice. On either side the soft conglomerates are cut away frequently to a greater extent than the overlying trachyte, which in that case broke off and fell down into the valley. On the east side, the bluffy wall is the terminus of the plateau of station 88, and from there basalt bowlders have fallen down. For a distance of nearly ten miles the glacier must have filled the valley, as shown by the morainal deposits and the characteristic carving of the rocks *in positu.* Below this the stream flows in the trachytic beds until it enters the Lower Cretaceous near the mouth of the cañon. On the plateau containing the most prominent striation and grooving a number of "drops" have occurred, which change the normal dip of the strata and the direction of the striation. They are found along a line running north to south, and measure 400 to 500 feet in vertical extent. Either none or very little lateral movement was connected with the vertical subsidence, still it is sufficient to change the course of the striæ. Probably the "drops" were produced by an erosion of the underlying conglomerates. They, yielding readily to the action both of water and ice, were excavated toward the heads of the cañons, and the superincumbent trachytes fell down vertically into the cavities thus produced. On the east side of the Chama cañon the wall furnished a very good section of the volcanic beds of that region. It is about 2,500 feet high. Near its base a talus composed of *débris* obscures the lowest strata, which are probably a brown trachyte. Above them the conglomerates set in, 600 to 800 feet in thickness, varying on account of having been deposited on a corrugated surface. Higher up we find a bed of massive trachyte, reddish-brown in color when fresh, but weathering dark brown. Bands and nodules of black porphyritic pitch-stone occur higher up, among a series of thin trachyte beds that show a banded appearance. This is produced by differences in the color, a number of very light beds setting in, which then contrast with the darker ones. A high mountain to the northwest of this locality has received the name of "Banded Peak," in consequence of a similar occurrence. Above these beds, that have altogether a thickness of about 800 feet, we find the black basalt of station 88. This measures 200 to 250 feet in thickness. It is vesicular in part, partly compact. Decomposition of the magnetite contained therein has produced the red variety that so frequently occurs at many other places. The Brazos heads in trachyte, but, leaving it, follows the outcrop of the metamorphic rocks, which there takes place in the depressions of the range. It passes through the steep quartzitic cañon south of station 94, and joins the Chama in the Cretaceous valley at the base of the mountains.

Besides the streams above enumerated, we have to consider those heading in the Sawatch Range and flowing into the San Juan, those on the western slope of the continental divide.

B.—SAN JUAN DRAINAGE.

Following along the western edge of the Sawatch Range, in a northwesterly direction, we first cross the Rio Navajo. This stream heads northwest of station 87, and flows south as long as it remains in the mountains, turning westward after leaving them. A portion of its headwaters rise in the glacial area of the Conejos glacier. It is probable, although the locality was not personally visited, so as to decide positively, that the ice extended down into the narrow valley of the Navajo. On the west side this valley is separated from the low country beyond by a prominent ridge composed of trachytic strata. Rugged mountains are placed in a row trending north to south. The boundary between the stratoid trachytes and the underlying Cretaceous beds is very clearly defined, and can be recognized even from a distance, on account of the characteristic forms and color of the volcanic rocks. Conglomerate crops out in the cañon, a continuation of the strata farther east and south, showing the same features that may there be observed.

Rio Blanco rises south of station 19, and flows from there in a southwesterly direction. It passes through the high trachytes of the mountains, until it leaves them south of station 77. This station is located on a prominent trachytic peak, belonging to that row nearest to the valley. Its altitude is 12,514 feet. Ascending it we first find the heavy beds of trachyte, compact, and of brown color. Light-brown to greyish-brown conglomerate covers it, and produces locally more gentle slopes. Above this follow the variegated bands described from the Chama region. Conspicuous among them is one black stratum, resembling basalt. Upon examination, however, it proved to be a trachyte containing a large percentage of magnetite, and numerous very thin transparent crystals of sanidite. These strata show some evidence of having been reheated; they are hard, very compact, brittle, and fragments have a submetallic ring. Columnar structure indicates reheating also, or slow cooling. Not much regularity is shown by these columns, among which the six-sided ones predominate, but they produce, in consequence of easy removal, steep, precipitous sides, on which the structure is visible from a long distance. Covering these strata, that remain constant in their occurrence throughout the southern end of the Sawatch Range, we find a massive brown trachyte, containing crystals of sanidite, some oligoclase, and small six-sided crystals of a splendent brown mica. Here and along the entire western edge of the range the mountains fall off very steeply, so that in this instance, camp 55, located five miles west of station 77, is more than 4,000 feet lower. It is this fact that imparts to the mountains the character of a high, rugged range, when seen from below. The general easterly dip of the strata, 2°–6° at this locality, effectually prevents any view of the sloping plateau behind them. Fissures and eroded caves traverse the upper beds of the trachyte and add to the rugged appearance of the mountains. The facility with which these strata can be eroded in a manner to form shallow caves, is noticeable wherever they occur. It is due probably to a want of homogeneousness of the physical constitution, in consequence of which erosive agents can more readily attack certain portions than others. Similar features to these found here, have been observed at many localities of the 1874 district, in the analogous strata. In but a few instances were the caves found to be of any depth, and mostly the mouth was larger than any portion of the interior. In case of rain or hail, so frequent in these volcanic regions, they afford temporary shelter, and some found farther west showed evidence of having been utilized for similar purposes by Indians.

Rio San Juan is the largest river of the 1875 district on the Pacific side of the divide. Several good-sized streams join about four miles northeast of station 76, and make up the river. The largest one of these heads just north of station 19, at the divide, and flowing in a northerly curve emerges from the mountains near station 76. Another branch, almost of equal length, heads south of station 28, and flows in a southerly direction, joining the first at the place mentioned. Both receive creeks carrying a considerable amount of water, so that the San Juan is a stream of some size already upon entering the lower country. From

Plate XXIV.

Fig. 1.

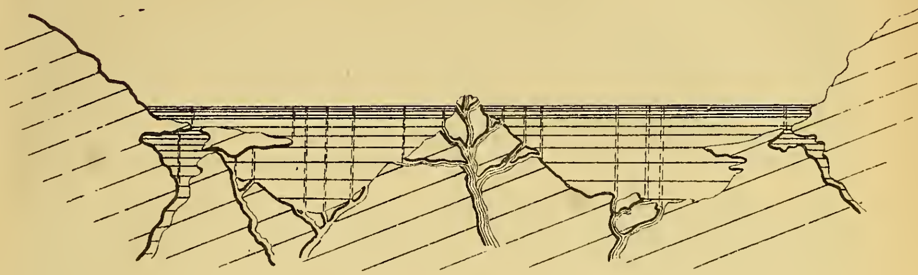


Fig. 2.

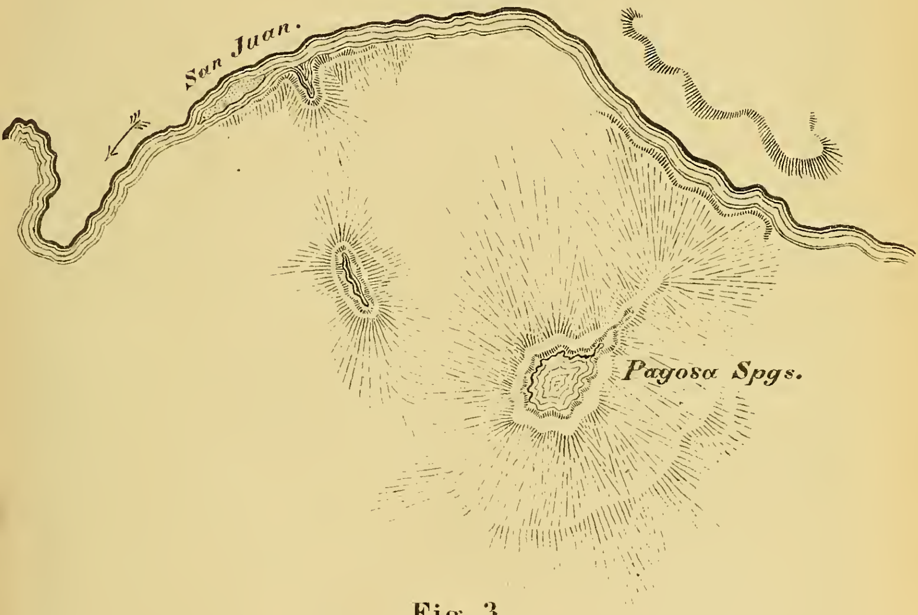


Fig 3.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

the vicinity of Pagosa Peak (station 38) a creek flows southward, with its branches, adding to the quantity of water. As farther south, at the headwaters of other streams, so here, too, trachyte surrounds the entire head-drainage. Cañons are cut into the strata, and there they show exposures that prove them to be identical with those both north and south. They show that the entire volcanic series belongs to one period, and that great constancy of its single members is maintained. In the deeper cañons and along the western border of the mountains the trachytic conglomerate appears, occurring in the same relative position as farther south. It retains its characteristic tendency to form steep walls and bluffs, which farther north changes, on account of its harder composition.

The largest northern tributary of the San Juan is Rio Piedra. This latter has, as the former, a number of branches that join a short distance southwest of station 39, from there downward forming the main river. As the most prominent among them I would mention Weeminuche Creek, which heads south of station 35, and flowing from there almost due south, enters the Piedra in its broad valley west of station 40. Running parallel to it are two streams farther east, the Rios Huerto and Abborato, carrying good supplies of water. Heading at station 28 is the Piedra proper. Its course through the mountains is almost straight, and remains so until southwest of station 39, where the river turns to the south. On the drainage of this stream Pagosa Peak (station 38) is located, reaching an altitude of 12,674 feet. As the entire range there, it is composed of trachyte, belonging mainly to No. 3. Pagosa Peak is a very prominent mountain of pyramidal shape, rising as it does 4,600 feet above the level of the adjoining valley west. Under the trachytes forming the summit of the mountain, we again find a good development of the trachytic conglomerate. Compared with that occurring farther south, it will be observed that it is by far harder, owing to an admixture of more clay in the cementing material, and perhaps to the fact of having been at that region subjected to heat. Although not decomposing or eroding so readily, it preserves in its outlines the somewhat fantastic features that are its characteristics at other places. Its thickness here is somewhat increased, the beds reaching about 1,200 to 1,300 feet. On the Piedra, just as it leaves the trachytic mountains, a very fine water-fall was found. Immense bowlders of the compact conglomerate are piled up before a vertical wall about 120 feet in height, over which the stream falls in a rapid torrent. On either side the vertical rocks reach a height of 500 to 600 feet so as to exclude any access from the fall upward. A little farther up-stream is another cascade, about 30 feet high, which pours its water into a deep basin from where it flows on to the lower fall. The picture is rendered unique in its character by the absence of any vegetation in the immediate vicinity of the falls. Nothing is presented to the eye but the barren rocks and the dark blue water collecting in deep pools worn into the conglomerate by the incessant action of the falling stream. Appropriately, and at the same time retaining the name of the river, we have called them Piedra Falls. On either side the conglomerate walls, containing numerous fissures and caves, inclose the upper cañon of the stream until it emerges therefrom and enters the broad grassy valley that is nowhere more beautiful than at the base of the mountains. Viewed from there the conglomerate shows many weird forms on the summit of the steep bluffs it forms. Spires and towers, the products of erosion, ornament the crest of the bluff, and descend along its edges into the timber below. Higher up in the background the mountains rise far above them, showing the horizontal edges of their variegated strata. Between the two nearest forks farther west station 37 is located on an isolated outcrop of trachyte. This is but a remnant of the main body, separated from it by erosion. Compact trachyte composes the base of the hill, while conglomerate forms its summit. Cretaceous shales surround it on all sides, and are underlying the volcanic rock. Both creeks head at the continental divide and flow through narrow, deep, trachytic cañons, whence they emerge and enter the adjoining Cretaceous valley. The western one of the two, Rio Huerto, flows through a meadow, after leaving its cañon, that formerly constituted the bed of a glacial lake. (See Appendix A.) Northwest of station 37 is station 36, located at an altitude of 11,347 feet on a southward spur of the main range. Again it is trachyte that forms the peak. The lower strata belonging to the series overlie Cretaceous beds, and are followed higher up by the conglomerate. At this locality the latter shows a light grey to greyish-brown color, and is more readily disintegrated than near Pagosa Peak. Near its upper edge a stratum of porphyritic pitchstone was found, varying in thickness from 6 to 18 inches. A portion of this must have flowed upon the conglomerate while the latter was yet under water, because specimens closely resembling pumice are found with it, that have probably assumed their present texture in consequence of having been cooled in water. On this peak the thickness of the conglomerate stratum is about 600 feet, having decreased toward the north, and still farther in the same direction its thickness is even more diminished. Beds of trachyte showing a variety of colors overlie it. From this station the outcrop of the trachytic conglomerate can be followed for a considerable distance along the steep edge of the mountains. It appears, generally presenting very steep or precipitous slopes, all around the edge, and in the cañons opening into the valley. In this entire region the dip of the trachytic strata remains an easterly one, varying locally on account of subsidences or slides. A case of this kind occurs near the mouth of the cañon through which Rio Huerto east of station 36 flows. There the conglomerate was soft, within reach of the former glacier and the stream afterward, and was washed away in part. Thus the overlying harder strata were undermined and dropped down on either side of the creek, now forming a steep synclinal fold, broken at its deepest depression.

West of station 36 flows Weeminuche Creek, heading at station 35. This latter station was made on an elevated cone in the plateau-like summit of the range, is situated on the continental divide, and reaches an altitude of 12,889 feet. Weeminuche Creek runs but a short distance in trachyte, as this is worn away farther down, exposing first the metamorphic granite, and then the underlying Cretaceous beds. This granite is a continuation of the main metamorphic area of the Quartzite Mountains farther west, and closely resembles that described from station 52 of 1874*. It extends northward for some distance toward Weeminuche Pass, and the well-worn Ute trail leads over it from there. West of it, the small plateau at which the west fork of Weeminuche Creek heads, is covered with trachyte. On the eastern side of Weeminuche Pass the spurs of the range are analogous in the arrangement of their trachytic strata to those of most of the Rio Grande Pyramid group. The conglomerate has thinned out considerably, and is no longer a prominent feature of the bluffs, though still found, and the trachytic beds have changed slightly, so as to fully agree with the characteristics given for No. 3, farther west. Above the conglomerate occur the variegated

* Report United States Geological Survey, 1874, page 189.

strata analogous with those described from the Rio Grande Pyramid,* and identical with those quoted as occurring farther south. The rock composing these strata weathers into small fragments that can almost deserve the name of gravel, and cover the rounded surface of the ridges leading up to the plateau. This latter shows the same features as farther south. Small lakelets and swamps change with either grassy slopes or immense fields of angular bowlders. Both are characteristic of the plateau, and are found wherever it has retained its nature as such. By way of Weeminuche Pass we cross the continental divide, and are once more on the waters of the Rio Grande.

Arrived at this point, we again connect our work with that of 1874. The great volcanic area continues westward, retaining for the lower member of its stratigraphical series the peculiarities of composition and occurrence that we have noted in the Lower Sawatch Range. Higher strata occur there, however, that are wanting in our district, and it is they that there produce the volcanic peaks reaching an elevation of 14,000 feet and more. Taking an average of the elevations of the higher and highest peaks in the district, it will be observed that the absolute altitude of their strata corresponds very well with that of the analogous beds to the west. This indicates that, although the dip to the eastward may be constant, hypsometric variations in the strata, from north to south, are almost entirely, if not entirely, wanting, save as very local occurrences.

DRIFT.

Mention has been made above of the morainal drift in the upper valley of the Chama, and of its probable occurrence in the valley of Rio Navajo. The erratic bowlders deposited near station 94 might be counted to this class, but the area covered by them is very small, and the accumulations but local. In Appendix A all the glacial evidence and deposits are discussed at greater length; therefore the mere notice of the same may here suffice.

River-drift, and that class that we are accustomed to term "avalanchial," occur quite frequently. They are found all along the western base of the Sawatch Range, where they often cover considerable areas. The bowlders and fragments have either rolled down from the mountains, or have been washed down. Bluffs sometimes several hundred feet in height are formed by them, running parallel to the courses of the streams. On the streams proper, alluvial soil has accumulated, which, on the Rio Grande, is utilized for agricultural purposes.

On the Rio Grande the same phenomena may be observed. Along the edges of the mountains bordering upon the river the avalanchial drift predominates, while lower down the rounded bowlders and alluvial soil set in. It is a matter of interest to observe the distances that such redeposited material is often transported. This may, perhaps, best be studied on the Rio Grande, where the metamorphic groups near its headwaters are represented nearly 100 miles lower down on the river. Bordering on the east side of the Sawatch Range is San Luis Valley, with its almost endless drift. This extends up on the easterly flowing rivers to some extent, and fills in the small valleys between the isolated bluffs that lie at the eastern edge of the mountains. This is represented in the first illustration given in this chapter. San Luis drift proper has been treated of in Chapter II, and it is therefore unnecessary to repeat a description of those portions lying contiguous to the edge of the mountains.

* Report United States Geological Survey 1874, page 200.

MINES.

About 25 miles southwest of Del Norte the Summit mining district is located. It is the only one within the area treated of in this chapter. A few years ago the discovery of the "Little Annie" there created intense excitement in the mining circles of Colorado. Since then the Little Annie has been worked steadily, and, I am told, has yielded a good profit. On one of the northern tributaries of the Alamosa, a small settlement has been started, at the northern base of the mountain upon which the mines are located. In speaking of the drainage of the San Francisco and of the Alamosa, the "*red stratum*" was mentioned. So far as my experience goes in the mines of Southern Colorado, this is indicative of the proximity of ore deposits, and in this instance the mines owe their paying ore to an impregnation similar to that observed in the red stratum. Ascending the mountain for nearly 600 feet from the creek-bed, we arrived at the opening denoting the Little Annie mine. It has been driven into the hill in a direction north 26° west. The absolute altitude of this mine is about 11,900 feet. No defined vein could be observed there. It is true that the work is continued in the same direction, but neither wall-rock nor vein exists, as such, to guide the miner. Upon examination, it was found that the entire rock, both that containing the "pay" and the dead rock, was alike. It is a very highly siliceous feldspathic paste, similar to that of the red stratum, containing siliceous concretions. This volcanic material, belonging to the upper series, is thoroughly impregnated with minute crystals of auriferous pyrite. Upon decomposition the sulphur escapes, and the iron is converted into hydrated sesquioxide of iron, thus freeing the gold. In accordance therewith, the gold-ore taken from the Little Annie contains that precious metal in the native state, occurring in small flakes or "strings", either in small cavities or more or less firmly imbedded in the quartz or quartzo-feldspathic paste. The entire mountain, with its perhaps limitless supply of gold ore, is one of great interest. Besides the Little Annie, three more openings were visited; the Dexter, with a strike north 75° east, the Golden Star, and the Golden Queen. All of these are lower down on the hill than the Little Annie. It was noticed that no two of them have the same strike. At none of these mines, upon which not a great deal of work had been done at the time of my visit, (June 28, 1875,) could any vein or semblance of vein be discovered. The miners were following a slight fissure of comparatively recent date, perhaps a quarter of an inch in width. On either side of this fissure the rock was more discolored, by sesquioxide of iron, than in its immediate vicinity, and this discoloration furnished a direction which might be followed in the search for gold.

My examinations at that locality were necessarily cut very short, as the party could not be detained, but I am satisfied that the entire mountain is impregnated with the pyrite-crystals, as well as several of the surrounding ones. Whether all of this pyrite is auriferous, however, will be a question for special examination to decide. It is possible that the gold occurs in certain zones in greater quantities, in which case the mining-claims must be so located as to cover the zones. Practical prospecting will soon develop this fact, if it exists, and action will be taken accordingly. After reaching greater depths than have heretofore been attained, the gold will probably occur only sparingly in its native state. The pyrite will then no longer be decomposed, but fresh, and the milling of ore will most likely receive a shock, because the gold contained in the fresh pyrite will not amalgamate. In that case, concentration of the ore, which can be very well accomplished with ore of that nature, and subsequently smelting, will come into requisition.

Résumé of Chapter III.—Viewing the portion of the Sawatch Range treated of in the above chapter as a whole, we find an exceedingly simple chain of mountains before us; simple, both as regards its orographic features and the formations composing it. Comparing the volcanic strata of this range with those in the district of 1874, we find that they correspond very well. No. 1 is not developed at any locality here. No. 2 occurs along the eastern base of the mountains, and, extending from there westward, underlies the higher numbers. No. 3 is by far the most prominently developed, attaining in the range a greater thickness than anywhere west of it. In its detail features, it compares very well with the parallel number of the Uncompahgre group, so far as weathering and mineralogical constitution is concerned. Above it, we find the often-mentioned conglomerate. This occurs, too, in the western regions, more particularly in Dr. Peale's district, at the base of the bluffs leading from the high Uncompahgre group toward the Gunnison River. Its first considerable development in our district is found south of the Alamosa, and from there continues on to the Conejos. At the southern end of the range (*i. e.*, so far as contained in this district), where the metamorphic rocks make their appearance, it occurs mainly in the cañons, not reaching up higher into the mountains. On the entire western slope of the range the conglomerate is well represented, varying in thickness, however, from 600 to 1,300 feet. Its geognostic position is constant, overlying the lower beds of No. 3, underlying its highest ones and the "nondescript" strata described from station 21 of 1874. No. 4 is but rarely found, only on some of the highest peaks of the range. Basalt is met with in large masses, of uniform character. The great flow that covers the western edge of San Luis Valley, and the adjoining bluffs and plateaus, like a huge black sheet, is one of great interest, both as regards its origin and the causes for its singularly equal distribution.

Touching the origin of the entire volcanic mass composing the Sawatch Range, I have come to the conclusion that it is but the continuation of the group to the northwest. At no point throughout the range was any evidence collected that might lead to an inference regarding any particular region within its limits as one of trachytic eruption. The highest mountains, as well as the plateaus and bluffs, show so decided a stratification that they cannot be regarded otherwise than as having been formed by a series of flows. After the first flows had subsided, a large quantity of water must have invaded the region, an evidence of which is to-day furnished by the existence and distribution of the conglomerate. At numerous localities it shows proof of having been deposited by water, not only by the marks of stratification, but also by the arrangement of the large and small bowlders. Frequently a thin stratum can be found, composed almost entirely of sand, while at other places nearly all the bowlders are large, with the interstices filled in with gravel and sand. It is clear that a large amount of erosion from trachytic beds must have taken place to produce this extensive deposit. So far as my observations go, nothing but trachyte and trachytic sand make up the conglomerate; therefore, if these observations are sufficiently complete, the material for its formation must have been furnished entirely by older volcanic beds. Although it would be a futile attempt to make any suggestions as to the courses taken by the drainage of that country after the eruptions of the oldest volcanic strata, a few hints are furnished by the outcropping of the older metamorphic rocks. From their present appearance, and from the relative position they occupy to the superincumbent trachytes, we can see that at the time of the eruptions they presented a varied surface, mountains and valleys. Inasmuch as the volcanic flows have shown themselves to be very constant in their vertical dimensions, it may be deduced that the first drainage existing after their deposition, before the older formations had been entirely covered, will have followed approximately its old courses. In accordance with this view we find the distribution of the conglomerate. Northeast of the nearest metamorphic outcrops of the Quartzite group, we find the conglomerates of South River and its vicinity. Beyond that, down the Rio Grande, they disappear. Southwest of the group mentioned, the same formation occurs along the edge of the mountains. Again, we find that, in the neighborhood of the station 94 metamorphics, the conglomerate reaches an extraordinary development both horizontally and vertically. Following the outcrops of the conglomerate, and keeping in view its thickness, I would infer that it has been composed mainly of material derived from the range itself, and that those places affording the greatest facilities for its deposition by water at present show both the greatest areas and the greatest thickness of it. From the fact that, wherever found, the conglomerate is covered by subsequent flows of volcanic rocks, it must be inferred that its level at the time of these second eruptions was a very uniform one. Had it been deposited by flowing water only, this would scarcely have been the case; local accumulations would have raised hills at one point, while erosion would have produced depressions at another. It is probable, therefore, that the drift-material was deposited into a large body of still water. This would account for the characteristic features of the conglomerate analogous to such as are often observed in sandstones.

Considering the basalt, we meet with a difficult question. It is the one referring to its place of eruption. Are we to assume that the entire mass, some of which reaches to an elevation of more than 12,000 feet, should have flowed from such points of eruption as Mount San Antonio, 10,900 feet high, and subsequently have been raised to its present altitude? It certainly is possible, and would explain the general easterly dip of the Sawatch Range, but where the force producing this uplift came from, or where else it manifested itself, is not completely answered by the study of the surrounding country. We have farther to the northwest, a long distance off, it is true, high basaltic plateaus upon which stations (stations 3, 4, 5, 19, and 20) were located during 1874. It seems more probable to me that the lower strata of basalt that we find in San Luis Valley, and the strata of the southern end of the Sawatch Range, should have originated near those plateaus and extended southward to the localities where now we find them. All the more does this seem probable, as we find them in both places overlying the same trachytic strata, a direct connection between which can by far more readily be established. Those points of outflow that we find in San Luis Valley are essentially of local significance only, and although their influence is felt in the volcanic beds occurring in the valley, they have scarcely supplied the material for the beds that cover plateaus 1,200 feet above their own summits. So far as lithological characters are concerned no definite opinion can be reached, as the varieties at every point of eruption are exceedingly numerous, and among these varieties such will certainly be found that correspond with others from distant localities. Comparing the rocks from separated plateaus where they occur merely as a covering, or from the capping of mountains, will furnish valuable hints, but at a point like Mount San Antonio, for instance, almost every conceivable variation can be collected.

Besides the volcanics only the limited areas covered by metamorphic rocks occur in the range. As stated above, they indicate a corrugated surface at the time of the trachytic eruptions, and they owe their present exposure to their elevation during that period. Of interest the anticlinal fold under station 94 may eventually prove to be. It will be remembered that through the Quartzite group of the 1874 district, an anticlinal axis was observed to follow a course approximately east to west. Whether there could possibly be any connection between the two, obscured by superincumbent volcanics, I am unable even to surmise. In case there were, however, it would be an important matter to have the connection established. Probably Silurian and Devonian strata furnished the material that now we find as quartzites, granites, and schists. These formations have been so generally subjected to metamorphosing influences in that region of the Rocky Mountains, that the assumption referring them to the same origin seems justified.

CHAPTER IV.

THE SAN JUAN REGION.

The area treated of in this chapter contains the drainage of Rio San Juan, so far as falling within the limits of our district. The river itself will be considered from its headwaters down to its junction with Rio Animas. In speaking of the Sawatch Range in the previous chapter, a number of streams flowing into the San Juan have been mentioned, and their headwaters discussed. Besides these, however, there are others farther west that belong to the same drainage. During 1874 the sources of these were examined and reported on, so that where we meet them, in the district of 1875, along its northern boundary they are good-sized streams, carrying a considerable amount of water. Lying between the tributaries of the San Juan, we find the country to be very uniform in appearance. Two "belts," mainly, may be observed, the one at the immediate base of the mountains, the other between that and the river. South of the river the country becomes monotonous, both in its orographic features and its geognostic character. As will be seen in the subsequent pages, the recognition of geological formations in this southern portion of the district becomes a rather complex question.

DRAINAGE.

Beginning in the west with the streams and rivers flowing in a southerly direction, we first find the Animas. This heads near station 15 of 1874, about 14 miles above Baker's Park, flows from the station through a narrow volcanic cañon, then enters the park. There it receives a number of tributaries, among which the Cunningham and Mineral Creeks are the largest. After leaving the park it enters the narrow quartzitic cañon, known as the Animas Cañon, and emerges from that south of station 38 of 1874. Cascade Creek joins it from the northwest at that point. Flowing for some distance through a narrow valley, the river enters the Animas Park, at the lower end of which it receives the waters of the Rio Arenoso. By that time we have arrived in Cretaceous beds, which form a series of west to east hogbacks and broken ridges. Within these, Junction Creek flows into the Animas at the crossing of the old Ute trail. Below that the district of 1874 ends. We now find the river winding a serpentine course through a broad valley, hugging at times the bluffs on its eastern side. At station 51 it forms the junction with the Rio Florida, which, rising in the mountains farther north, flows in a southerly direction, until near station 50 it takes a westerly turn and joins the Animas. Thus far the general course of this river has been nearly due south, but now it bends off to the westward, and forms a junction with the San Juan about 10 miles below station 54. Below station 51 the river has no tributaries that carry water during the entire year. Only a few of them, probably, carry water during the early spring months and during the rainy season.

After leaving the light-colored bluffs and hogbacks near Junction Creek, the appearance of the surrounding country becomes very monotonous. To the west of the Animas long continued mesas stretch off into an apparently interminable distance, cut into bluffs and small hills near the border of the Animas Valley by streams that contain water only during a very short season of the year. A continuation of these is found on the east side. Generally the river hugs its eastern bank very closely there, which bank consists of yellow bluffs, composed of shales and sandstones. Local variations in the coloring enliven the scene from time to time, and are produced by different stages of oxidation of iron contained in the strata.

All along the river evidences are found of the ancient inhabitants that once populated the valley. Innumerable fragments of pottery, remnants of houses built of river-bowlders and mud, and watch-towers upon prominent points denote the former existence at that locality of a large number of people. South of station 53, on the west side of the Animas, a large town was found. On the north side of it walls and the remnants of what appeared to be ditches were observed. Fragments of chalcedony, jasper, and obsidian were strewn all over the ground, and some rude arrow and spear heads were found. Within the walls, which probably stretched across the valley from west to east formerly, were the ruins of the houses. All that remains of them to-day is either a circular or square, elevated mound, composed of mud and rounded bowlders, that have been taken from the river. Its outlines indicate the size of the building. In the center of this town was a very large structure of sandstone.* It was constructed in the shape of a horseshoe, with right angles, however, opening toward the south. About two-thirds of it still remain standing. It was originally four stories high, and the southern opening guarded by three concentric towers. It was found, upon examination, that the sandstone had been taken from one of the adjoining Tertiary bluffs, had been broken into rectangular pieces, the sides of which were smoothed by being rubbed with another piece of stone, probably also sandstone. The entire building was divided into small rooms or compartments, most of which had no light whatever. They are well preserved still in the lower stories. Their dimensions are surprisingly small, if it is to be assumed that human beings lived in them. Eight feet long, six wide, and four and a half high may be considered the average size. Denoting their use as human habitations, we find in some of them a triangular or square piece of sandstone placed in one corner, which served as a fireplace. Of the woodwork a large portion is preserved. Juniper obtained from the surrounding bluffs was utilized. Round beams are let into the wall at short distances from each other, and are covered with split pieces of the same wood, lying at right angles on them. This in turn is covered by a layer, again at right angles, of juniper-bark. Upon this is spread a floor of cement, from one to two inches in thickness. It is merely a mechanical mixture of sand and some of the friable, shaly marls occurring in the bluffs near by. In some of the compartments the walls and ceilings are covered with this same cement. Indians of the present tribes have adorned them with sketches representing themselves and their ponies, which they have scratched into the soft wall. An estimate made of the number of rooms that existed at the time when the building was still entire, resulted in the conclusion that it must have contained upward of 500 of them, a sufficiently large number, perhaps,

* Compare Report Exploring Expedition, 1859, Captain Macomb. Geology, by J. S. Newberry, 1876, page 79.

to accommodate all the inhabitants of the surrounding town in case of war or danger from invasion. Taking this view of the case, I have given that ancient town the name of Acropolis. It is interesting to observe the accuracy of the angles in the wall, in the rectangular doors, and in the few windows that furnish light to some of the larger rooms. At first sight the care with which the building had been constructed, and the regularity of design and execution visible in every detail, suggested to us the idea that Spaniards might have had something to do with its erection, and that we had before us, perhaps, the ruins of an ancient mission. Upon very careful examination, however, not even a trace of the use of any metal tool or instrument could be found. The beams were cut off perfectly smooth, but showed no marks of cutting whatever, and all the stones were smoothed off in a manner that would not have been produced by metal tools. No metal of any kind was observed in the building itself, willow thongs supplying the places of nails and bolts. In the court-yard heaps of broken pottery were found, some of them showing very pretty designs. The only specimen that could be regarded as a household article was a stone, such as many of the present Indians, more particularly the Moquis and allied tribes, use for grinding their corn. It is natural that at a place where our present Indians pass so frequently, no entire pieces of pottery will be found, except by excavation. Whatever may be exposed to view and appear serviceable to them they will appropriate to their own uses.

This brief description has merely been given, because I am not aware that any other members of this survey visited the same locality. It is not my province to discuss archæological matters, I will therefore refer for information on this subject to United States Geological Survey Bulletin, March 21, 1876, which discusses at length the by far more complete discoveries made farther west. It is of interest to know the eastern limits reached by this ancient people, and mention shall therefore be made at the proper place, of observations made which indicate their presence at any given point.

East of the Animas is the Rio Pinos. It heads near station 21 of 1874, and flows about southwest for some distance. At first it passes through the metamorphic quartzites of the high mountain group of the same name, then enters Carboniferous, and afterward Cretaceous sedimentary beds. On the west side of the Pinos is Rio Vallecito, bringing a good supply of water into the former. Below station 48 the stream receives no tributaries of any importance. From there downward it passes through the same beds of sandstone and shale that we find on the Animas, and it is their lithological constitution that prevents water from running any considerable distance in them. Beds in which creeks flow during some seasons of the year, show that at those times large quantities of water pass over them, but for the greater portion of time they are dry. The Pinos joins the San Juan at station 58, which was located on a bluff, immediately south of the latter. Regarding the character of the country through which Rio Pinos flows, it may be said that it closely resembles that of the Animas region. Starting in the deep, rugged cañons of the Quartzite Mountains, it emerges from them into the densely timbered hills of the Carboniferous area. Thence it reaches the Cretaceous beds, cutting cañons into the sandstones and precipitous gullies into the higher, soft shales. After leaving the latter, it enters the regions of bluffs, of sandstone and of shale, there confining itself to a comparatively narrow cañon, and losing in its volume of water as it advances southward.

Rio Piedra, east of the Pinos, is the most important tributary of the

San Juan. Its headwaters, consisting of a number of streams of almost equal size, have been described in Chapter III. After leaving the trachytic mountains these streams flow through very fine valleys.

West of station 40 they have all joined, and the Piedra has attained considerable size. Two more creeks flow into it from the northeast, the Rio Nutria being the larger one. This heads south of station 38, in the Cretaceous shales, and remains within their area for nearly the entire length of its flow. South of it the Post-Cretaceous bluffs set in. The Piedra flows into the San Juan at station 67, after having passed through a broad valley, trending north to south. Higher up it is inclosed in cañons formed by Lower Cretaceous beds.

East of the Piedra we find the San Juan itself. It rises near station 19 on the continental divide and keeps, throughout its entire course (so far as in our district), a general southwesterly course. After leaving the western edge of the Sawatch Range, it flows through Cretaceous strata, belonging mostly to Nos. 2 and 3. In these, Pagosa Springs are located, the largest hot springs in the district. They are famous among the Indians and well known to American and Mexican settlers. One of the former built a cabin at their edge, but the Indians burned it for him, preferring, as they informed us, to retain the "*agua caliente*" for their own personal use. At the proper place a description of these springs will be given. About 13 miles below them, near station 74, Rio Blanco flows into the San Juan from the northeast, and 15 miles lower down Rio Navajo joins it. Both these last-named streams have a considerable drainage area, considering their length and size. From this last junction downward the river makes many curves, flowing a little more to the west than higher up. It receives large quantities of water from the south, during certain seasons of the year, but at the time of our visit, August, they were all dry, and water could only be found in springs, or small pools.

South of station 54 on the San Juan another ruined town of the ancient inhabitants of that region was found. It resembled, in the arrangement of its houses and the "castle" in the center, the city and ruins discovered on the Animas. The river had washed away a portion of the stone building, and on its banks a number of interesting facts were observed. Fire seems to have destroyed at least part of the building. Gradually the river deposited about 10 feet of sand and silt in the court-yard and in the northern chambers, which it probably reached through the windows or doors. At that depth below the surface a layer of what at first appeared to be charcoal was observed, 2 to 5 inches in thickness. Upon examination, however, this proved to be Indian corn, still unhusked, but completely charred. Probably the chamber thus cut by the river, which exposes its section, was used as a granary. Beyond that, along the same vertical bank of sand, innumerable fragments of pottery, bones of deer, of rabbits, and what appeared to be sheep, were found. Had it been possible to spare more time, I am confident that excavations at that locality would have developed many interesting facts. The time that it must have taken the river to wash away one-third of the building, which probably was not erected immediately upon its banks, must have been considerable, but in spite of such evidence as this, it has been impossible for us to assign, with any semblance of correctness, any definite age to these and other ruins. An estimate, little better than a guess, may claim for them an age, as ruins, not much exceeding 300 years.

In the subjoined pages the discussion of the district is divided according to formations, as they furnish a better basis for classification than the drainage, and are sufficiently characteristic at the same time to connect regions of the same orographic features.

A synopsis of the approximate lengths of rivers and their tributaries occurring in the region to which this chapter is devoted, may give some idea of the relative areas they drain. Only the main branches of the tributaries of the San Juan are taken, because it is they that determine the horizontal extent of the drainage, and not the small creeks flowing directly into the main stream. The northern and northeastern portion of the section is well watered; but as soon as the Post-Cretaceous beds are reached, a change takes place, owing mainly to the lithological character of the strata composing the bluffs and mesas.

Main tributaries.

Name of river.	Length of river in miles.	Length of main tributaries added.	Total length of main drainage.
Rio Animas	115	157	272
Rio Pinos	52	28	80
Rio Piedra	58	92	150
Rio Blanco	32	16	48
Rio Navajo	48	23	71

Branches of main tributaries.

		Length in miles.
Animas	Mineral Creek	16
	Cascade Creek	18
	Rio Arenosa	30
	Junction Creek	17
	Rio Florida	56
Pinos	Rio Vallecito	28
Piedra	Weeminuche Creek	22
	Rio Huerto	21
	Dead Man's Creek	19
	Rio Nutria	30
Navajo	South Branch	23

The length of Rio San Juan to its junction with the Animas is about one hundred and forty miles, and the sum of its entire main drainage amounts to 621 miles.

CRETACEOUS.

Cretaceous beds cover a considerable area in this section of the district. Resting against the base of the mountains toward the north and northeast, we find the Dakota group. It is strongly developed south of Weeminuche Creek but soon disappears, being covered at many localities by the younger trachorheïtic beds. In some of the cañons that cut deeply into the volcanic mass the characteristic sandstones crop out, but upon reaching the base proper of the mountains we find them covered by the shales of the Colorado group (Cretaceous No. 2). This latter comprises a by far greater area than the former, extending for a long distance from east to west. Many of the streams heading in the Sawatch Range flow through its strata, cutting deep, narrow gorges and ravines, or producing valleys of but limited breadth. In discussing the group, it will be observed that its main features are very closely related to those given from the Rio Animas region in the report of 1874. They differ, however, from those described as occurring along the base of the Front Range. It has been impossible to retain the systematic division of the Cretaceous here that is applicable to the same formation farther east and northeast. Three groups have eventually been decided upon: Dakota, Colorado, and Fox Hills. The first of these includes the heavy beds of white and yellowish sandstones, containing narrow interstrata of shales and thin seams of a hard coal in its upper members. To the Colorado group we have assigned the heavy strata of dark gray shales with characteristic fossils. The Fox Hills group comprises the series of yellow and greyish shales interbedded with sandstones and showing a number of good coal-beds.* Above these we find in a continuous section the lower members of the Tertiary formation, which farther south reach a very considerable development, and become of the greatest interest to the palæontologist. In the district assigned to us we were not fortunate enough to find any vertebrate remains in these formations, probably being still too low down in the succession of strata. A number of interesting stratigraphical relations were noticed in the Cretaceous beds under discussion, and they will be referred to at the proper place in the subjoined pages.

Dakota group.—Outcrops belonging to this group were first noticed after having crossed Weeminuche Pass. In the district of 1874 the sandstones belonging to it were overlying the Carboniferous strata, crowding out the latter more and more as we proceeded northward along their western edge. After leaving the metamorphic granite, which contains the headwaters of Weeminuche Creek, we found a series of thinly-bedded yellow sandstones exposed in a narrow ravine. They rested immediately upon the granite, and bore evidence of having been subjected to altering influences. Thin layers of greyish-brown, sometimes laminated, shales appear, together with the sandstones, until both are lost under the glacial drift of Weeminuche Valley. On either side the lower portions of the bluffs or mountain slopes, inclosing this valley, are composed of the same sandstones. From there they continue southward, forming the rounded ridge which runs approximately parallel with the general course of the Piedra west of this river. Densely wooded as it is, the ridge affords but little facility for the study of structural geognosy. So far as could be learned, the dip of the sandstone strata is toward the southeast, at an angle of 4° to 7°. From here it connects, turning westward, with the outcrops of the Dakota group in the 1874 district. Newberry † speaks of these sandstone strata being on their exposed surface "cut by joints into blocks of nearly uniform size." This characteristic feature is certainly noticeable, and is the result, probably, of metamorphosing agents primarily, the effect of which has been increased by subsequent action of water both in a liquid and frozen state. I have been unable to determine any definite relation of these "cleavage-planes" with either the dip or strike of the sandstone strata. Nor do I regard the phenomenon as essential to any one formation in particular. It is merely the expression either of metamorphosis, or a certain kind of pressure, or both.

All along this ridge the thickness of the Dakota group reaches over 1,000 feet. As farther west, so here, the upper members show greater variety of lithological constitution. Strata of shales, some of them showing indications of coal set in, forming, as it were, a transition to the heavy beds of shale belonging to the Colorado group.

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* Report United States Geological Survey 1874, p. 223.
† Report Exploring Expedition Captain Macomb, 1859–1876, p. 77.

A short distance southeast of station 36 the Dakota sandstone is entirely covered by trachorheïtes. We do not again find it along the western edge of the mountains, until we reach, farther south, the cañons that have cut down deeply, removing the superincumbent beds and exposing the Lower Cretaceous. Unless local disturbances, of small extent only, have taken place, we find the dip of these sedimentaries to be away from the mountains. The sandstone, which is comparatively yielding to active erosive influences, forms narrow cañons with steep walls. At many localities, besides the one under discussion, this may be regarded as a regularly-recurring feature. Although in many instances, of course, erosion by flowing water, or by glaciers, has widened the valley composed of or walled in by these sandstones, it is not the rule, but rather an exception. But a short distance from the mountains, the Colorado shales regularly set in.

Traveling along the base of the mountains in a southerly direction, we no longer find any outcrops of the Dakota sandstones. They are either covered by the volcanic rocks, or by the avalanchial and glacial drift immediately at the western foot of the Sawatch Range. On a northern tributary of Rio Blanco we met with the first exposure again. It was found in a small cañon leading up toward station 77, and there the yellow sandstones were exposed along the bed of the creek. No local disturbance was noticed, and the beds had the prevailing general dip toward the southwest. Following up Rio Blanco we find the same outcrop again, appearing in its upper valley. At these localities the sandstones cover but a small area, as they are soon hidden from sight by the volcanic beds on the east and the shales of the Colorado group on the west. A more extensive exposure can be observed in the upper valley of the Navajo. A prominent ridge, Sierra del Navajo, forms a detached spur of the main range, and having a trend north to south, permits the formation of a valley between itself and the range. In this valley the Dakota sandstone flanks its edge, while near the center it is overlaid by Colorado shales. An anticlinal fold, occurring a short distance farther off toward the southwest, has changed the dip, making it slightly to the east, or very nearly horizontal, instead of westward. After leaving this narrow valley, the sandstone soon disappears under the volcanics. We again notice it in the upper valley of the Chama. At its exit from the mountains this river flows through a narrow cañon with vertical walls for a short distance. This is formed by Dakota sandstone. From there it extends northward, covered on either side by trachyte, until its outcrop is lost under the morainal deposits of Conejos glacier. So far as could be observed, the dip was a westerly one, although slight. Professor Stevenson* mentions Carboniferous strata "in an almost vertical position" as occurring on the trail from Tierra Amarilla to Conejos. I did not pass over the trail, but from analogy with the exposures farther north, along the range, I should feel inclined to question the identification as Carboniferous.

In our district there is but one more outcrop of the Dakota group. This occurs west of station 94, between the Chama and the Brazos. Dipping steeply from the high quartzitic mass upon which the station was located, the sandstones fall off toward the Tierra Amarilla Valley. They are covered in part by basalt, which again appears on small tables in the valley itself. The road from Puenta to Nutritas passes over such basalt, although there it covers shales of the Colorado group. Only for a short distance, flanking the mountains and then extending down along the river-beds, does the Dakota sandstone there appear within the limits

* Explorations and Surveys West of the One Hundredth Meridian, 1875, p. 375.

of our district. It seems, judging from what was seen from some distance, to extend farther south, in the same relative position. At the base of station 94 it dips steeply to the westward, but is soon covered by the grey shales which form the level of the valley. Agricultural pursuits are followed by the Mexicans who have settled the region, and we were informed that the rich soil was productive of good results. A sufficiently large supply of water is at hand to answer for purposes of irrigation.

Colorado group.—This group is by far more varied in its occurrence as well as in its stratigraphy than the preceding one. It covers a large area and displays many features of interest to a geologist. In 1874* the shales belonging to this division of the Cretaceous were first found on Junction Creek. From there they extend eastward, forming in the region of the Nutria, San Juan, and Blanco, the bases of the broad valleys through which these streams flow. It has been mentioned above that the shales extend to the very edge of the mountains at a number of points, and directly underlie the trachyte, in that case excluding exposures of any of the lower strata. A general southerly dip of the beds can be observed, but quite a number of minor disturbances have locally changed this. A general shallow fold, extending from west to east, which involves these shales, will be discussed in the subjoined pages. Although its dimensions vertically are but small, the effect it has had upon the entire region cannot be overlooked, and the knowledge of its existence is necessary for the proper understanding of facts observed.

We first found the shales of this group overlying the Dakota sandstone south of station 36. They are exposed all along the valleys and low divides separating the northern tributaries of the Piedra, west of station 36. Dark grey when fresh, they change to almost white upon being subjected for a long time to atmospheric influences. Efflorescence of alkali at many localities produces "salt-licks," the favorite resort for game. Station 37, which is located upon an isolated remnant of the trachyte farther east, is entirely surrounded by these shales; creeks and streams cut down steeply into the yielding material, producing precipitous banks. Frequently very fine carving, by water, can be observed on the sides of bluffs or hills, resembling *en miniature* regular mountain ridges. Slight changes of color, varying from different shades of grey to brown, produce in such an instance an exceedingly picturesque effect. *Inocerami* and *Ostreæ* occur in abundance in the shales all along its outcrop, the former, however, most frequently in fragments only.

Station 40, 8,374 feet above sea-level, is located south of the Piedra, on a small knoll composed of Colorado shales. From there they extend westward to the wooded ridge east of Piedra, overlying Dakota sandstone, which composes the latter. A dip of 4° to 6° was noticeable to the eastward, forming most likely a shallow synclinal, the eastern edge of which is obscured both by the drift at the base of the mountains and by the superincumbent volcanics. Fossils were found here identifying the strata. Crossing a low divide we reach Rio Nutria, and find that it flows entirely in these shales. Isolated strata of sandstone occur in their upper members and form cappings for low bluffs and tables that occur along the higher portions of the region. About nine miles southeast of station 41 we strike the Rio San Juan. At that point Pagosa Springs are located. Among the Indians of the region the waters of these springs have become very famous. Their high temperature, perhaps, too, the mineral constituents they hold in solution, have won for

* Report United States Geological Survey 1874, p. 224.

them the unqualified admiration of the natives, so far as medicinal properties are concerned.

A wide basin, approximately oval in shape, about 30 feet wide and 40 feet long, contains the bubbling water. This basin is 10 to 12 feet deep, and the water a deep greenish-blue color. A very extensive deposit has been formed by the spring, which is evidently growing smaller, and shifting its location from east to west, toward the river. A number of other springs, in connection, probably, with this main one, were at one time scattered around it; but now the orifices through which they discharged their waters into the basins have become choked up, the basins have dwindled down to mere cracks, owing to the long-continued depositions of tufa, and where they once flowed we find nothing to-day but a small opening. From the main spring the water flows off through a subterranean passage into the San Juan. The banks of the river are there formed by the tufaceous deposit, a portion of which can be observed on its western side also. This leads to the inference that the San Juan has changed its course since the formation of the springs, and flowed farther west formerly. Taking a section through the spring, along its shorter dimensions, (Fig 1,) we perceive at a glance how its ultimate destruction will be accomplished. In the center of the spring a cone-shaped deposit is gradually growing, reaching at present about 9 inches above the level of the water. Through orifices in this cone, both below and above the water's surface the hot jets issue, depositing more and more of the tufa. Along the entire edge of the main basin subordinate springs boil up, and have formed their own little basins, connected either below, or at the upper opening, with the large body of water. The accompanying diagram (Fig. 3) will give an idea of the outlines of the main basin, of the small ones surrounding it, and of the points of outflow for the waters through fissures or tubes in the tufa. This latter is composed chiefly of carbonates of lime, soda, and potash, sulphate of lime, and crystallized sulphur. Gases escape in great volume, consisting of carbonic acid and sulphureted hydrogen.

Professor Newberry * describes this spring and dilates upon the beauty of its surroundings, prophesying that "in future years it will become a celebrated place of resort." Certainly there are very few hot springs that are located as favorably, so far as scenery is concerned, but it may be many years before the Indians and facilities for transportation will permit invalids or pleasure-seekers to derive benefit or enjoyment from them.

The temperature of the main basin is higher than that of the smaller ones surrounding it. As given by Newberry and Loew, † it compares favorably with my own observations:

Newberry, July 28	140° F.
Loew	141° F.
Endlich, August 11, 6 p. m	138° F.
Temperature of atmosphere	70° F.
Endlich, August 12, 7 a. m	138° F.
Temperature of atmosphere	56° F.

The temperatures of the smaller basins range from 110° to 115° F. Although no doubt a very warm season of sufficient length of time would have some effect on the temperature of the main spring, the difference observed in atmospheric temperature between evening and morning produced no change. This is due, probably, to the very rapid influx and

* Report Exploring Expedition, 1859, Macomb, 1876, p. 74.

† Report Explorations and Surveys West One Hundredth Meridian, vol. iii, 1875, p. 626.

egress of water from the basin and to the fact that the thermal agents upon which the high temperature of the water depends are very constant in their action.

An analysis of the main spring given by Dr. Loew* furnishes the following result:

In one hundred thousand parts of water are contained—

Sodium carbonate	4.70
Lithium carbonate	0.71
Calcium carbonate	59.00
Magnesium carbonate	4.85
Potassium sulphate	7.13
Sodium sulphate	221.66
Sodium chloride	29.25
Silicic acid	5.70
Organic matter	Trace.
Total solid constituents	333.00

Analyses of three of the smaller springs give results closely agreeing with those obtained from the main spring, indicating their common origin. Professor Stevenson† gives an elaborate description of the tufaceous deposit, and the minor details of the various openings and "blow-holes" that are scattered throughout the former. To his report I would therefore refer for information regarding such features.

Pagosa Springs have their origin, probably, and appear at the surface in shales of the Colorado group. In the same shales, about a mile below Pagosa, there is another mineral spring, of small dimensions, however. It is located at the base of a bluff and sends its water directly into the San Juan. It is a fact well known to geologists that the shales of the Colorado group are productive of many mineral springs, but it is exceedingly difficult, if not altogether impossible, to explain satisfactorily the reason why the water should have so high a temperature. The ancient theory of reservoirs extending down to the regions of perpetual heat, and sending their waters upward for miles through narrow tubes or fissures, has long since failed to explain the origin of hot springs. It seems to me that in this particular instance we have some process of chemical alteration going on in the Colorado shales whereby not only heat is produced, but the mineral constituents of the shales rendered more soluble for the percolating waters. These latter becoming heated during their passage through the portions affected by a process of chemical metamorphosis, find their way to the surface, as any other springs would, at the nearest point offering the greatest facilities for egress. This assumption, *i. e.*, that hot water is in contact with the products of chemical decomposition, would account for the large percentage of mineral constituents in solution, even though the passage through the shales should be but limited as to length. It is always a matter of difficulty to explain the origin of heat for warm springs, and the above view is presented merely as the most probable solution of the question in this particular instance.

Near Pagoso Springs a local anticlinal fold was observed in the shales. A section, (Section X,) taken from station 78, looking westward will explain the relative positions taken by the shale, the superincumbent Fox Hills strata, and the volcanic beds. The Colorado shales (*a*), 1,000 to 1,200 feet in thickness, form a valley along one of the small tributaries

* *Ibid.*, p. 627.

† Report on Explorations and Surveys West of One Hundredth Meridian, 1875, vol. iii, p. 478.

of the San Juan. *Inocerami* and *Ostreæ* are found abundantly in them. They dip both north and south at angles of 9°. Above them occurs a stratum (*b*,) consisting of yellowish, shaly sandstone, with indistinct remains of plants. It is about 250 feet in thickness, dipping in both directions as the underlying shales, but at a decreased angle. This I regard as the same that we found on station 47 of 1874,* where it contained innumerable fragments of *Inoceramus*. Overlaying the sandstone there are 850 feet of yellow-grey shales, sandy in part (*c*), that I regard as belonging to the Colorado group, having found fossils characteristic of that horizon. This in turn is capped by 250 to 300 feet of a yellow to reddish sandstone (*d*), forming a prominent bluff, upon which station 75 was located, at an absolute elevation of 8,064 feet. Here the southerly dip has decreased to 6°. With this sandstone I commence the Fox Hills group. At the north end of the section, trachytic conglomerate (*e*) overlies the shales, and trachyte (*f*) covers the former. Traveling northward from the junction of Rio Blanco with the San Juan, I at first assumed the occurrence of the two groups of shale, *a* and *c* to indicate a fault. Having passed the anticlinal axis, however, in the lower shales, I found the series *c* repeated farther north, and no evidence of any other disturbance than that produced by the fold. On the San Juan, below its junction with the Blanco, this section can be studied with greater success, as the beds there become nearly horizontal, dipping southward only 3°. Local disturbances, produced, probably, by subsidences, occur quite frequently; are of small extent however.

Below the junction of the two rivers the beds above the lower shales increase in thickness. A section constructed there would show the following result:

4. Yellow and white sandstones. Lower strata massive, white; upper interstratified with shaly sandstone and shales, yellow	350 feet.
3. Greyish-brown and yellowish shales, containing *Inoceramus* and *Ostrea* within 400 of the upper sandstone	1,200 feet.
2. Yellow sandstone, fine to middle-grained, interbedded with thin strata of shales	230 feet.
1. Dark grey shales, weathering lighter, containing fossils	1,100 feet.

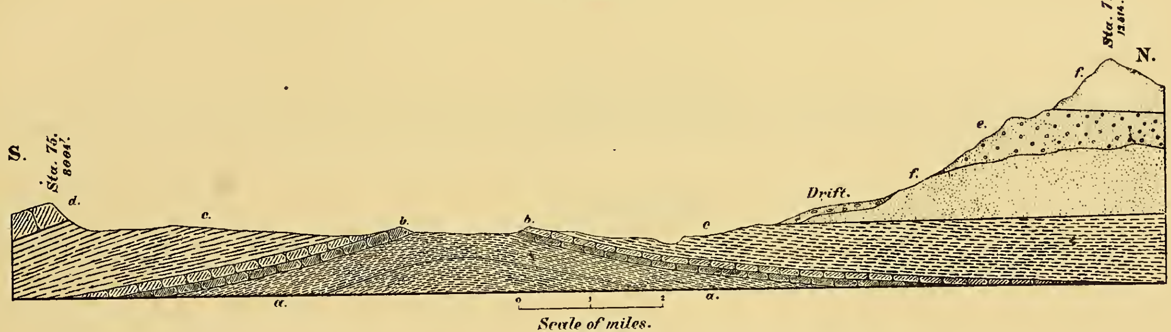
We have, therefore, in this region a total thickness of about 2,500 feet for the Colorado group. This is greater than farther west, but it has frequently been observed that shales of this character either gradually merge into sandstones, or that sandstones, losing their character as such, may turn into shales. Difference of thickness, even within comparatively limited districts, can consequently not be regarded as a safe criterion upon which to base or reject identification.

Leaving Rio Blanco, and traveling southeast, we remain within the borders of the Colorado group. Station 63 is located east of Rio Navajo, on a remnant of trachorheïtes, that at one time was in connection with the main body farther east. It has an altitude of 9,905 feet, and is surrounded by Cretaceous beds. A section (Section XI), taken from the ridge on the south side of the Navajo through station 63, shows an anticlinal fold very similar to that observed west of Rio Blanco. As there, the Lower Colorado shales (*a*) form the base of the valley, dipping both north and south at angles of 8° to 10°. Overlying them we find a yellow sandstone (*b*) about 200 feet in thickness, which in turn is covered by yellowish-grey, partly sandy shales (*c*). Upon these, which are capped unconformably by the volcanic rock (*d*) of station 63,

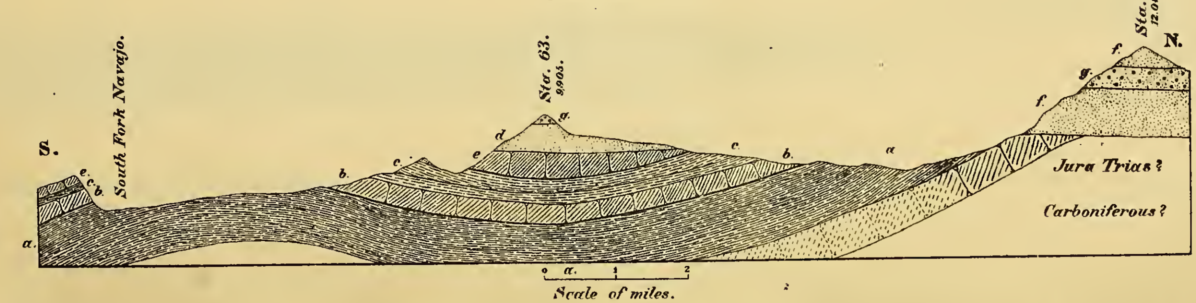
* Report United States Geological Survey, 1874, Section VI, p. 224.

Plate XXVI.

Section X.



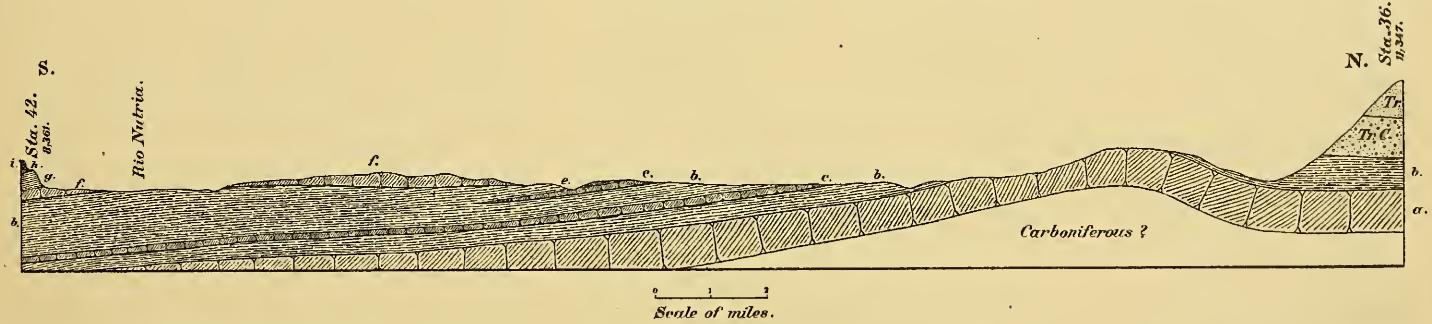
Section XI.



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

Plate XXVII.

Section XII.



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

rests a heavy bed of sandstone (*e*), a small portion of which appears to crop out east of the station. In that direction the dip of the strata gradually decreases, until eventually, at the immediate base of the mountains, it inclines westward again, and is then soon hidden from sight by the overlying trachyte (*f*). Whether this anticlinal fold is in direct connection with that given in Section X I am unable to say, but presume that a connection could be traced, subject probably to many local variations of the angle of dip.

Viewing this group as a whole from the Piedra southeastward to the Navajo, we find that it must be regarded, stratigraphically, as a very low anticlinal fold, the axis of which runs east of north. At the same time the gentle southerly dip of the sedimentary strata throughout that region does not disappear, but combining with the easterly and westerly dips on either side of the axis, produces an effect that at first is decidedly puzzling. Local dips also greatly affect the youngest Cretaceous group, the Fox Hills series, which will be discussed further on.

Southeast of station 63 is the valley of the Chama and its tributaries. It is formed by shales of the Colorado group. These are covered mostly by the Fox Hills sandstones, which gave occasion for the formation of the high bluffs to the south and southwest. Near the settlements in the valley small tables or mesas occur where basalt overlies the shales. They are of limited extent, and fall beyond the southern border of our district.

Here the area of the Colorado group ceases, so far as contained in the section to which this chapter is devoted. A comparatively arbitrary division of the entire Cretaceous formation had to be made in order to arrive at any acceptable classification whatever. Owing to the gradation of sandstones into shales and marls and *vice versa*, the five established Cretaceous groups of Meek and Hayden could no longer be recognized, and a different application of the group-names was necessary. So far as the names applied to the three groups are concerned, they are parallel to those of other regions, and indicate as nearly as possible the same geological ages.

Fox Hills group.—Resting conformably upon the Colorado shales, we find the shales and sandstones of the Fox Hills group. They cover quite an extensive area along the northern drainage of the San Juan, which area is terminated on the north and east by the appearance of lower Cretaceous, on the south by Tertiary beds. On the Animas a good section of all the strata, from the Carboniferous upward, is exposed. We find there that the hogback-ridge upon which station 44 of 1874 is located is formed by a yellow sandstone belonging to the Fox Hills. South of this a number of lower hogbacks, composed of Cretaceous shales and sandstones, occur, until we reach the base of the Puerco marls. A section (Section XII) taken from station 36 to station 42 will give some idea of the arrangement of the strata. Underlying the Colorado group are the yellow to white Dakota sandstones (*a*). Above them follow 1,000 feet of dark grey shales (*b*), containing two interstrata of sandstone (*c*). These shales reach a greater vertical development as we proceed eastward, and remain either the same or decrease as we go farther west. Above the second sandstone 700 feet of lighter grey shales (*e*) set in, belonging still to the Colorado group. They are capped on a small hill north of station 42 by 400 to 600 feet of yellow argillaceous sandstone (*f*), the base of the Fox Hills. Passing southward over this rise, we descend into the valley of the Rio Nutria, which runs in the lower shales. Facing northward is a bluff about 1,400 feet high. At its foot we find the same sandstone (*f*), overlaid by 900 feet of yellowish-grey shales (*g*). They show considerable variation of color, changing from the subdued yellow and grey shades to reddish orange and brown. At many places within these 900 feet of shale it becomes so sandy as to pass for a very argillaceous sandstone. Indistinct remains of plants are found there. About 150 feet of sandstone (*h*) cover the shales. There is here no evidence of the Puerco marls, unless, indeed, the colors, red and pink, of the overlying sandstone (*i*) should furnish an indication of them. With this latter I commence the Tertiary series. In the entire region under discussion shales, marls, and sandstones so gradually merge into each other that the local absence of any member, that is elsewhere found in the same horizon, is not surprising. More particularly in the horizontal direction does this change take place, less in the vertical. Assuming for the Dakota group a thickness of about 1,200 feet, we find the entire vertical dimensions of the Cretaceous to amount to about 4,500 feet in this locality. Within short distances, even, this changes considerably, however. One or the other series of shales or shales and sandstones may dwindle down to comparatively an insignificant thickness, while on the other hand it may be increased.

About eight miles west of station 42 the old trail leaves the Nutria, and taking a more direct course, crosses the Piedra some distance above the junction of the two streams. South of the trail we find, on the summit of a prominent hill, an isolated column of sandstone and shales (station 44). To explorers this landmark, La Piedra Parada, has long been known.* It rises as a column to a height of over 400 feet, and is made still more conspicuous by the position it occupies.

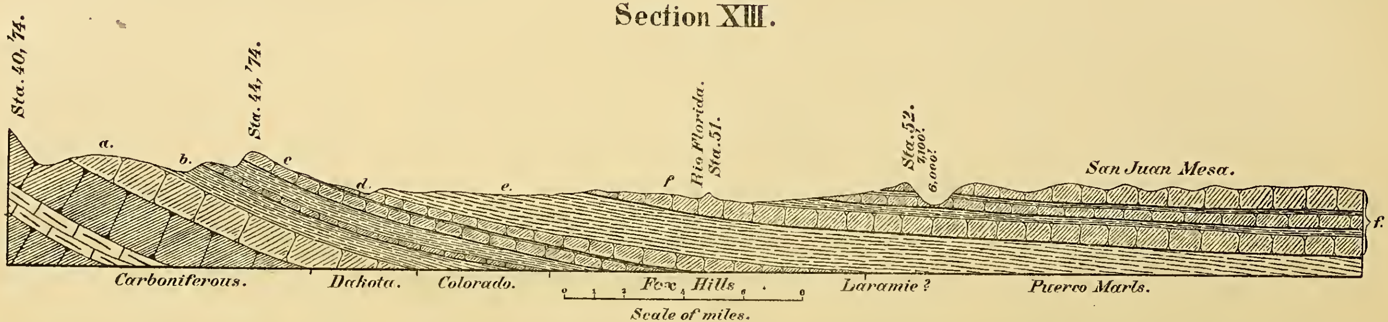
Southwest of the Rio San Juan the Cretaceous follows the base of the Sawatch Range. By the numerous streams there, the once connected plateaus are cut into fragments. Local disturbances, of but small extent, however, have produced changes in the general southerly dip. They have been mentioned while speaking of the Colorado group. It seems possible that a large portion of this former plateau was at one time covered by basalt. Station 64 is located on the southern edge of the Cerro del Navajo, the entire summit of which is covered by basalt. At that point the elevation is 9,115 feet, while on the same horizon, about 15 miles farther southwest, it is 9,019. The niveau, in that direction, has undergone but slight changes. An unbroken bluff is presented by the strata of the Fox Hills on the western side of the Chama Valley, and on its southwestern slope, in the valley, we find a lake (Laguna de los Caballos) very nearly on the continental divide, which here has an altitude of but 7,700 feet. This is one of the lowest, if not the lowest continental pass in the UnitedStates.

To the north and northeast of the bluff mentioned, there are several remnants of the ancient plateau, separated from each other by the outcropping, underlying Colorado shales. Station 63 is one of the highest points in the valley there, and owes its present altitude to a protecting cap of trachorheïtes and trachytic conglomerate. Ascending it, we pass through westward-dipping shales of the Colorado group, then reach the shales and sandstones of the Fox Hills, and finally arrive at the trachyte. The anticlinal fold described as occurring in the valley of the Navajo extends eastward to this locality, and is shown by a slight convex curving of the strata. Barometric measurement determined the summit of the mountain to reach an altitude of 9,905 feet. Could we assume a perfect connection of all the scattered outcrops, which connection existed at the time the Tertiary beds were deposited and the later volcanic rocks

* Compare Report Exploring Expedition J. N. Macomb, 1859, 1876, p. 78.

Plate XXVIII.

Section XIII.



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

were ejected, we would infer that the plateau then existing was, to a large extent, covered with trachorheïtes. From the evidence furnished by station 63, it would appear that then already the dip of the sedimentary strata was a westerly one. After the flows of lava had covered the plateau, that period followed during which the trachytic conglomerate was formed. This would have accumulated, as usual, in varying thickness, at places best adapted for its reception. Subsequent to the trachytic flows were the basaltic ones, and we would have but a repetition of the succession observed at the southern end of the Sawatch Range. Could this be established, the interesting question as to the former connection of the San Luis basalts with those of Tierra Amarilla would be solved. I am inclined to accept such connection, and hold that it was eventually broken by the gradual elevation of the Sawatch Range. This breaking of superficial strata produced cracks and fissures which were utilized by water, and thus the process of erosion and transportation was greatly augmented. How far south the volcanic capping may have extended over the ancient plateau I am unable to say, but I do not think that it was for any great distance. Under the basalt of the Cerro del Navajo we find no trachyte. It is true that this may be owing to erosion during the post-trachytic period before the eruption of basalt, but this view is not warranted by the observations made. Most likely the trachyte "pinched out" gradually as it extended southward, and the subsequently ejected basalt flowed beyond the limits of the former.

TERTIARY.

Quite an extensive area is covered by Tertiary beds in the district of 1875. It has been mentioned above that the Puerco marls of Cope* form there the lowest member of the Wasatch group. They were best observed on the Lower Animas. A section (Section XIII) running along the eastern side of the Animas will demonstrate the succession of the strata. Resting upon the sandstones of the Dakota group (*a*) we find the Colorado shales (*b*). They are covered in turn by a series of shales and sandstones (*c*) belonging to the Fox Hills. This group is closed by a heavy bed of yellow sandstone (*d*). Above that follow 1,000 to 1,200 feet of variegated shales and marls (*e*), the Puerco marls. At the base they are a muddy green, changing into yellow or almost blue. Farther up, pink, pale orange, lilac, and reddish colors predominate, varied by interstrata of white or light yellow. Thin beds of sandstone merely of local occurrence, however, separate these beds; not, forming definite, recognizable horizons. I have no doubt that this group, thoroughly characteristic in its physical features at least, is the same one which Cope found in New Mexico and of which he says: † "The discovery of the variegated marls was one of no little interest to the writer, inasmuch as I had made special efforts to find Eocene beds in this region, and they were now crowned with success;" ...... "the thickness of the strata exhibited in the walls of the Cañoncita de los Vegas I estimated at 1,200 feet;" ...... "the red and grey marls, with alternating beds of white and yellowish sandstone, appear on their summits (of the red sandstones) and ..... form a mass of bad-land bluffs from 600 to 1,000 feet elevation." In my field-notes for 1875, I state: "The sandstones,

*Annual Report of Explorations and Surveys West of the One Hundredth Meridian, Appendix 44, 1875, p. 88.

†Annual Report of Explorations and Surveys West of the One Hundredth Meridian, Appendix 44, 1875, p. 89.

sandy shales and marls of this group weather very much like the formation of the 'bad-lands.'"

Professor Newberry* regards these marls, as well as the overlying sandstones, as Cretaceous. Cope is positive in his identification as Eocene, however, and by comparing carefully the descriptions, &c., given by Newberry and Cope with my own observations, I do not doubt that we have on the Lower Animas the same formation in which Cope found (p. 89) "a lower molar of *Bathmodon*." A section given by Newberry, taken near his camp, (46,)† shows the same general arrangement and physical character that has been noticed by Cope, Holmes, and myself. Farther east these variegated marls gradually change into shales and sandstones, so that they are no longer characteristic. Above them we find in our section about 1,000 feet of yellow to brown sandstones and shales (*f*). As a rule the beds of sandstone are heavy, weathering massively, but they frequently show but small thickness and are interstratified with yellow and greyish shales. In some of the shales indications of coal may be observed, but nowhere throughout the San Juan region was any vein found that would have been sufficiently large or of good quality to be worked.

All the lower cañons of the San Juan drainage, and that of the river itself, are formed by this series of sandstones and others superincumbent. Over the entire region which they cover, they are uniform, both in occurrence and in lithological character. Their very small dip to the south, 2° to 4°, and their total thickness of about 3,000 feet, enables them to extend over a large area of country, so long as neither of these conditions are seriously changed. Farther south than our investigations carried us, Cope has discovered higher Tertiary beds that yielded vast numbers of fossils of unique interest.‡ Within the borders of our district we found none, excepting some poorly preserved leaves and silicified wood.

In its highest members (so far as seen by us) the sandstone-shale series becomes more changeable. Interstrata of shales and marls occur, mostly yellow and grey, containing coaled remains of plants, and, in several instances, finely developed beds of selenite.

VOLCANICS.

Volcanic outcrops are but local in this region of the Cretaceous and Tertiary. A number of dikes were observed, besides the capping of the Cerro del Navajo. The latter is composed of a black, vesicular basalt, about 250 feet in thickness.

For the dikes no prevalent direction could be established. Many of them trend west of north, but others show directions totally different. Station 41 is located on basalt that evidently came up through a chimney-like fissure and formed a mound about 400 feet high, on the Colorado shales. Other dikes show the same characteristics that are elsewhere observed. They stand out prominently, if they have penetrated sandstones or sandy shales, because these yield readily to erosion. When we find them in tough shales, they have not unfrequently given rise to the formation of hogback-shaped hills. This is due mainly to the fact that the shales on either side of the dike have been hardened

* Report of Exploring Expedition of J. M. Macomb, 1859–1876, p. 80.

† Annual Report of Explorations and Surveys West of the One Hundredth Meridian, Appendix 44, 1875, p. 111.

‡ Since writing the above I have seen Professor Cope, and comparing notes, we have established the two horizons of variegated marls. The lower one on the Animas, which extends south, is devoid of fossils, while the upper, not reaching northward into our district, furnishes numerous most interesting species.—E.

by heat, and are therefore better able to resist atmospheric agents than the unaltered portions adjoining. No features that are either new, or even of particular interest, were observed in connection with the dikes of this region.

DRIFT.

Along the western base of the Sawatch Range, avalanchial and river drift obscures the contact between the sedimentary and volcanic beds. It is derived entirely from the mountains immediately adjoining, and often deposited in bluff-ridges of considerable relative height.

South of the Tierra Amarilla drift was noticed, on a number of the the Fox Hills bluffs, that slope southward and show steep faces toward the north. Upon examination, the rounded, well-worn bowlders and pebbles proved to be granite, gneiss, quartzite, micaceous, hornblendic, and chloritic schists, *i. e.*, all of them metamorphic. Trachyte and basalt were represented but sparingly. If we assume that at the time posterior to the outflow of basalt in that region, the ancient plateau alluded to in speaking of the Cerro del Navajo was still in existence, we can satisfactorily explain the presence of this drift. The metamorphic group upon which station 94 was located, near the junction of the Chama and Brazos, was probably never entirely covered by either trachyte or basalt. It remained as an island, surrounded on all sides by volcanic rocks. Mention has been made (Chapter III) of glacial evidence observed on and near that station. It is possible, therefore, granting the first premise. the existence of the southward-sloping plateau, that either flowing water or moving ice could have transported the erratic, metamorphic material to the localities where we now find it. I am inclined to the former view. An absence of all defined moraines, and the comparatively small size of the bowlders, lead to the inference that probably water effected the transportation, and not ice. It would be utterly impossible for any stream of the present drainage-system to carry these erratics to the summits of the mesas. Even if we allow all possible latitude for changes of niveau, of course and quantity of water, we cannot accept such an explanation. Two views only are satisfactory: either the drift came from some region farther south, or, if it came from the metamorphic group near the Chama and Brazos, the plateau must then have been in existence, must have extended to the very base of the mountains, and was eroded away along that base during the period of the gradual elevation of the mountain-range. Of these two views, I hold the latter. It is, at the same time, an additional argument for the theory of a Post-Cretaceous elevation of the main Rocky Mountain chain. The geological age of our volcanic rocks has been sufficiently well established (at least in Colorado) to admit of their being utilized as direct evidence regarding geological age, together with the sedimentary formations.

In the cañons and valleys of some of the rivers, drift, both river-drift and alluvial, has accumulated, choosing such places that would furnish the greatest local inducements for its deposition.

CHAPTER V.

POST-CRETACEOUS BEDS OF THE TRINIDAD REGION.

In speaking of the Trinidad region, not only the immediate vicinity of that town is understood, but the area covered by the Lignitic formation so well developed at Trinidad is included. This extends from the sandstone bluffs along the eastern base of the Sangre de Cristo Range northward to Spanish Peaks; from there, in an easterly direction, to the Santa Clara; and is limited on the east by the edge of the great plains. The southern boundary is formed by the boundary of our district, North latitude 36° 45′, including the northern extension of the Raton Mountains. About 750 square miles are contained in the area under discussion, and it is to them that this chapter is devoted. Inasmuch as the vicinity of Trinidad affords the most easily-obtainable information, which at the same time is susceptible of being utilized in forming final conclusions, the heading of this chapter has been selected with reference thereto. With the consideration of this region the report upon the district of 1875 will be closed, and its place at the end of this report has been chosen for the purpose of giving a section of country, that has already caused much argument, a prominent position, and for the purpose of awaiting any additional publications that might be made on the subject.

DRAINAGE.

The main stream of this region is Purgatory River. Three main branches, the North, Middle, and South, compose it, joining near station 128. Of these, the first heads east of Trinchera Peak, the second north of Culebra Peak, and the third at station 113. Descending from the mountains, the North Fork flows through Stonewall Valley in a southerly direction, until it there joins the middle branch, which crosses the valley. About eight miles farther down stream they are joined by the South Fork, which has crossed the valley and then flowed through cañons cut into the sandstones and shales of the region. Settlements, mostly Mexican, but also some made by Americans, are strung along the streams and along the valley of the Purgatory, farther east. During its entire course, after the junction, the river flows in the beds of the Lignitic group, until within a short distance of Trinidad, where it has cut through to Cretaceous beds. Streams both from north and south carry their water into it, producing eventually a good-sized river. Owing to the regularity of the strata in which they head, and through which they flow, their horizontal distribution is one of great uniformity. South of the Purgatory we find the waters of the Canadian. That river heads at station 113 also, and from there flows in a southeasterly direction. Several streams head in the northern portion of the Raton Mountains, having a course parallel to the Canadian south of the Purgatory. At the Spanish Peaks, head the Apishpa and the Santa Clara, both flowing northeast. All the country containing this drainage presents a uniform appearance. The streams flow in narrow, grassy valleys, some of which are cultivated, and are inclosed by steep walls of yellow sandstones and shales. At times the water has cut a passage through these sandstones sufficiently narrow to be inaccessible. Vertical bluffs, though often not very high, greatly impede the travel "across country." An almost equal level is maintained by the summits of the bluffs and plateau-like ridges, varied only occasionally by a prominent point that may be utilized as a topographical or geological station. These conditions remain constant until we reach, on the Arapahoe, the underlying Cretaceous strata, and then the beds of the Lignitic group disappear. Facing toward the great plains on the east, we find a long continued row of bluffs, with steep slopes to the eastward. But little variation can be observed in the stratigraphical relations, although the beds are mostly well exposed. Features in detail that have been noticed in the group, will be discussed below. A number of settlements have been made along the western edge of the plains, just within the limits of the bluff region. Several small towns have started into life, and with the vitality of young western colonies have a comparatively flourishing existence.

In this region the coal, that has given rise to so many able arguments regarding its age and geological position, is found. It occurs at a number of points, is mined at some of them, neglected for the present at others. Evidences of it have been found in the accustomed horizon, over almost the entire area, but it is mined only at those points where facilities for transportation insure a market. Its character and geological relations will be discussed in the following pages, and it may be hoped that the result obtained will tend to throw some additional light upon the questions at issue. Special attention has been given to the coal-beds, and more particularly the immediate vicinity of Trinidad has been examined as carefully and as much in detail as the time at my command would permit. Inasmuch as I had the opportunity of examining not only the strata inclosing the coal at Trinidad, but westward to the terminus of their outcrop, and there to observe the underlying formations, and to note the stratigraphical relations to each other, I shall endeavor to present a synopsis of everything observed as clearly as possible, and one affording material for future comparison.

GENERAL ARRANGEMENT OF STRATA.

Mention has been made in Chapter I of the Cretaceous strata belonging to the Dakota and Colorado groups, which flank the eastern slope of the Sangre de Cristo Range south of Trinchera Peak. It will be remembered that there we find the white Dakota sandstone, either standing on edge or covered by Carboniferous strata, that have been overturned. The younger shales of the Colorado group, east of the sandstone, are, so far as could be observed, conformable with it, but the dip is very much obscured. They weather readily, form soil, and in addition to this feature the *débris* and drift from the adjoining mountains succeeded very effectually in hiding from sight nearly every otherwise available outcrop. Very imperfect data, therefore, were obtained as regards this point, and the thorough discussion of the stratigraphical relations of the Colorado shales must necessarily suffer. Dikes penetrating them have furnished, through their preserving influence, the only data from which anything could be learned. Owing to the changes, however, to which the shales have been subjected, by the passage of hot volcanic matter, the stratigraphical conditions have, from that cause alone, suffered greatly. On the South Fork of Rio Purgatorio the last outcrop of the Colorado shales was seen, about one mile north of station 125. There the dark shales, with characteristic fossils, appeared in the bed of the creek, where they had been protected from erosion by a basaltic dike, cutting through parallel to their dip. So far as could be made out the latter was about 20° to the eastward. I cannot regard this as certain, however, for reasons above indicated. Forming a long-continued bluff which commences south of Spanish Peaks and extends for about 30 miles almost due south, we observe a series of yellow sandstones and shales. This bluff is about 800 feet above the level of the valley, immediately west of it. As a rule, the strata composing it have a dip of 4° to 6° toward the east. Local variations therefrom occur frequently, however. The latter case may be observed near station 125, on the South Fork of the Purgatorio. In the valley, which is narrow, trending eastward, the Colorado shales appear, as stated above, while the sandstones and yellow shales dip off, locally, on either side, at angles of 15° to 20°. This small anticlinal fold soon disappears, as we descend along the stream, and with it the Colorado shales. At that point the regular easterly dip, diminished to about 3°, again sets in, until, as we go farther eastward, the strata become horizontal and finally show a westerly inclination of 1° to 3°. At Trinidad this latter dip is developed more than elsewhere, and it is there, too, that we find undoubted Cretaceous beds in the lowest portions of the Purgatory Valley. Thus a shallow synclinal fold is formed. Going north from Trinidad along the edge of these same bluffs we can observe first an almost horizontal arrangement of the strata, until we have passed the Cucharas. There they begin to dip southward at a small angle, which does not increase much toward the northern terminus of the bluffs. Combining this inclination with the synclinal from west to east we have a perfect "trough," the deepest portions of which have been selected by the Purgatorio as its channel.

Whether or not the variation of the dips observed between the Cretaceous strata and the younger, yellow sandstones and shales forming the long bluff, should be regarded as evidence of an unconformability becomes a difficult question. In the field I could not persuade myself that the Cretaceous beds, standing either vertical or dipping westward, could change, within the horizontal distance of two miles, their dip so as to conform with that of the overlying strata (6° east). Nothing was found to prove that they did, unless indeed the occurrence at Trinidad, 30 miles distant, where there is no unconformability noticeable, be accepted as evidence. It is certainly contrary to all former experience that we should expect an unconformability. We have numerous instances along the Front Range, similar to this one, where the beds in the immediate vicinity of the mountains dip very steeply, but soon lose their dip and become almost horizontal.*

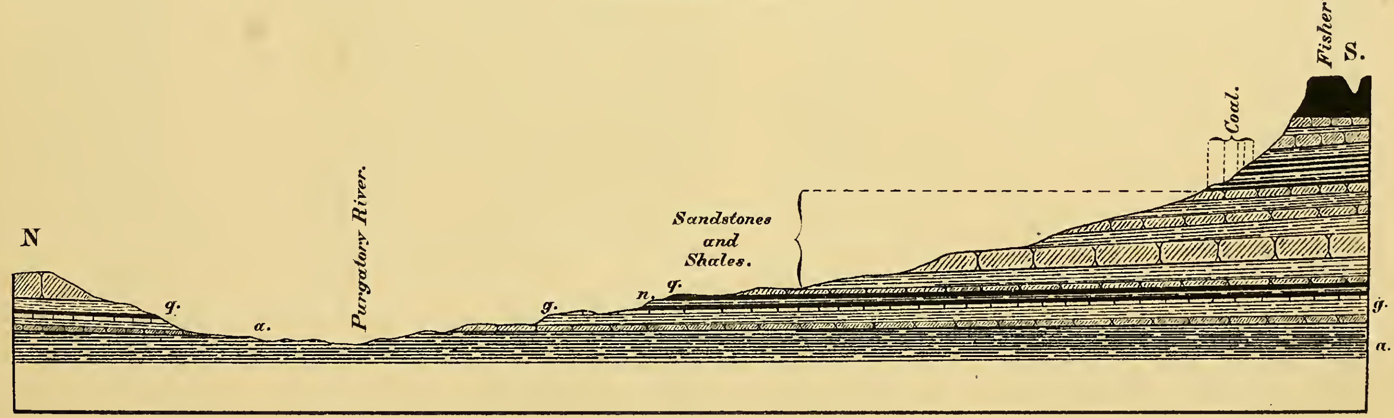
Nevertheless, I am inclined to regard the occurrence in the Purgatorio region as an unconformability, although I by no means deny that subsequent detail-study may prove me to be in error. In assuming that this unconformability exists, I argue that the strata underlying the yellow sandstones and shales rapidly lose their steep dip and become conformable with the latter, as they appear at Trinidad.

With certainty it can be made out at least that the yellow sandstones and shales directly overlie undoubted Cretaceous beds at Trinidad.

* Compare United States Geological Report, 1873, p. 136.

Plate XXIX.

Section XIV.



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

These shales and sandstones reach a thickness of about 2,000 feet between Trinidad and the volcanic capping of Fisher's Peak. Regarded as a whole, the group is one of uniformity, both as regards the arrangement and general character, and the lithological constitution of its single members. Studying the formation from this standpoint, the conclusion is forced upon the observer that it represents essentially one single epoch in the geological history of the region. The entire character of the older Cretaceous period is changed, and we find instead one new, to a certain extent, both in the features of its geognostic details and in its palæontological remains.

THE COAL-BEARING SERIES.

Ascending from the Cretaceous shales in the bed of the Purgatorio, toward Fisher's Peak, we pass through 170 feet of them, finding *Inocerami* for 155 feet of the vertical distance. Characteristic concretionary nodules of dolomite contain the fragments of this fossil as well as of *Ostrea*. Wherever freshly exposed, the shales are a dark grey, weathering like those of the Colorado group. At first glance I was inclined to regard them as belonging to a higher group, but now see no reason why they should not be considered as Colorado shales.* As will be seen subsequently, there is stratigraphical evidence also in support of this view. Above that we find alternating sandstones and shales 120 feet in thickness, forming a low bluff trending south of west. From the top of this bluff to the base of the coal there are 270 feet of sandstones and shales, varying in thickness and color locally. Then follow two banks of coal, covered in turn by sandstones and shales. A section (Section XIV) taken from the river-bed southward toward Fisher's Peak will illustrate the contours of the region, and give the beds in greater detail than has been done above:

		Ft.	In.
I.	*u.* Yellow sandstone, shaly in part	20	0
	t. Greyish and yellow laminated shales	35	0
	s. Light-yellow sandstone, weathering in rounded outcrops	25	0
	r. Greyish-brown shales, with coaled remains of plants	18	0
	q. Coal	9	6
	p. White middle-grained sandstone	4	0
	o. Yellowish-brown shales	8	0
	n. Coal	2	10
	m. Light-yellow sandstone	3	8
	l. Yellow shales, partly sandy	3	6
	k. Light-yellow sandstones	45	0
	i. Greyish-yellow shales	56	0
	h. Yellow sandstone	28	0
	g. Yellow and greyish shales	130	0
	f. Yellow sandstone	30	0
	e. Grey shales	38	0
	d. Yellow sandstones	26	0
	c. Yellow-brown shales	16	0
	b. Yellow sandstone	24	0
	a. Dark-grey shales, with *Inoceramus*	170	0

This section gives, as nearly as possible, the arrangement of strata

* Compare Report United States Geological Survey, 1867–'69, p. 154.

underlying the lower outcrop of coal. At the different banks local changes have taken place, and detail sections were therefore made.

II. Riffenburg bank. Section XV.

	Ft.	In.
h. Yellow sandstone	6	0
g. Greyish yellow shales, with coaled remains of plants	7	6
f. Coal	9	3
e. Light-yellow, middle-grained sandstone	8	0
d. Yellowish-grey shales, laminated	14	0
c. Coal	2	9
b. Grey shales	6	0
a. Yellow sandstone in bed of small creek	4	0

At Blum's bank the coal is 9 feet in thickness, and is the same as *f* in the preceding section. Another mine located on this largest coal-bed is that of the—

III. Munger and Broomfield bank. Section XVI.

	Ft.	In.
k. Greyish-yellow shales, laminated	8	0
i. Coal	3	3
h. Dark-grey coaly shales	0	9
g. Coal	0	11
f. Yellowish shales, sandy, containing coaled remnants of plants	18	0
e. Coal	9	9
d. Light-yellow sandstone	4	0
c. Coal	1	4
b. Very shaly sandstones, showing lamination, no stratification	11	6
a. Coal	1	4

Above *k* a few thin seams of coal set in that are of no value, however, for mining purposes. They are too insignificant, and the coal is shaly.

At the Stephens bank the thickness of this main bed of coal is 9 feet. It is there overlaid by 16 feet of greyish-brown shales. For comparison of the series, Section XVII is introduced on the same plate with the two preceding ones. It is a vertical projection of Section XIV.

Above the second heavier bed of coal, the one usually measuring between 3 and 4 feet, a series of shales nearly 50 feet in thickness sets in. A heavy *white* sandstone covers these shales and forms the foot-wall for a coal-bed. Alternating shales and sandstones then occur, higher up, containing a number of thin coal-seams that are not worked. We have, therefore, two horizons for coal in this region, the lower one with the heavier beds, and the upper with but thin layers of the mineral. They all belong to one continuous series, however. A map of the region immediately south of Trinidad will furnish some idea as to the occurrence of the Cretaceous beds, of the coal-bearing group, and of the line of outcrop as followed by the main bed of coal. The dips, as observed, are indicated. It will be seen from this map that the remunerative coal horizon has an equally good counterpart on the north side of the Purgatorio. Although indications occur there, no workable banks have been located as yet until we reach the vicinity of the Rio Cucharas.

On this river, about a mile above Walsenburg, several openings have been made, furnishing coal that is utilized by the blacksmiths of

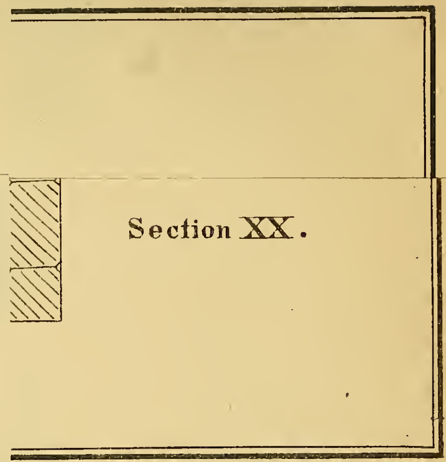
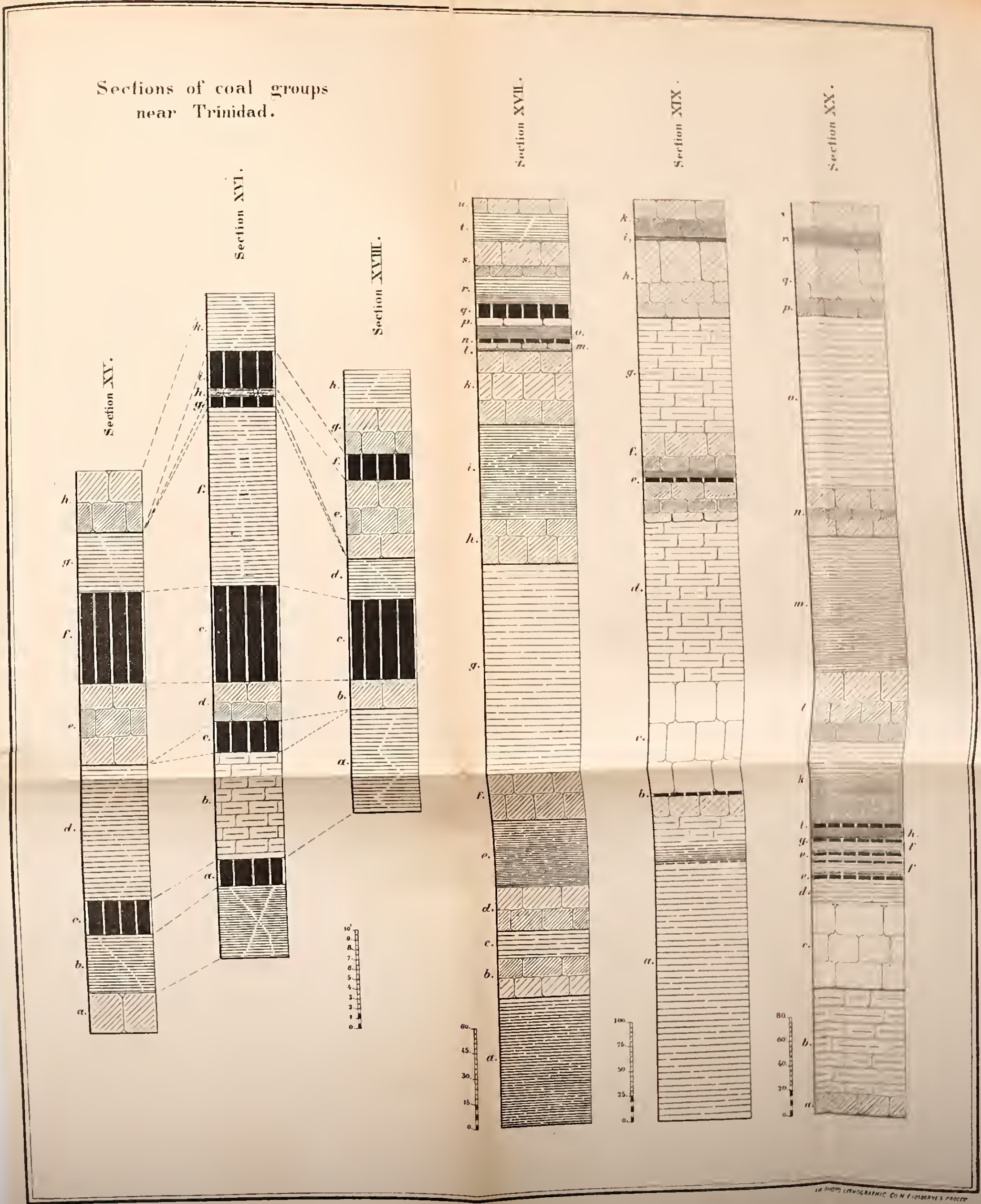

Section XX.

Plate XXX.



Sections of coal groups near Trinidad.
Section XV.
Section XVI.
Section XVIII.
Section XVII.
Section XIX.
Section XX.

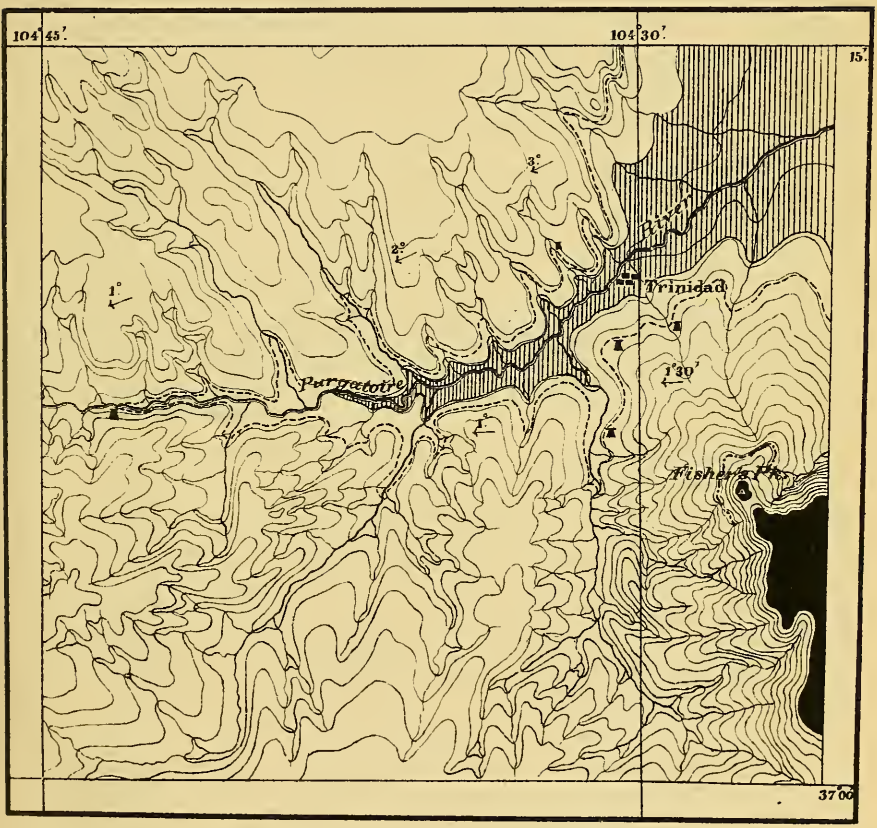
Plate XXXI.

Map of Trinidad region.

Colorado Group.

Lower coal horizon. *Upper coal horizon.*

Coal-openings. *Basaltic Cap.*



0 1 2 3 4 8

Scale of miles.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

the neighboring settlements. A section (Section XVIII) through the coal exposures showed the arrangement to be as follows:

		Ft.	In.
IV.	*h.* Greyish-yellow shales	4	0
	g. Yellow argillaceous sandstone	5	0
	f. Coal, partly slaty	2	6
	e. Yellow sandstone	7	0
	d. Grey shales with coaled remains of plants	4	6
	c. Coal, partly slaty	8	0
	b. Light yellow sandstone	3	6
	a. Greyish-brown shales down to bed of river	11	0

Besides these two localities, a number of others were observed where coal appeared. Near station 125 a section (Section XIX) was taken, which shows the occurrence of small coal-seams in that region. Local disturbances have taken place there which have resulted in producing an abnormal position of the strata, but they are slight, and connections can readily be traced.

		Ft.	In.
V.	*k.* Yellow sandstone, shaly at its lower edge	40	0
	i. Yellow shale, laminated	4	0
	h. Yellow to reddish sandstone	76	0
	g. Yellow to grey shales, sandy, with thin interstrata of sandstone	120	0
	f. Yellow sandstone with indistinct remains of plants	40	0
	e. Coal	1	4
	d. Series of greyish-yellow shales with slight indications of coal	210	0
	c. Massive white sandstone, yellow in part	115	0
	b. Coal	1	7
	a. Grey shales, partly sandy	300	0

Near station 138, at the eastern edge of the coal-bearing group, while the above section is taken from the western border, another locality was found where indications of coal occurred. A section (Section XX) was taken through the bluff upon which the station was located, cutting the beds containing coal.

		Ft.	In.
VI.	*s.* Yellow to reddish sandstone, with indistinct remains of leaves	23	0
	r. Light yellow to grey shales	17	0
	q. Light yellow coarse-grained sandstone	45	0
	p. Dark yellow to brown sandstone	14	0
	o. Greyish-brown shales	146	0
	n. Yellow sandstone	40	0
	m. Dark grey to brown shales, laminated	110	0
	l. Prominent yellow sandstone	60	0
	k. Dark grey to brown shales, with coaled remains of plants in its lower beds	80	0
	i. Coal	1	7
	h. Thinly bedded, very dark shales	9	0
	g. Coal	2	0
	f. Very dark shales with coaled plants	12	0
	e. Coal	1	5
	d. Grey to brown shales	24	0
	c. Massive white sandstone ("fucoidal")	70	0
	b. Beds of sandy shales, marly in some places, with thin interstrata of yellow sandstone	90	0
	a. Yellow argillaceous sandstone, reaching to base of bluff	20	0

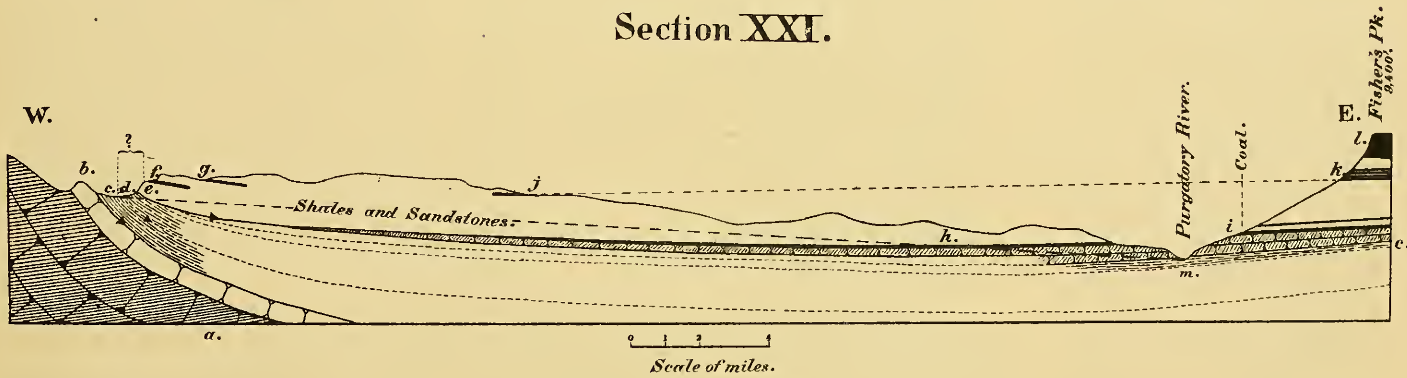
About 12 miles above Trinidad coal crops out on a level with the river-bed. Several small openings were seen there, but were not examined, as evidently no work was being done. At that locality the bed was thicker than at either of the two preceding ones.

CORRELATION OF COAL-BEDS.

As has been stated above, we have in the coal-bearing group of the Trinidad region two horizons of coal-deposits—the lower and the upper. As belonging to the former I count the main banks south of Trinidad, the outcrops on the Purgatorio and the Cucharas mines, to the latter the occurrences at stations 125, 138, and at a number of other unimportant points. It has been mentioned that the entire group forms a "trough" or "basin". At its western edge the dip of the strata is eastward; from its northern border they dip south, and the eastern bluffs show an inclination westward. At Trinidad, on the north side of the river, a northerly dip, combined with the western one, can be observed. This continues for some distance, until it is changed south of the Cucharas, where a dip to the southward sets in. South of Trinidad (5,980 feet, elevation of camp,) the base of the main bank is about 590 feet above the town, giving it an absolute elevation of 6,570 feet. On the Cucharas the altitude above sea-level of the mines is about 6,390 feet. Allowing for the synclinal north to south fold, the existence of which has been mentioned above, and considering that the southerly dip commences but a short distance below the Cucharas, which dip will elevate the coal-beds, we find the Cucharas coal-beds 180 feet lower than those of Trinidad, just about at the locality where we would expect to find them. In the coal-bearing beds south of Trinidad a dip to the northwest is noticeable. It is very slight, amounting to about 1° or a little more. At that point the coal is 590 feet above the river. Allowing for this dip with slight variation, and the increased height of the river-bed as we travel up-stream, we would again find the coal on a level with the river where it was actually observed. In addition to this stratigraphical evidence we have the similarity of the beds accompanying the coal to support the view that these three localities show outcrops belonging to the same horizon. Farther up the river, the coal, if it still continues, dips under, is hidden from sight, and does not appear on the face of the western bluffs. This again argues for the acceptation of an unconformability between the Cretaceous and the coal-bearing series. The outcrops found near stations 125 and 138, I regard as belonging to the upper horizon, a conclusion that is sustained by the character of the accompanying strata. From Fisher's Peak, a section (Section XXI) was taken following approximately the course of the Purgatorio and its southern fork. This will explain more readily than otherwise could be done the relative positions occupied by the various formations and their members. Leaning at a high angle against the metamorphic rocks of the Sangre de Cristo, are the red Carboniferous sandstones (*a*); with a vertical dip, the sandstones of the Dakota group (*b*) follow, and after them the dark grey Colorado shales (*c*). These latter afford but very poor opportunity of studying their dip, more particularly after we have passed the slight rise produced by this interstratum of sandstones (*d*). The shales appear as covered by the yellow shales and sandstones (*e*) of the prominent bluff upon which station 125 was located. At the junction between the two, the dip of the Colorado shales has not been given because it was too much obscured to admit of any definite determination. At an angle of 4° to 6° the sandstones and shales dip eastward, soon causing the dis-

Plate XXXII.

Section XXI.



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

appearance of the Colorado shales from the bed of the river. Indications of coal (*f*) are found both in the station 125 bluff and in the one composed of alternating sandstones and shales (*g*) overlying it. As we proceed eastward the dip of the strata becomes smaller until it ceases altogether, and we soon find that it has been reversed, that it is now westward. In the section these dips are necessarily exaggerated in order to shorten its length as compared to the thickness of the strata. On the Purgatorio, 12 miles above Trinidad, we find, therefore, the outcrop of a heavy bed of coal (*h*) which, rising farther eastward, seems to correspond exactly to the main bank (*i*) south of Trinidad. Ascending from that point, the slope leading to the summit of Fisher's Peak, we find in the higher strata coal-beds (*k*) of no economic importance, corresponding to the small ones (*j*) observed farther west. Fisher's Peak is the northern terminus of an extensive plateau sloping southward. It is covered by 600 to 650 feet of a black, vesicular basalt (*l*), and stands out prominently, as it rises to an absolute elevation of 9,460 feet, 3,300 feet above the valley adjoining it on the east side. In the narrow valley of the Purgatorio, the Colorado shales (*m*) are found, containing *Inoceramus*, *Baculites*, and *Ostrea*.

In tracing connections of coal-beds over so extensive an area it must be remembered that they are at best but local deposits. While the conditions favorable to the formation of coal may have existed at any one given locality, they may have been wanting at the same time but a short distance off. Hence it is not advisable to attach too much importance to over- and under-lying beds in determining the identity of coal strata. Observation has shown that whereas we may have a sandstone in a geognostic horizon at one place, that same sandstone may be replaced by shales or marls not far distant. In such instances the general stratigraphical arrangement, particularly when large areas are involved, will furnish by far the better data upon which to base a decision. It would not only be ill advised, but might generally lead to erroneous results, were the lithological constitution only of certain beds or strata employed as an agent for determination. Wherever fossils can be found, recognized as being characteristic of certain groups or members of groups, their evidence is preferable. If such is not the case, however, the method above employed in making an attempt at deciding the identity of strata widely separated will usually prove to be the most acceptable. It will furnish a more complete view of the entire stratigraphical arrangement, and though due consideration should be given to lithological evidence as far as it goes, the former will aid more materially in definitely settling the question.

COAL.

Having completed the discussion of the geognostic and geological position occupied by the coal of the Trinidad region a few words may be said as to its economic merits. On the Riffenburg bank a good deal of work has been done. Nine feet three inches is the thickness of the vein. A tunnel has been driven in, having an easterly direction. It was at the time of my visit (October 1, 1875) 180 feet long, 6 to 7 feet high and 9 feet wide. The coal from this mine represents, in exterior character and component parts, very fairly the type of the entire region. According to Dana's classification* I should term these coals *caking or binding bituminous coal.* The term of *lignite* is generally used, but speaking from the strict standpoint of a mineralogist, this name is

* Syst. of Min., 1870, p. 654.

not applicable. Inasmuch, however, as it has been universally applied and has given a general name to the formation in which the coal occurs, it would not be advisable to attempt any change at present. Regarded as a mineral, however, this coal is no lignite.

The Riffenburg coal furnishes a good coke, an average percentage of volatile, combustible matter, and a very light, grey ash. An assay made of it gave the following result:*

Riffenburg bank.

	Per cent.
Loss at 110° C. (water)	0.26
Carbon, fixed	65.76
Volatile combustible matter (by difference)	29.66
Ash	4.32
	100.00

Specific gravity: 1.28.

Blum's bank is located a short distance west of the Riffenburg, and shows a vein of 11 feet thickness. It is the same as the latter, having, as might be expected, local variations of thickness. A tunnel has been driven in to the distance of 60 feet, and the quality of the coal is very nearly that of the Riffenburg. At the surface partial decomposition has increased the relative quantity of ash, but upon reaching the fresh portion this is again reduced. An assay made furnished the following results:

Blum's bank.

	Per cent.
Loss at 110° C. (water)	1.00
Carbon, fixed	53.80
Volatile combustible matter (by difference)	27.80
Ash	17.40
	100.00

Specific gravity: 1.42.

This coal furnishes a compact hard coke, that may readily be utilized for metallurgical purposes. Although the percentage of ash seems large in the specimen examined, its character is such as to lead to the inference above indicated, that it may be owing to partial decomposition.

Stephen's bank is situated still farther west, on the Santa Fé wagon-road. It is the largest of the three mines mentioned. A tunnel 250 feet in length has been driven in, and several chambers have been cut out. At this mine the thickness of the coal-bed is 9 feet. Some of it has been coked at the entrance of the tunnel in an improvised kiln. The result was very satisfactory. At Trinidad the coal from this locality is used for blacksmithing purposes and answers very well. Two assays were made, one of good, the other of very poor coal.

Stephen's bank.

No. 1.

	Per cent.
Loss at 110° C. (water)	1.06
Carbon, fixed	65.00
Volatile combustible matter (by difference)	27.68
Ash	6.26
	100.00

Specific gravity: 1.31

*It must be stated that all the coals, assays of which are given below, had been placed for about a year in a room warmed by steam radiators. This may, in part, account for the low percentages of moisture.

It furnishes a good coke. Ash is grey, slightly reddish, the result of a very minute quantity of ferric oxide.

No. 2.

	Per cent.
Loss at 110° C. (water)	0.20
Carbon, fixed	49.66
Volatile combustible matter (by difference)	26.94
Ash	23.20
	100.00

Specific gravity: 1.53.

In this instance the higher specific gravity is owing to the large percentage of ash. The coke obtained from the coal is good, deducting, of course, the considerable amount of incombustible matter.

In preceding pages of this chapter the coal occurring in the Dry Arroya has been mentioned. It has been exposed to atmospheric influences for a long period of time. Interest was attached to the question regarding its composition, and therefore an assay was made which confirmed the expectations held. Good coke was obtained from the coal, and the ash was very light, both in color and weight of the volume.

Dry Arroya.

	Per cent.
Loss at 110° C. (water)	0.52
Carbon, fixed	40.06
Volatile combustible matter (by difference)	27.56
Ash	31.86
	100.00

Specific gravity: 1.36.

With this I conclude the coal-assays from Trinidad. For the sake of convenience I shall append two from the Cucharas.

About a mile above Walsenburg (Placita) several openings have been made on the south side of Cucharas River, but no work of any extent has been done. As I could find none of the owners, I visited these openings alone, hence failed to learn the names that have probably been given them. The largest vein seen was one of 8 feet in thickness, but several smaller ones were observed. It was noticed that the coal here was not so uniform in character as that from Trinidad. Admixtures of shale and very fine-grained arenaceous deposits have produced a comparatively higher percentage of ash. Lamination may be seen, as a rule, therefore, the result of such admixture. The coke obtained from this coal does not equal in quality that from Trinidad. It is possible that with increasing depth of the mines the coal found may become more homogeneous, thus producing better coke. Two specimens were selected, choosing a high average quality, so far as exterior appearance could indicate it. Analyses furnished the following results:

Cucharas coal.

No. 1.

	Per cent.
Loss at 110° C. (water)	1.46
Carbon, fixed	48.12
Volatile combustible matter (by difference)	41.76
Ash	8.66
	100.00

Specific gravity: 1.32.

No. 2.

	Per cent.
Loss at 110° C. (water)	0.32
Carbon, fixed	47.60
Volatile combustible matter (by difference)	41.76
Ash	10.32
	100.00

Specific gravity: 1.38.

Besides these two regions, where the mining of coal is carried on more or less systematically, numerous outcrops have been observed at a number of localities, and reference to some of them has been made at the proper place. No doubt some of them may eventually prove to be of value, but the mines already started will be able to supply, for a long time, even a rapidly increasing demand. For smelting purposes, the coal from Trinidad will answer sufficiently well, while for the manufacture of gas both Cucharas and Trinidad can furnish desirable material. Coal-mining in both these regions is comparatively cheap, owing to the favorable location of the beds and the hard, safe character of both hanging and foot walls.

In order to give a comparison of the coals throughout Colorado, I have prepared a table containing all assays and analyses that were available. It will be found, upon examination, that one group differs very decidedly from the rest. This is the group from the Elk Mountains. In composition, the coal from that region closely resembles anthracite, as also in its physical character. Dr. A. C. Peale, with reference thereto, says:* "The eruption of the trachyte found near the coal first mentioned, probably so heated it as to deprive it of the bituminous matter. In some instances volcanic dikes have been observed to pass through beds of this bituminous coal." In that case the portions immediately adjacent were found to show a composition closely resembling that of anthracite. We may therefore regard the coal from the Elk Mountains and those from the vicinity of the Gunnison not as true anthracite primarily, but as a bituminous coal having lost nearly all of its volatile constituents.

Number.	Locality.	Specific gravity.	Loss at 110° C., (water.)	Fixed carbon.	Volatile combustible matter.	Ash.	Analysis made by—
	Region of the Animas.						
1		1.56	3.26	58.86	31.65	6.23	Endlich.
2		1.15	6.00	60.72	28.48	4.80	Do.
3		1.29	3.06	62.20	31.54	3.20	Do.
4		1.38	2.60	62.72	31.02	3.66	Do.
	Rio Colorado, Colo. (?)						
5	Red River		2.70	59.36	24.44	13.50	Loew.
	Trinidad.						
6	Dry Arroya	1.36	0.52	40.06	27.56	31.86	Endlich.
7	Blum's bank	1.42	1.00	53.80	27.80	17.40	Do.
8	Stephen's bank	1.31	1.06	65.00	27.68	6.26	Do.
9	do	1.53	0.20	49.66	26.94	23.20	Do.
10	Riffenburg bank	1.28	0.26	65.76	29.66	4.32	Do.
11	Trinidad	1.28	0.84	54.10	26.98	18.98	Mallett.
12	do		0.80	40.18	50.32	8.70	Loew.
	Cucharas.						
13	Cucharas	1.32	1.46	48.12	41.76	8.66	Endlich.
14	do	1.38	0.32	47.60	41.76	10.32	Do.

* Report United States Geological Survey 1874, p. 176.

Number.	Locality.	Specific gravity.	Loss at 110° C., (water.)	Fixed carbon.	Volatile combustible matter.	Ash.	Analysis made by—
	Cañon City.						
15	Cañon City	....	5.37	56.66	35.08	2.89	Loew.
16	......do	1.29	5.40	54.70	36.40	3.50	C. L. Mees.
17	......do	1.28	4.50	56.80	34.20	4.50	E. T. Cox.
	Colorado Springs.						
18	East of Colorado Springs	....	7.14	52.27	24.56	16.03	Loew.
19	Northwest of Colorado Springs	....	8.12	47.29	37.09	7.50	Do.
20	......do	1.27	12.90	46.00	39.10	2.00	C. L. Mees.
21	Frances mine	1.38	8.66	47.66	40.68	3.00	F. A. Lowe.
	Golden City.						
22	Bear Creek	....	....	48.15	*47.80	4.01	Mallett.
23	Marshall mine	....	12.00	59.20	26.00	2.80	Torrey.
24	......do	1.33	12.00	49.72	33.08	5.20	J. T. Hodge.
25	Murphy mine	1.34	13.83	44.44	35.88	5.85	Do.
26	......do	....	11.70	55.31	29.07	3.92	J. H. Le Conte.
27	......do	1.39	11.70	55.31	29.07	3.92	G. J. Brush.
28	Baker mine	1.32	15.00	50.65	30.50	3.85	J. T. Hodge.
29	Golden	....	8.32	58.25	29.92	3.51	Loew.
30	......do	1.32	13.43	45.57	37.15	3.85	J. T. Hodge.
31	......do	1.35	13.67	47.58	34.75	4.00	Do.
32	Coal Creek	....	20.00	57.70	19.30	2.00	Torrey.
	Boulder region.						
33	Boulder	....	11.81	53.38	31.40	3.41	Loew.
34	Erie mine, (Briggs)	1.27	14.80	47.30	34.50	3.40	J. T. Hodge.
	Gunnison region.						
35	Gunnison River	1.67	....	91.02	*3.63	5.30	Mallett.
36	Uncompahgre	1.78	1.86	77.32	10.70	10.12	Endlich.
37	Cebolla Creek	1.45	7.26	41.72	43.42	7.60	Do.
	Elk Mountains.						
38	Coal Creek	....	5.04	59.50	30.46	5.00	Peale.
39	.... do	....	....	59.68	*36.02	4.30	Do.
40	Anthracite Creek	....	2.00	91.90	2.50	3.60	Do.
41	......do	....	1.60	88.20	3.40	6.80	Do.
42	O Be Joyful Creek	....	4.00	74.00	14.00	8.00	Do.
43	Rock Creek	....	....	88.92	*7.40	3.68	Do.
44	O Be Joyful Creek	1.74	6.66	79.32	1.36	12.66	F. A. Lowe.

* Plus water.

From the above-given coal-assays a table has been prepared, giving the average percentages of constituents from each locality. Although the data available are at best too meager, the average may indicate, to a certain extent, the general quality of coal occuring at each particular locality.

Locality.	Average specific gravity.	Average percentage of water.	Average percentage of fixed carbon.	Average percentage of volatile combustible matter.	Average percentage of ash.
Animas	1.346	3.730	61.126	30.677	4.472
Trinidad	1.363	0.668	52.651	30.991	15.817
Cucharas	1.350	0.890	47.860	41.700	9.490
Cañon	1.285	5.090	56.053	35.226	3.630
Colorado Springs	1.325	9.205	48.305	35.357	7.132
Golden City	1.341	12.165	51.989	31.776	3.900
Boulder	1.270	13.305	50.340	32.950	3.405
Gunnison	1.633	3.040	70.020	19.250	7.673
Elk Mountains	1.740	2.757	77.360	13.620	6.291

Leaving out the surface specimen from the Dry Arroya and the poor specimens from Stephens bank (No. 9), the average percentage of ash in the Trinidad coal would 11.15 per cent.

A total average taken of the Colorado coal, excluding the anthracite varieties from the Gunnison and the Elk Mountains, gives an approximate idea of their position in a mineralogical classification. The subjoined average is prepared from thirty-four analyses:

Specific gravity: 1.325.

	Per cent.
Water	6.436
Carbon, fixed	52.617
Volatile matter	34.096
Ash	6.835

In contradistinction to the above is the total average of the anthracite coals, prepared from ten analyses, all that were available at the time of writing:

Specific gravity: 1.686.

	Per cent.
Water	2.898
Carbon, fixed	73.690
Volatile matter	16.435
Ash	6.987

From the above tables it will be seen that the average specific gravity varies to a certain extent commensurate with the increase of non-combustible component parts. Of all the constituents the volatile are the most constant in their relative proportion, excepting the coal from the Gunnison and the Elk Mountains. Having but comparatively few analyses from each locality, the table showing averages has not the same value that a larger number would have given it. As an indication, however, serving for comparison, it may answer. In the United States Geological Report, 1873, p. 112, a large number of coal analyses will be found, furnishing not only data regarding Colorado coals, but also from other regions where they occur in formations analogous or related to those treated of in this chapter.

IRON-ORE.

In connection with the coal-bearing strata we find at Trinidad a variety of iron-ore known popularly as "kidney-ore." At other localities, either in the same or analogous formations, it has also been discovered, and in some instances utilized. It is mainly a carbonate of iron, associated with silica, silicate of alumina, and some carbonates. Upon decomposition the percentage of iron increases, through the loss of carbonic acid. Generally the quantity of iron contained in "fresh" ore is small. It occurs in the shales and sandstones, forming more or less irregular, hard, nodular concretions. These resist atmospheric influences more successfully than the material surrounding them, and weather out, forming sometimes deposits not unlike those of river-drift.

Two specimens were taken from the immediate vicinity of coal-beds south of Trinidad. No. 1 was "fresh"; color, grey; no sign of decomposition. No. 2 was decomposed, color reddish-brown, easily broken with a hammer. It formed the exterior crust of one of the nodules, the interior of which was still in its undecomposed state.

An analysis for iron furnished the following result:

	Per cent. *a.*	Per cent. *b.*
No. 1:		
Iron (calculated as metal)	4.76	4.35
No. 2:		
Iron (calculated as metal)	43.93	43.29

An analysis made by E. M. Kent * of a specimen of this "kidney-ore" from Golden City showed the following constituents:

	Per cent.
Iron	41.3
Oxygen	17.7
Gangue	27.8
Water	12.4
Loss	0.8
	100.00

This agrees very well with the decomposed specimen, No. 2. No doubt No. 1 is a very poor one, and its percentage of iron would be but little increased even by a loss of certain constituents that decomposition would effect.

GEOLOGICAL AGE OF THE COAL-BEARING GROUP.

A large mass of literature has accumulated, with a view to arrive at a final determination of the geological age of the coal-bearing groups throughout the Rocky Mountains. I do not propose to prepare an elaborate discussion of the subject. I am prevented from doing this, all the more, as anything I could state with reference to localities, other than those of Trinidad and Cañon City, I should be forced to base upon the observations of others. If it were possible that a survey or portion of a survey, organized for this especial purpose, could visit all the localities involved, and trace distinctly the connections between each region under dispute, it would require but a comparatively short time to arrive at a final conclusion; one that would, no doubt, be acceptable to all who have had occasion to study and report upon the "Lignitic" formations of the West.

There is now no longer room for any doubt that we have in the Rocky Mountains, coal of undisputable Cretaceous age. On the Lower Animas,† at the mouth of the Gunnison,‡ on Anthracite Creek,§ and a number of other localities, coal has been observed in Colorado, that ranges, in geological age, from the upper members of the Dakota to the Fox Hills groups.

These all occupy their relative, well defined horizons, determined by palæontological and stratigraphical evidence. The coal from these groups is found to be, upon analysis, different from that of the "Lignitic" group. More especially is this difference manifest in their physical characteristics. On the other hand, we find coal in undoubted Tertiary deposits which are equally well determined by ample evidence. All that coal-bearing series of sandstones and shales, however, in the region of Trinidad has been, together with others, a bone of contention. It is claimed for the Cretaceous and for the Tertiary. Both views are argued on the strength of palæontological evidence, besides other apparently satisfactory proof.

From a study of the case as it now stands, I cannot agree with the view that includes the "Lignitic" group of Trinidad in the Cretaceous. We find, at the base of the Sangre de Cristo Mountains, that the Cretaceous beds occupy a position far different from that of original deposition. We have seen that the coal-bearing strata were deposited in a basin. They comprise a group entirely distinct and separate from the adjoining

* Report United States Geological Exploration, 40th Parallel, 1870, vol. iii, p. 483.
† Report United States Geological Survey, 1874, p. 223.
‡ Ibid., p. 175.
§ Ibid., 176, and Report United States Geological Survey, 1873, p. 259.

ones west and north. Prof. Lesquereux says:* "The Lower Lignitic flora has not as yet a single species identical with any of the Cretaceous, and even very few have a distinct relation to them." So far as the value of palæontological evidence is concerned, I should give preference to interpretations derived from the study of invertebrate animals and plants, over those based upon the occurrence of vertebrates. In case we do even find the persistence of some Cretaceous types carried up into the "Lignitic" series, this will prove to be no formidable argument in favor of Cretaceous age. The very fact of having but an imperfect representation of the entire series of the geological groups on any one continent has given rise to the separation into conventional "formations." Could we imagine the series completed and every missing link supplied on one continent, we would probably be still less able than now to arrange and place every formation into a pigeon-hole prepared for its reception. So far as I am able to judge, we have in the case of the "Lignitic" group, (I restrict myself to speaking of Trinidad and Cañon, where I have made personal observations), a formation analogous to the "Wealden" of Europe. For a long time there was much doubt as to the position of the latter in the geological scale, until, upon palæontological and lithological evidence, it was decided to be *Post*-Jurassic—*Pre* Cretaceous. Taking the same ground with reference to the "Lignitic" group, I do not hesitate to call it *Post-Cretaceous*, and inasmuch as it does not seem to have sufficiently well developed the characteristics that we require of our North American Eocene, I call it *Pre*-Tertiary. In the Report of 1873, p. 349, I have regarded the Coal-Measures at Cañon as a "transition" series, and I find additional proof of the position there taken, in the region of Trinidad.†

Professor Stevenson‡ includes the Lignitic beds of both Cañon and Trinidad in the Cretaceous. He regards them merely as an amplification of Cretaceous No. 5, laying all possible stress upon the "rusty yellow sandstone" of that horizon. He states (p. 25) that "in Colorado the fossils of No. 5 are usually absent from the lower sandstones, so that the Lignitic group appears to rest directly upon the shales of the Middle Cretaceous." With the exception of the word "appears," I agree in this with Professor Stevenson. At Trinidad there is no doubt whatever that the extensive series of shales and sandstones *does* rest "directly upon the shales of the Middle Cretaceous" (Colorado group). From these latter we pass up through a characteristically uniform succession of strata, until, 480 feet *above* the shales, we find the first coal. Instead of assuming that the fossils of Cretaceous No. 5 are "usually absent from the lower sandstones," I have come to the conclusion that not only the fossils, but No. 5 itself is absent. It is scarcely ever possible to find even a limited district where some member of the "standard" succession of geological strata is not wanting. Wherever, then, it is impossible to establish beyond a doubt the existence of such missing stratum, it is not only admissible, but necessary, to regard the succession as incomplete. All the more is this the case when we have (as in the Trinidad region) an area of more than 700 square miles over which to extend our investigations. It is certainly the most aggravating obstinacy in a sandstone to appear over so large an extent of country, unaccompanied by the fossils that it elsewhere usually carries.

In the Trinidad region I consider the Cretaceous members above the

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* United States Geological Survey Bulletin, 5, II ser., 1876, p. 243.

† Compare Bulletin United States Geological Survey, No. 5, second series, January 8, 1876, p. 402.

‡ Paper read before the American Philosophical Society June 18, 1875.

Middle Cretaceous shales as wanting. In case they did exist there, *then* it might become a difficult matter to draw the line of separation between Cretaceous and Post-Cretaceous.

VOLCANIC ROCKS.

Volcanic formations are but very sparingly represented in the district of which this chapter treats. Station 126, on the headwaters of the Canadian, is located on a small outcrop of trachyte, a remnant of the formerly extensive mass farther southwest. From there the trachyte flowed down upon the Post-Cretaceous beds, covering a large portion of them. Gradual erosion, however, carried away the volcanic beds, and once more exposed the underlying sandstones and shales, save at such places where, for local reasons, small portions were suffered to remain. In the northern region of the area dikes traverse the sandstones and shales, having had an origin, probably, synchronous with those of the Spanish Peaks. They reach into the Post-Cretaceous group but for a short distance only. Dikes of the entire region have been described in Chapter I, and the same characteristics there given, the same metamorphosing influences quoted, hold good wherever they occur in the Lignitic group.

DRIFT.

No large drift areas were found in this section of country. If we exclude the western edge of Stonewall Valley and its southern continuation, there will be but few localities left where drift occurs. The physical character of the rocks composing hills and bluffs is such that erosion by water will be productive of clay and finely separated detritus rather than voluminous drift. Wherever the character of a valley has permitted it, we find in consequence of this peculiarity a deposit of soil. This is turned to good account at some places on the Purgatorio drainage, where farms, worked by Mexicans, testify to the richness of the alluvium. Comparable with the lower San Juan drainage, we find that the valleys are most frequently narrow, with steep sides, a form that is incident to the ready disintegration of the slopes inclosing it.

CONCLUSION.

In the conclusion I propose to present in a concise manner such deductions as may have been made from the facts observed in the district which is the subject of this report. Inasmuch as both the districts of 1873 and 1874 adjoin the one treated of above, it is possible to state with more clearness and a fuller understanding, the purport of generalizations resulting from the season's observations. Where we have large areas of one single formation (as is the case in this instance) it becomes a matter of considerable difficulty to arrive at definite conclusions when the examination of such areas is restricted to a portion only. In order, therefore, to complete the synopsis, references will be made to the adjoining districts wherever that may appear desirable. It seems best to discuss the characteristics of each formation in a succession based upon their geological age, thus facilitating allusions to one or the other, and at the same time retaining a definite classification. I regret that much must still remain incomplete, owing to the want of information as regards the more minute details of many localities. Could they be supplied, the ultimate results obtained would be by far more satisfactory. This is particularly the case with reference to the early geological history of San Luis Valley.

Metamorphics.—Rocks belonging to this group crop out in but two regions, in the Sangre de Cristo and the Sawatch Ranges. In the former they occupy a central position, being flanked on either side by sedimentary or by volcanic formations. In their structure they resemble sedimentary beds at some places, but at others any similarity that might be so construed is too much obliterated to admit of direct comparison. Wherever their character is such as to permit speaking of their "strata," it will be found that the latter agree in their relations with the overlying, unchanged sedimentary beds. This we find to be the case more particularly on the western slope of the range. Following the metamorphic outcrops northward, we establish a connection with those occurring on the Arkansas River, and it is there that we obtain a clew as to their origin. In the report of 1873 (p. 308) Silurian beds identified by fossils and geognostic position have been described as overlying the granite of the immediate Arkansas region. In the northern portion of the Sangre de Cristo Range, however, they disappear in the vicinity of Hunt's Peak. South of that it may be observed that the metamorphic rocks change. Instead of an unbroken series of granite, we find schists, gneissic, micaceous, and chloritic, showing evidence of having been subjected to very intense metamorphosing influences. At Mosco Pass the number of varieties reaches its maximum, continuing southward into the Blanca group. No Silurian whatever is found in the southern extension of the range. The general lithological character of the rocks agrees with that observed farther north, but differs from that of the Arkansas vicinity. Considering the conformability of younger formations with the Silurian strata on that river, and considering furthermore the conformability metamorphic strata show after the disappearance of the Silurian, at the same time noting the change that takes place in the lithological character of these strata, south of the Silurian outcrops, I have come to the conclusion that the metamorphic rocks of the Sangre de Cristo Range represent the original Silurian beds. By following the dips and general courses of the strikes, and comparing them with those of the superincumbent, younger strata, the similarity of arrangement between the two expresses itself very definitely.

In the Sawatch Range the metamorphic outcrop is not so extensive, but of great interest. In Chapter III mention has been made of its stratigraphical conditions, as well as of its lithological character. Granite, coarse-grained, with a flesh-colored feldspar, forms the higher members of the group, overlying pure quartzites, and quartzites gradually merging into micaceous and gneissic schists. We have here, therefore, the same relative position that was observed in the Quartzite Mountains during the preceding year. This might point to the fact of the two having been formed by the metamorphosis of at least similarly arranged if not identical beds. It is a noticeable feature, that none of the older formations occur along the western base of the range, so far as I have been able to determine. From the character of the younger ones (Cretaceous and Post-Cretaceous) it must be inferred that if they exist there, it is at considerable depth. In the Quartzite Mountains we have definite observations,* showing the metamorphic granite and a portion of the underlying schists and quartzites to have been formed by an alteration of the Silurian, and, in part, Devonian strata. This same origin I as-

* United States Geological Report 1874, p. 191.

sume for the group exposed at station 94. Between the two outcrops lies an intervening distance of 85 miles, that affords no clew to any connection, either in former periods or at the present time, below the surface. It is impossible, therefore, to make any assertions relative to an identity of the two groups as regards age, but I incline to the opinion that the connection formerly existed, mainly following, perhaps, the continental divide, and that the present high altitude of the volcanic beds in the Sawatch Range is due to such connection. In speaking of the volcanic area below, a synopsis of the metamorphic outcrops occurring within its limits will be given, with a view to presenting the former hypsometric conditions as far as possible.

Carboniferous.—In the districts of 1873 and 1874 the Lower Carboniferous strata reached a good development. On the north side of the Arkansas and along the Animas they were found containing characteristic fossils. A small area only shows an exposure of the same in our present section. On and in the vicinity of Trinchera Peak, the strata are found that belong to this formation. They do not correspond entirely with those observed elsewhere, evidently having been subjected to metamorphosing influences. In geognostic position they are parallel to the lower group exposed on the west side of the Animas,* but their sandstones are changed into a quartzitic variety, their shales into argillites, hard and brittle. Above them a blue limestone generally occurs, containing fossils that denote its age.† This was not observed in the range, unless, indeed, the limestones found in Sangre de Cristo and Indian Passes should represent it. They, however, show beds of the same sandstone on either side, so that they were regarded as interstrata rather than as this lower group. It is possible that the contortions to which all the strata were subjected at those localities have rendered the position they now occupy a relatively abnormal one. Reaching a very considerable thickness and playing an important part in the structure of the Sangre de Cristo Range, is the red Carboniferous sandstone. It generally rests upon the metamorphics, having assumed a similar position at the northern end of the range. On either side of the summit it dips off toward the valleys, forming only at one point, station 21 of 1873, the summit itself. On the Arkansas this group was first noticed, and from its geognostic position referred to the Carboniferous. During 1875 the ground then taken was vindicated by the discovery of undoubted Carboniferous fossils in interstrata of limestone at three localities. Besides this, Carboniferous plants were found in the sandstone proper. During the Cretaceous period the beds belonging to this group must already have occupied the elevated position in which we find them at present, thus debarring that younger formation from entering the western country beyond. It is highly probable that subsequent local disturbances have produced the minor plications and folds we observe, but the general position of the sandstone strata was determined at many points before the advent of the later Cretaceous waters, although at others they are perfectly conformable. During the Carboniferous period this sandstone must have formed a beach for a very long time, invaded every now and then by the waters that deposited the limestones. It is owing to this temporary invasion that we find them to be of local occurrence only, and not forming constant geognostic horizons. As the latest action these sandstones have taken in the geological history of the region, we may regard the furnishing of drift in San Luis Valley. Consequent upon being subjected to the repeated

* United States Geological Report 1874, p. 214.
† United States Geological Report 1873, p. 311; Report 1874, p. 216.

and long-continued action of water, the drift there has not preserved the characteristic red color that may elsewhere be observed in still more recent deposits. The clay, which contains the coloring-matter, has been gradually washed away, or has been so distributed that it can no longer have any effect upon the general coloring of the drift, which now appears as greyish-brown.

It is possible, upon cursory examination only, to mistake these red Carboniferous beds for the "red beds" of Mesozoic age. As characteristics, however, it may be mentioned, that the latter show greater intensity of coloring, greater tendency to weather in steep bluffs, and more interstrata of reddish-white or pure white sandstones. Furthermore, they are comparatively rarely met with within the limits of the high mountains, occurring mainly along their borders. An examination as to lithological features will disclose the fact, that generally the Mesozoic beds show a more abundant supply of clay in the sandstones, as well as more interstrata of bright red shales and shaly marls.

Jura-Trias.—This group is represented at but one locality in our district. Extending southward along the Front Range, it curves around the southern end of the Greenhorn Mountains. A short distance west of the main peak of that spur the characteristic "red beds" no longer appear. It differs in nothing here from the analogous occurrences farther north.

Cretaceous.—Three groups represent the Cretaceous formation in our district—the Dakota, Colorado, and Fox Hills. Owing to considerable changes, both in vertical dimensions and in the lithological character of the strata, as well as in the fossils, it was impossible to apply the former division into five groups. It is but natural that, where large areas intervene, as in this instance, very decided changes should take place, altering the general arrangement and detail-features in such a manner that the former scale is no longer applicable. By classifying the formation, as above stated, we have been able to carry out successfully a division that is perfectly natural for that region, and have had no difficulty in recognizing the horizons established.

Along the eastern base of the Lower Sangre de Cristo Range the typical upturning of Cretaceous beds against the slope of the mountains could again be observed. In this case it was rather extreme, inasmuch as the older Carboniferous strata several times were noticed to rest upon the Dakota sandstones. No trace of the Jura-Trias was seen to occur between the Carboniferous and the Cretaceous, as is the case along the foot of the Front Range. There seems to me no doubt that the upturning of the Cretaceous edges is due to the rise of the main Rocky Mountains at some time during the Tertiary period. This view has been very ably presented and sustained by Dr. Peale.* It is the only way in which to account for the uniformity of the upturn observed for a distance of many miles. As I have expressed myself in the report of 1873, I hold that the elevation took place along certain lines to a greater extent than in the entire mass of mountains, and we can thereby explain an apparent contradiction, when we do not find the corresponding effect on both sides of a range. No Cretaceous waters penetrated westward through any opening in the Sangre de Cristo Range. With the exception of small local deposits belonging to the Miocene, we find no sedimentary beds younger than the Carboniferous until we arrive at the western slope of the Sawatch Range. From there southward the youngest Mesozoic and the Cenozoic formations set in. It is here more par-

* American Journal of Science and Arts, April, 1877, p. 172.

ticularly, on the northern drainage of the San Juan, that the classification above given finds its most complete application. Descriptions of each group are contained in the fourth chapter, which is devoted to that region. Viewing the entire system, both Cretaceous and the overlying Tertiary, as a whole, we recognize the existence of a Cretaceous inland sea, that gradually filled with the material carried to it by the streams from which it obtained its waters. Soon after the filling process was completed, in part only, vegetation sprang up on the dry land thus formed. Local deposits of coal, that frequently, however, extend for a number of miles, indicate the boundaries of the former land. Lakes, probably of shallow depth only, separated the various regions of land. While depositing near their center the shales and marls, the proximity of sandy shores caused these latter to change and become sandstones. This phenomenon at present greatly impedes the progress of a stratigraphical geologist, who is accustomed to trace each individual bed as such, like the contour of a map. We cannot, therefore, place too much reliance upon the recurrence of strata in a formation of this character. Eventually the rise of the mountains drained the regions south of them, and, flowing off, the water began to cut many narrow valleys and cañons through the rapidly-yielding material. Subsequent erosion, aided perhaps by seismic action during the volcanic period, increased the depth of these cañons, without adding much to their width. Local disturbances have produced effects which were taken advantage of by flowing water, and we now find valleys where they would certainly not be expected, were it not that displacements gave the first impulse to their formation.

Post-Cretaceous.—Chapter five has been devoted to this group, and there are stated the essential reasons why the "Lignitic" series should not be included either in the older Cretaceous or the younger Tertiary. Regarding the successions of geological "periods" from an evolutionary stand-point, we should expect to find a transition, almost imperceptible, so far as organic remains are concerned, from one "formation" to the other. As a rule, however, the entire series, as compiled from the limited knowledge that we now have of the earth's surface and superficial structure, is broken very often on each continent. We find not only very abrupt changes in the character of the strata, but in the faunal remains, as we pass from one "formation" to another. Forms that we have become familiar with in the Jura cease to exist in the Cretaceous, while new species and genera are supplied in their stead. Unless we choose to accept the hypothesis of "catastrophes," we must assume that at the point of observation the formation producing a transition that eliminates abrupt termination and beginning is wanting. When we do find it, however, we shall expect to see that forms of both the older and younger formations to which it is allied will be perpetuated therein. A case of such a transition-formation the Post-Cretaceous "Lignitic" group offers us. Instead of forcing it into the Cretaceous or Tertiary, with neither of which the group fully agrees, I deem it more in conformity with geological science of the present day, and certainly more convenient for classificatory purposes, to regard it as an independent formation, representing a transition from the Cretaceous to the Tertiary.

Tertiary.—The lowest member of this formation that we find represented in our district is the Wasatch group. On the Lower Animas the Puerco marls of Cope set in, overlying the Fox Hills beds. Wanting here, or very imperfectly developed, is the Lignitic series proper. Above the marls massive beds of sandstone set in, continuing southward for a long distance. We did not travel far enough in that direction to observe the fossiliferous variegated beds above them. In Chapter

IV, the views of Professor Newberry are given, and issue is taken with him as regards the age of the entire group. But little can be said of the series, as our work did not carry us far enough to correlate it thoroughly with over- as well as under lying strata. It can be said, however, that it is entirely conformable with the Fox Hills. The general character of the country is one that agrees fully with the lithological constitution of the beds, and very similar to that produced by the same formation at other localities. It is to be regretted that the southern extension could not have been followed sufficiently far to prove of interest palæontologically. From the evidence obtained by Professor Cope farther south, and the negative evidence in our own district, there is scarcely any doubt but that the position assigned to this group at the base of the Tertiary is the correct one. Room is left for doubt only by the absence of fossils. Our march through that region was necessarily a hurried one, and but little time could be spent at any particular locality. Had we been able to make investigations more in detail, we probably should have found our conclusions sustained by palæontological evidence.

Volcanic rocks.—Of these we have essentially three groups in our district: (1) the trachorheïtes, (2) the porphyritic trachytes, and, (3) the basaltic group. The first covers large areas, extending in Southern Colorado in one unbroken mass over about 7,000 square miles. This great deposit I had occasion to study during three successive years. It was found to be, lithologically and geognostically speaking, of great uniformity. In 1874 I found a region which bore evidence of having been the main point of outflow, for at least a very large portion of the volcanic material.* Neither in 1873 nor 1875 was any other locality found that could at all be considered as having been at one time the center from which large areas were overflowed by the volcanic material. Throughout the region of the Uncompahgre Mountains (with the exception of the locality above mentioned) the trachorheïtes show a regular stratification, on a grand scale, however. At many points the single strata or "flows" can be traced for miles, or, if not traced, can be recognized by their lithological character. The present position of well-determined volcanic strata is a strong argument for the theory which claims a gradual rise of the mountain ranges since the cessation of the earlier volcanic activity. We find on high ranges, on peaks reaching an elevation of 14,000 feet above sea-level, the strata as distinctly marked as 6,000 feet lower down. We can scarcely assume that the region of outflow was at one time so high that it occupied a sufficiently elevated position to send its flows for a distance of more than a hundred miles, where they now are found at an altitude over 12,000 feet. It is more reasonable to suppose that, at the period of the massive eruption, the ranges now composed of trachorheïtes were lower, and have, since that time, changed their absolute elevation. During the outflows the surface of the country was already corrugated, as is shown by the outcrops of underlying metamorphic rocks. It might at first sight be supposed that the volcanic material had been the agent producing a metamorphosis, which now we would find at places best adapted for exposures. Ample evidence has been obtained, however, more particularly along the northern border of the Quartzite Mountains, that whatever local influence the hot lavas of that period may have had, they have not been productive of any extensive metamorphosis of older formation. Wherever shales and sandstones have been found in immediate contact with the volcanic rocks,

* Comp. Report United States Geological Survey, 1874, p. 208.

an alteration of the former has generally been observed. This, however, is invariably local, confined to narrow limits vertically. Were it possible to make examination below the present surface of the trachorheïtes, we could, no doubt, reproduce a comparatively accurate picture of the configuration of the country before the period of eruption. Natural agents have furnished us with too limited a number of outcrops to form any but the most general idea as to the distribution of ranges and valleys at that time. It can scarcely even be made out with any degree of accuracy where the largest masses of mountains or hills, now covered, were to be found. So much is certain, however, that the Quartzite Mountains were then already too high to be invaded by the flowing lavas, and that they were the highest group of the entire region. Toward the north they sloped off in ridges, that now appear as isolated outcrops of metamorphic rocks. At the southern end of the Sawatch Range we find another locality that must have been too high (station 94) for the trachorheïtes to cover with any heavy beds. Possibly that and the Quartzite Mountains were in connection at the time; if so, there existed a low depression in the region where now Pagosa Peak rises to an elevation of more than 13,000 feet.

A very interesting feature of this region is the trachytic conglomerate occurring with such great regularity along the north and southwestern edge of the volcanic area. It is directly included between two series of trachorheïtic flows, and is composed entirely of material originating from the lower. Evidently the conglomerate was deposited by water that flowed over the trachorheïtes, as its composition fully proves. Whether it was deposited *into* water might seem doubtful, considering the absence of all animal remains. Structural character, however, admits of no doubt that it was deposited into either gently-moving or still water, more probably the former. It seems, judging from the physical character of the conglomerate, that its deposition must have taken place during a comparatively short period of time. Comparing the eruption of all this volcanic material with phenomena observed in connection with active volcanoes of the present time, it is but reasonable to suppose, that at certain stages of the expulsion of lava, bowlders, fragments, and "ashy" lava were ejected. In reality, we do find deposits that very closely resemble the "ash" from existing volcanoes. If this was the case, it would have been an easy matter for the waters flowing over the hardened lava to remove in a short time a vast amount of material, which was then deposited at the places most favorably situated.

As to the origin of this mass of volcanic rocks, I have no occasion to change the suggestion made* three years ago. Although I am not at present able to prove conclusively the hypothesis that we have in the trachorheïtes nothing but a highly-fused granite, the entire *habitus* of the formation, and the constancy of its constituents shown upon ultimate analysis, are so characteristic, and so closely agree with observations on Archæan groups, that I cannot otherwise than regard the view formerly expressed as correct in the main. Dr. Oscar Loew† says: "Here (*Burro Mountains, N. Mex.*) the rock (*rhyolite*) exhibits a close relation to the granite which it overlies, inasmuch as it incloses semi-fused fragments of the latter. Moreover, we can trace quite distinctly the effects of various degrees of heat upon masses of feldspar, which have, in some instances, assumed a glassy appearance; extensive veins of quartz also penetrate the rhyolite. From this it would appear that we here have a granite with partial transformation into a rhyolite."

* Report United States Geological Survey 1873, p. 350.

† Explorations and Surveys West of One Hundredth Meridian, vol. iii, 1875, p. 641.

This observation points to the fact that different processes of cooling will furnish products which physically differ, though chemically they may show the same ultimate constituents.

The second group, porphyritic trachytes, varies from the first mainly by their mode of occurrence and age. They form principally isolated volcanic masses, rising considerably above the level of the surrounding country. A number of the detached mountain groups in Western Colorado—Sierra La Sal, Sierra Abajo, La Plata Mountains, and others—are composed of this material. In the eastern portion of the State they are not wanting, although not so frequently met with. Dr. Peale is preparing an exhaustive paper on this subject for the annual report of 1876, which will give, in detail, the mode of occurrence and features of mountains and ranges belonging to this formation. He has had occasion to examine quite a number of them, and has obtained data that enable him to treat of the subject thoroughly.

Dolerite and basalt comprise the third group. The former is but sparingly represented, while the latter is very frequently met with. In the southern portion of San Luis Valley and on the eastern slope of the southerly extension of the Sawatch Range the largest mass of basalt was observed. It has been described in Chapter II.

Both the porphyritic trachyte and the basalt form dikes, that often extend for a number of miles, traversing sedimentary beds. All the volcanic eruptions in Southern Colorado are "massive," in contradistinction to "volcanic" eruptions. Nowhere was even a single well-defined crater found. Instead of the volcanic material being ejected, as we see it done to-day, from a more or less regular cone, building up a crater by the deposition of lava around the orifice, through which the expulsion takes place, we have, at best, hills or mountains, most frequently of irregular shape. Through the agency of either plutonic or volcanic earthquakes (less probably through contraction of the earth's crust or portions thereof) "cracks" were formed, reaching down to a depth where the liquid or plastic material occurred, or to which it could force its way. This, forced upward, passed through the fissure, and, upon its arrival at the surface, spread in every available direction commensurate with the propelling pressure from below. In the dikes we have evidence that the material composing them must have reached the walls of the fissure, at least near the surface, in a plastic and not viscous state. This, too, was probably the case with many of the porphyritic trachytes. If we assume that the pressure producing their ejection through fissures, that owed their existence either to the action of this same pressure or to other causes, was but little more than adequate to force the liquefied mass to the surface, we can infer that the passage of this mass was slower than if the pressure had been greater. Opportunity is therefore given to the material to cool gradually while ascending, and to assume rigidity more rapidly after reaching the surface than otherwise would have been the case. Having become rigid, it would naturally require a by far greater force than up to that point of time had been employed to produce any further motion in the mass. Should, then, the pressure below not be fully expended, although no longer able to exert any direct influence upon the volcanic body it has brought to the surface, it is highly probable that phenomena comparable to present seismic action would take place. In that case we could expect accessory fissures to be formed, into which the liquid or plastic material would be injected by the remnant of the original pressure. If the volcanic mass reaches the surface in a sufficiently liquid state to permit its flowing, and the pressure brought to bear upon it from below still continues, we will find that, although rapidly becoming rigid, it is still able to form either comparatively high mountains or cover a considerable area, or both.

Regarding the relative age of these volcanic groups, we once more have occasion to admire the accuracy of Richthofen's excellent classification.* At all places where they were observed in our district of 1875, the succession as given by him was found to hold good. From evidence collected, we find that the porphyritic trachyte is younger than the trachorheïtes, older than the basalt. The entire series of volcanic eruptions in Southern Colorado falls into a geological period that is subsequent to the deposition of the Lignitic group. Each of the three eras of volcanic activity has no doubt occupied a long space of time, less, perhaps, the second one than any other. In discussing the glacial phenomena, mention has been made of a conglomeritic deposit, probably belonging to that age, which is covered by basalt, and this latter, therefore, must be regarded as the youngest of the volcanic rocks in that section of country. Its last eruptions have taken place at a time when the configuration of the surface already closely resembled that of to-day in its general outlines. All the volcanic rocks that we find in Southern Colorado must be classed as being Post-Cretaceous.

Glacial phenomena.—These have been treated of in the appendix, and the results derived from observations during two seasons, more particularly, have been given.

Drift.—Of drift we find a number of varieties—glacial, avalanchial, river-drift, lake-drift, and alluvial drift. All of them occur at places where we would most naturally expect to find them. The amount of redeposited material in Southern Colorado is enormous, but we can readily understand that this must be so, when we see the cañons and eroded mountain-slopes that have furnished it. For the first time have I used the term "avalancial" drift, denoting that species of more or less heterogeneous secondary deposit that owes its removal from the original position to earth- and rock-slides, or to subsidences that are sometimes accompanied by movements resulting in a general breaking up of the rocks. For the regions under consideration, the application of this name is characteristic, and expresses a typical occurrence of drift.

Mines.—In the district of 1875 gold and coal are mined. Of these the former occurs in the Summit district, southwest of Del Norte, and in the southern portion of the Sangre de Cristo Range, the Trinidad gold-mining district. At the former locality it is found in the trachorheïtic, in the latter in metamorphic rocks. More time and work will be required before a final decision as to merit can be formed, though at present the indications looking toward eventual remuneration are favorable. Coal-mines have been started, and are worked with varying industry in the Trinidad region. In Chapter V they are described, and analyses of the coal obtained there are given. This coal is of a fair quality, applicable both for smelting purposes and for the manufacture of gas. Increasing population and connection of the settlements by railroads will go far toward developing these mines, as with such advantages a greater demand will establish itself, and enterprising miners will be able to find a ready market for their coal.

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* Memoirs California Academy of Science, 1868, vol. 1, part ii.

APPENDIX.

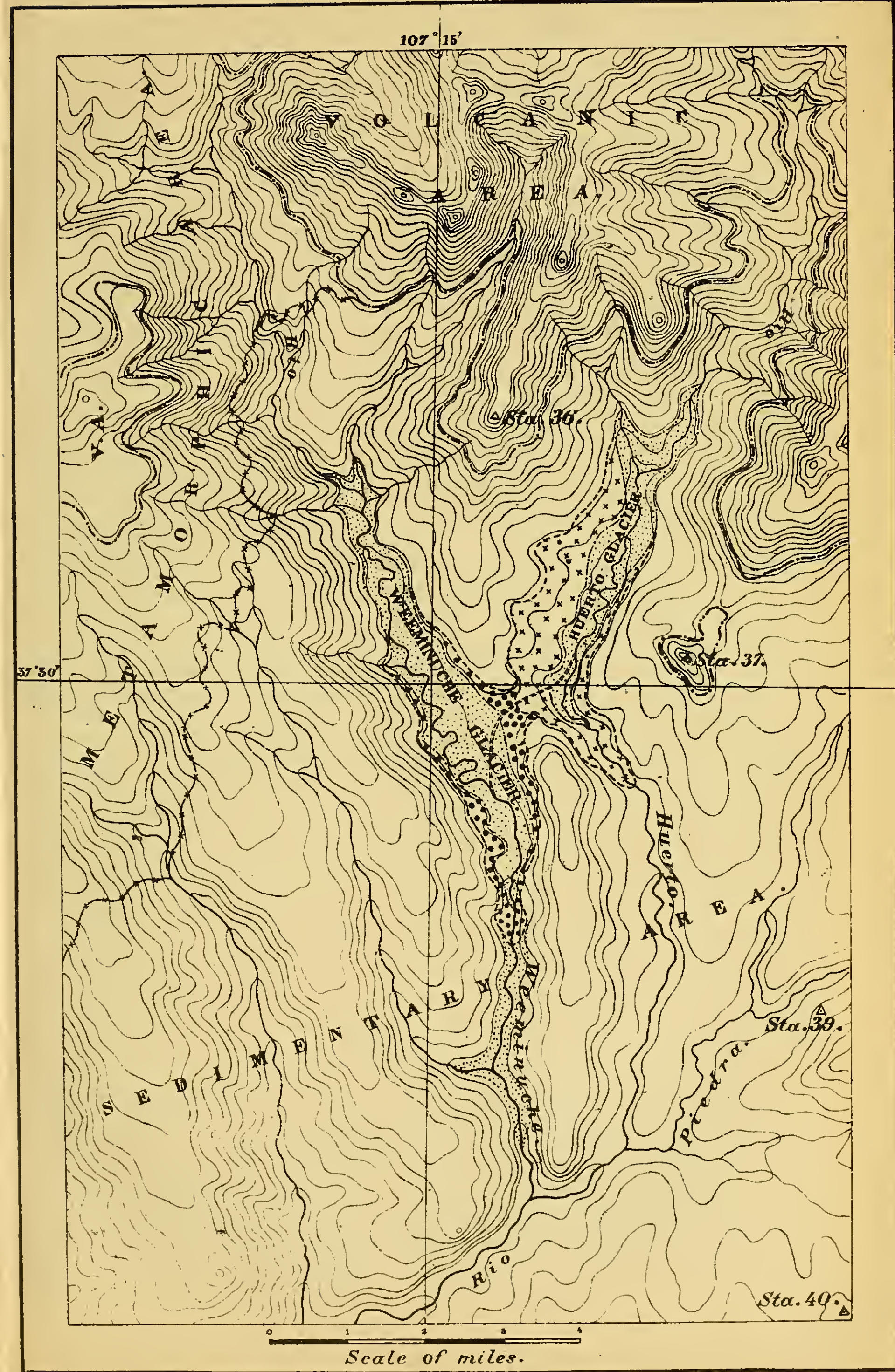
A.—ANCIENT GLACIERS IN SOUTHERN COLORADO.
B.—CATALOGUE OF THE MINERALS OF COLORADO.

A.

ANCIENT GLACIERS IN SOUTHERN COLORADO.

In the United States Geological and Geographical Report, 1874, p. 192, evidence of ancient glaciers has been mentioned as existing near station 38 of 1874, and near station 23 of 1874 (Mount Oso). At the former place the glaciers were small, moving parallel to each other over a gently-sloping bench about at timber-line (11,800 feet). Polished and grooved rocks, erratic bowlders carried for several miles in a westerly direction, and the presence of numerous small shallow ponds denote the existence of moving ice at that point, in former times. Were it possible to traverse that wild section of country as thoroughly as might be desired, I have no doubt that numerous other indications of glacial action could be observed. The locality in question is at the western edge of that high group of mountains which has received the name of Quartzite Mountains. Deep cañons, almost impassable, cut down into the hard metamorphic quartzite and schist rock, and are slowly worn still deeper by the swift currents of streams carrying comparatively very large quantities of water. Fog and rain, accompanied by low temperatures, are abundant there, even during the hottest portion of the year. This, then, is a region singularly well adapted to the formation and existence of glaciers. The hard, smooth sides of the rock, wherever it is free from *débris*, the deep cañons, into which the rays of a warming sun rarely penetrate, and the unusually large amount of precipitated moisture, are all circumstances that combine favorably for the early freezing and late thawing of accumulated masses of snow and ice. In the cañons themselves, at the headquarters of Rio Vallecito, the polishing and striation of the rocks *in positu* may be observed. Both those forming the base and those forming the slopes show the evidence of having been subjected to the process of erosion by moving ice, carrying with it pebbles and bowlders. Descending with that tributary of Lime Creek where we have first noticed the language, written by glaciers, and descending still farther into the valley of the Animas, the indications that, at a higher elevation, admitted of no doubt, become more and more indistinct. Granite lies exposed *in positu*, the rounded appearance of its surface strikingly reminding of the classical "*roches moutonnées*", but owing to the peculiar physical condition of this granite (coarse-grained, with the mica and feldspar approximately in one plane), it would be possible that such forms might result without the aid of moving ice, or even flowing water. Frost and other atmospheric agents could readily produce

Plate XXXIII.



AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

the effect there observed. On the other hand, the evenness of the valley, the presence of shallow lakes, and the long-continued appearance of this granite, in the same manner, strongly argue for the acceptance of glacial action in having thus shaped its surface. Granite decomposing as readily as the one in question does would not retain striation for the same length of time as either the hard quartzite or the schists would, and it is quite possible, therefore, that the more positive evidences of moving ice may have been obliterated by the never-ceasing activity of atmospheric influences. Traveling farther toward the south, the exposed granite increases in quantity until we reach Animas City. From there downward heavy drift occurs, marking probably the end of the ancient glacier, if such it was, as a terminal moraine. This drift is composed of the rocks through which a glacier coming from the north would have passed. Quartzites, hornblende, and mica-schists, gneiss, and granite, each of many varieties, are represented there. Striation could not be noticed on any of the specimens examined, but their shape was more uniform than probably it would have been did they owe their transportation for so many miles from the place of their original occurrence to water solely. Taking into consideration all these facts, it seems to me that the most rational conclusion to arrive at is, that the glacier descending into and partly down the Animas Valley is of older date than those observed higher up in the mountains, and those more sheltered from evaporation in the deep cañons of the Quartzite Mountains. It does not seem that ice had at these points a very great influence upon the configuration of the country. Certain it is, that many of the minor details now to be observed owe their existence to it, but the main features of the region had been formed before glaciers.

Near the headwaters of Rio Piedra, south of Weeminuche Pass, evidences of glacial action can again be observed. Crossing the pass, we find trachyte, which soon, however, disappears, permitting the underlying metamorphic granite to appear. Here rounded bowlders, having been carried from their place of occurrence for several miles, and polished metamorphic rocks along the hill-sides speak for the existence of glaciers. Although the proof of their existence is good at the points where it was observed, it soon becomes obliterated farther down stream. It is probable, therefore, that the ice-fields here were of but small extent. They evidently carried bowlders of large size with them and deposited them all along their route. This leads me to conclude that the size of the glaciers was a variable one, changing, perhaps, with the mean temperature of the cold seasons.

Near stations 36 and 37 the remains of old glaciers are very easily recognized, as also the influence that was brought to bear on the shaping of the water-courses. A map showing the relative conditions of the region is annexed. One of the main branches of the Piedra (Weeminuche Creek) flows a little east of south, about two miles west of station 36. It runs first through an area of metamorphic granite, then through a narrow strip of Lower Cretaceous, resting upon the former, and finally enters a valley about five miles long and a mile wide. While evidence of the passage of glaciers was found above the valley, this latter it covered entirely by glacial drift. The glacier moved down along the course of the stream, depositing on either side lateral moraines of small extent, while the central portion remained filled with the ice. After moving on for about four miles, the glacier made a curve to the eastward, but soon changed again to its old course. In the lower part of the valley—Cretaceous—we now find deposited the metamorphic and partly volcanic, erratic material that was brought down by the movement of the ice.

On either side of the valley are Cretaceous ridges, which close at its end to a narrow cañon. At one time evidently this cañon was choked up with the accumulating drift, and the ice found itself forced to expand laterally. Thereby a large mass of the bowlders was pushed against the low divide eastward, through which formerly the next stream to the east entered and joined the ice-field. At the same time this eastern fork (Rio Huerto), situated between stations 36 and 37, was but a glacial stream, resulting from the melted ice that filled the valley between the two stations.

To-day that valley consists of a beautiful green meadow four miles long and about a mile wide. It is flat, with a pretty stream running along its eastern edge. Along both the sides morainal benches follow its entire length, and at the lower end of the valley a terminal moraine has constructed a "dam" about 60 feet high. Near the center of this dam is an opening of regular shape through which the stream finds its outlet. It turns sharply to the east, runs in a southerly direction around a Cretaceous bluff and joins the stream of Weeminuche Valley about six miles lower down. The glacier coming out of the narrow gorge of volcanic mountains at the head of the valley moved down it, depositing more erratic material on the west than on the east side, owing to the slope of the latter. At that time the waters flowing off from it joined the western creek five miles higher up than at present. Gradually, however, the passage became obstructed by the deposition of moraines, and the water could no longer flow through the accustomed channel. During the same time the eastern glacier pushed its own terminal moraine toward the narrow southern entrance of the valley, until it was no longer possible for the water to escape there, save in disconnected, small brooks. Either synchronous with this period or shortly after, the glaciers of both valleys began to recede, first, perhaps, the eastern one, and then the accumulating waters of the Huerto Valley formed a lake. From the present appearance of the moraines, from reduction of their prominent irregular shapes to that of continuous benches, and from the gradual but extensive erosion produced by overflowing waters, I have concluded that the lake remained there for quite a long time. Finally, however, the resisting terminal moraines seem to have been weakened and the water rushed forth, breaking the opening into the dam that now exists. Instead of being able to flow in the same southwesterly direction that it followed before the deposition of moraines at the point of its egress, it was forced thereby to turn eastward, and only after flowing for six miles could it find an opening through which to join the stream that it formerly entered higher up. These two instances are the most indisputable that I have seen in Southern Colorado of the former existence of glacial lakes. Whereby the recessionof the glaciers throughout the region was produced, will be discussed in subsequent pages. How slowly or rapidly it may have occurred, however, and how much opportunity for the formation of lakes may thereby have been afforded, is a question that cannot be answered by the observations and experience of to-day.

It seems probable that a number of the cañons through which tributaries of the Rios Piedra and San Juan flow were cut in part by glaciers. The large amount of drift deposition in the immediate vicinity of the mountains, which there form a long line of steep slopes, cannot well be otherwise accounted for. In case we could assume that the mean annual temperature in that region was at any time low enough to admit of the existence of glaciers—and we have the undoubted evidence of their former presence—there are but few localities in Southern Colorado that would be so favorable to their formation. An elevated plateau, a large portion of which is above timber-line, stretches nearly horizontally from northwest to southeast, cut at right angles to its strike by deep cañons. Precipitation of moisture is there, at least at the present time, very plentiful, and nothing would prevent the formation of large masses of ice. After descending into the lower valleys, the glaciers probably would have succumbed to the change of temperature, as there is about 5,000 feet difference of elevation along the edge of that volcanic plateau and the valleys immediately west of it. This, of course, may account for the fact that so few glaciers descended as low as the two above described (8,000 feet above sea-level).

Of by far greater extent was the glacier occupying a position on the summit of the volcanic plateau, at the headwaters of Rio Conejos and Rio Chama. Riding up this latter river the first indications of glacial action were observed at an altitude of 8,450 feet. The surrounding rock was trachyte and trachytic conglomerate, strewn upon which erratic bowlders of mica-schist and gneiss were found. Irregular knolls of erratic material along the cañon gave evidence of morainal deposits. Large quantities of earth and gravel, obtained partly from the metamorphic rocks, whose site we had not yet discovered, partly from the trachyte and conglomerate, formed small hills, scattered across the narrow valley without order. From the land and rock slides near the cañon-walls they were readily distinguishable. For the distance of about five miles this continued, until the cañon closed in very suddenly. This occurrence is the most southerly one that I have observed in Colorado, reaching south of north latitude 37° into New Mexico. Examining a wall that seemed to shut every egress off completely, the metamorphic rocks were discovered *in positu*, and were found to be the same that furnished the erratic bowlders. It was seen that the glaciers transporting the material had descended 2,700 feet from the summit of the plateau from the northwest in a horizontal distance of about three miles, and then had pushed before it the material that had accumulated for ages in the narrow valley below. Polished rocks *in positu* and striation of the same gave evidence of the course followed by the glacier. Probably one or two smaller branches of the glacier above descended from the northeast, but the nature of the rock is such that striation or polish would there soon have vanished. Small outcrops of granite at that locality show the thickness of the volcanic beds to be about 3,000 feet. Although the lower and upper beds of the volcanic rock are hard and firm, the middle ones are composed of conglomerate, which readily yields to erosive agents. Farther north this becomes more apparent still.

Ascending to the plateau, evidences of glaciers are found in the presence of small shallow lakes within the timber-line. On the plateau itself, just at the headwaters of Rio Chama, the greater portion of the volcanic strata is exposed to view without having formed any soil. Striation and polishing of the most beautiful type extends from here (station 84, about 11,800 feet) for four miles farther north, along the headwaters of the Rio Conejos. At this place, too, there is evidence of a "drop" of about 400 to 500 feet vertical distance. But very little lateral displacement has occurred in consequence thereof. Near station 84, the striæ lead toward the cañon of the Chama south. From the fine striæ, the diameter of a hair on a highly polished surface, these witnesses of former glacial motion occur, increasing to grooves 3 and 4 inches wide and ½ to 1 inch deep. The material showing them is a light-brown trachyte, belonging to No. 3, upper. Its compact feldspathic paste and the diminutive crystals of segregated minerals have tended to preserve as completely as possible the finest lines and the mirror-like polish that the repeated passage of ice over its surface has produced. Though through unimportant local displacements the direction of the striation on many, even large portions of rocks, has been changed from its original position, the main direction is toward the deep valley of the Chama. As we proceed farther north, however, riding over the bare rocks that are striated and grooved, a change takes place, and we find that instead of their main direction being toward the south, it was now toward the east, in a line with the headwater drainage of Rio Conejos. Hundreds of little ponds have formed in the shallow depressions produced by the slight excavating action of the ice and its accompanying bowlders and detritus. More than 25 square miles must have been covered on the plateau by this extensive glacier, although there were some points there that could not be reached by the ice. The plateau slopes toward the east about at the center of the ancient glacier, and in that direction the ice moved. Bowlders are found lying around but not in any regular order, for obvious reasons. As soon as the moving agent of erosion separated into several arms and reached the easily crumbling trachytic conglomerate, it turned its power to account and aided in the production of narrow cañons of great depth. Probably the waters leaving the glacier had selected the most favorable directions for their passage, and the ice, with rocks coming after them, wrought so successful an erosion that the cañons entered from above are almost impassable. So far as I could observe, no striation remains on the walls of the conglomerate, neither do the erratic bowlders within the cañons show any regular morainal deposition. The latter dropped down as they were pushed over the steep edges by the ice, and merely form irregular heaps, the irregularity of which was further increased by the superposition of the ice. How far down these cañons the glaciers may have extended I am unable to say, but am of the opinion that they soon succumbed to the higher temperature that they must have found 3,000 to 3,500 feet lower. Where the Rio Conejos reaches San Luis Valley, it runs in a cañon of basalt. Soil has been deposited on either side of the river by it, while the surrounding country shows nothing but the sterile basaltic cover. Probably this soil may have been to a great extent the smaller detritus formed by the grinding action of the glaciers. Nothing was found there, however, that might warrant the belief that any of the glaciers could have reached the valley. Although the pressure from above must have been very great and the impetus given the motion of the glaciers very considerable, by descending so rapidly, it does not seem as if they traveled more than perhaps seven or eight miles from the point where their western limit may be located. This is the largest single glacier or rather series of glaciers from one starting-point that I have observed in Southern Colorado, and it is a particularly satisfactory one, inasmuch as it has left the record of its history in so unequivocal and easily read a legend. I call it the Conejos glacier.

Small indications of local glacial action may be observed in some of the cañons of the Sangre de Cristo Range. They are of such a character as to lead to the conclusion that the same results might have been produced by a repeated accumulation of snow and the subsequent movement of both snow and the adjoining bowlders upon thawing. At all events there is no certainty as to their true glacial character, and they are not considered here. The above enumeration includes all the undoubted glacial regions of Southern Colorado that I have had occasion to visit during the years 1874 and 1875. An interesting question presents itself when considering whether these glacial occurrences were synchronous or not, firstly, among themselves, and secondly, with the accepted glacial epoch of this continent. Inasmuch as the latter extended over a very large period of time, there is but little to be gained or lost by discussing that portion of the question. The first part of it, however, has a direct bearing upon the physical history of Colorado, and it will be well to examine into the facts that may lead to the one or other view. Undoubtedly the most valuable evidence in determining the geological age of this glacier is to be gained by observing upon what rocks or beds they were located. But little will be learned on this point from that at the head of the Animas. During the Carboniferous period, probably, or late during the Devonian, the rocks that now exist as quartzites, schists, and granites, were metamorphosed so as to attain their present character. Those near station 38 of 1874 are of Silurian age, so that nothing regarding younger formations can be learned at that locality. On the Piedra the glaciers have covered Lower Cretaceous sandstones and shales; but as this is the youngest group in existence there, the age is too remote for us to take the relative position in evidence. The Conejos glacier, however, affords more of a clew. A spur of the plateau from which it started runs in a southeasterly direction, and upon this station 88 is located at an elevation of 12,181 feet. This is lower than station 85, 12,282 feet, which latter station is still within the original domain of the glacier. In spite of this difference in altitude the plateau of 88 is covered by a black vesicular basalt, while 85 is located on trachyte. Experience and observation have taught that basalt (as a rule, though exceptions in favor of rhyolite are claimed) is the youngest of the volcanic rocks. Both trachyte and basalt are regarded as being of Tertiary origin, extending in time to the Miocene period. Here, then, we have a tangible fact, whereby to determine the relative age of at least one glacier. A portion of the Conejos glacier extended toward the southeast and covered a portion of the basalt which there overlies the trachyte. It is certain, then, that the period of existence for that glacier must have fallen into late Tertiary times, provided our premise as to the age of trachyte and basalt is correct. How much later than the period stated it may have existed there, however, is beyond the possibility of determination. We have merely the extreme limit of "old age."

Taking into consideration the accumulation of finely separated mineral matter in San Luis Valley, which may in part owe its existence to the action of the glaciers as stated above, we see between the two items a connection as to time. The glacier covered basalt and the *detritus* produced by the glacier covers basalt.* Having seen this to be the case, we have at hand the means to explain the afflux of an unusual amount of water into San Luis Valley, which at that time must have been in a condition resembling the present in its general features. If the basalt was there the bluffs and mountains in the south of the valley were already formed, and the gentle slope from the southeast was also existing. That the glacier did disappear is a fact, also that it could not have vanished solely by the agency of evaporation. Melting of the ice would of necessity accompany any process of that nature, and the supply of water for San Luis Valley would have been greatly increased. It is possible to answer the question of contemporaneous

* Report on Northern California and Oregon, J. S. Newberry, 1857, p. 42, mentions "trap-ledges" grooved and striated by glaciers.

existence of these glaciers at different localities indirectly only. By studying the causes that produced glaciers in Southern Colorado, and arriving at a satisfactory conclusion as to their efficacy, we may judge that like cause produces like effect, and may thus indirectly deduce for all our former glaciers in that region, the result that they were active at the same time. I am of the opinion that, although a general glacial period may readily be accepted, local influences determine in many instances the perpetuation of glaciers at given points. The glaciers of our own country, those of Switzerland, and numerous other regions are but in support of this view. Remove the cause of their perpetuation either by a change of the mean annual temperature or an inadequate supply of precipitated moisture, and the glacier will gradually disappear. It has been my endeavor to draw conclusions from analogous occurrences of other localities, as to the origin and fate of our glaciers in Southern Colorado, and the result thereof is contained in the subjoined pages.

Before proceeding to a more general discussion as to the causes and the origin of the glaciers in Southwestern Colorado, I wish to make reference to an interesting group of drift on the eastern side of San Luis Valley. In Chapter II mention has already been made of the "compact drift" observed at station 115, extending from there northward beyond station 118. It is by no means an easy matter to explain an accumulation of drift bowlders covering so extensive an area, and reaching a thickness of more than 1,000 feet. I have not seen the "regular stratification" mentioned by others as existing in these bluffs. There is an attempt at stratoid arrangement noticeable, but it is too obscure to admit of terming the poorly-defined layers strata. We found (station 118) that this compact drift was there covered by about 200 feet of basalt. At the same time pebbles and bowlders of basalt were found in the conglomeritic mass underlying the volcanic cap. Metamorphic, sedimentary (Carboniferous), trachytic, and, as stated, basaltic material compose the "compact drift." On the western slope of the Sangre de Cristo Range, at the immediate base of the high mountains forming its crest, cañons are cut into the metamorphic rocks, showing detail-features that closely resemble those produced by glacial erosion. This is particularly noticeable due east of the drift-bluffs. It seems highly probable to me, therefore, that the drift in question was deposited in the region where we now find it, by glaciers extending and moving from east to west. In Chapter II the former lakes of San Luis Valley have been treated of, and with reference thereto I explain the stratoid appearance of a portion of this drift by assuming that such portion was deposited into still water, into the waters of the great lake. It may seem rash to assign an accumulation of drift *capped by basalt* to glacial action. This appears all the more unorthodox when we remember that farther west glacial erosion was observed on the basalt itself. Taking into consideration, however, the long period of time that must have elapsed before the last of the basaltic flows made its appearance, and taking into consideration, furthermore, the intermissions of suspended volcanic activity between many of these flows, there is no reason why glaciers should not have formed and removed large masses of rocky material during such period of inactivity. These redeposited masses were eventually reached by the lava of the latest volcanic eruptions. This case, or rather this interpretation of facts observed, is not isolated, although I am not aware of any similar or identical occurrence having been observed on the North American continent.

Lyell,* following the view of Gastaldi, considers erratic deposits in the Miocene formation of Turino as owing their present position to glacial action. By Godwin-Austen deposits in the Cretaceous formation of England are claimed as having had a similar origin, and Escher von der Linth, considers conglomeritic accumulations in the Cretaceous of Switzerland as having been produced by glaciers. A number of English geologists have even asserted that a breccia, belonging to the Permian (at Whitehaven) formation, could not have been deposited by anything but ice. At all events, explanations of this kind must be received with caution, but the fact of such comparatively numerous observations, at different localities, goes far to show that the assumption of the existence of either very early glacial periods or very early local glaciers is one not foreign to the views of a geologist. Nothing that I can conceive of, either in the arrangement of the conglomerate or in its correlation with neighboring formations, argues against the conclusion that it may have been transported to its present place of deposition by the action of moving ice.

Considering the influence that ancient glaciers must have had upon the configuration of San Luis Valley, I cannot regard it as having been other than subordinate. Experience has shown that glaciers will follow a course best adapted to their development, and that, although they determine in a very large measure the detail-features of the region they traverse, they rarely have been productive of radical changes extending over thousands of square miles. B. v. Cotta † states that glaciers certainly have no opportunity of forming unless valleys to receive them already exist.‡ He contends that, although the influence of moving ice upon the orographic features of a region invaded by it cannot be denied or overlooked, it has heretofore generally been overestimated. It is possible for glaciers, according to Cotta, to widen valleys, or change their form and dimensions, not, however, to excavate deep fjords or valleys at places where such, or their beginning, never before existed. A case corresponding to these views we seem to have in San Luis Valley. The easterly dip of the volcanic strata west of the valley, and the elevation of the Sangre de Cristo Range, together, have, in my opinion, produced the depression of San Luis Valley. No doubt the glaciers near its border had a very considerable influence in shaping its edges, but I am not prepared to concede that the entire valley was covered by a single glacier, or that the entire valley owes its present configuration to the action of such glacier. Professor Stevenson says: § "The whole character here (*San Luis Valley*) seems to admit of no inference other than that the valley is the result of glacial erosion." For the reasons above given, I cannot agree with this "inference", as it seems to me altogether too much at variance with the results usually produced by

* Principles of Geology, I, pp. 203 to 207.

† Geologie der Gegenwart, 1872, p. 354.

‡ An exception to this rule may be noted as occurring in the regions of very low mean annual temperatures. Dr. Bessels, of the Polaris north polar expedition, has furnished me with the following data regarding the formation of glaciers, in very high latitudes, on perfectly level table-lands. In case the temperature of the warmer seasons be too low to produce a melting of the ice and snow which had accumulated during the cold seasons, the formation of a glacier or complex of glaciers is possible, even on a level plateau, which contains no elevations either as mountains or as a crest. Cases of this kind was observed by Dr. Bessels on both sides of Petermann Fjord, north of north latitude 80°. The ice then has a motion resulting from the combined effect of centrifugal force and regelation. This case, of course, can only occur in regions where we have arctic climatal conditions.

§ Report Explorations and Surveys West One Hundredth Meridian, 1875, vol. iii, p. 460.

glacial erosion. It requires from the glacier, that at best could have had but comparatively short headings, and must soon have spread over a very wide area, thus losing in active force, more work than in my estimation a glacier of such original extent could have performed.

As the last question involved in the discussion of the ancient glaciers of Southern Colorado, we have to consider their origin. Without entering into an elaborate discussion on glacial periods in general, I shall cite such instances as may corroborate the views I hold with regard to the subject.* From many localities west of the Missouri River, evidences of ancient glaciers have been mentioned by geologists exploring the country. Professor Newberry enumerates a large number from the Cascade Range,† including in the glaciated area Mounts Hood, Rainier, Adams, and others. Whitney‡ cites many localities in that State where the traces of former glaciers have been found. In Arizona, New Mexico, Utah, Colorado, and other Territories, they have been observed, and are described in the reports of the various surveying and exploring expeditions. We have, therefore, numerous ancient glaciers spread over an enormous area of country. For those of the Cascade Range Newberry claims the same period of time that is assigned to the great glacial epoch of our central continental regions. Gilbert § describes a number of the phenomena he has observed, and explains some of the orographic features of the regions he examined as owing their present characteristics to the influence of moving ice. Gilbert comes to the conclusion || that the "general glaciation of the Eastern United States had no counterpart in the same latitudes, over the region extending from the Rocky Mountains to the Sierra Nevada inclusive", and elaborates this statement by saying that "the phenomena of the glacial epoch at the west differed from the synchronous phenomena in the same latitudes at the East, for the reason that then, as now, the former region was comparatively arid, and material was lacking for a great ice-field". It is to be understood, then, from these expressions, that the glaciation of our western country did not partake of the same character as that farther east. In other words, instead of having a great expanse covered by ice, we have, owing to the "arid" character of the region, but isolated groups of glaciers. It seems to me, in case a general glacial epoch is accepted for our entire continent, that the orographic and topographical features of the country "from the Rocky Mountains to the Sierra Nevada inclusive" might more effectually account for the absence of a "great ice-field" than the want of moisture. At the same time it becomes a matter of some difficulty to reconcile the "then as now" "arid" character of the country to conclusion No. III at which Gilbert arrives. He says:¶ "There was a general accession of water to the valleys of the great basin, [*during the period of glaciation, would undoubtedly be understood from the connection this sentence has with the preceding and following*.—E.] Lakes were formed where now are only deserts, and valleys, now nearly empty, were filled to overflowing."

Two conditions, above all, are necessary for the formation of glaciers: an abundance of precipitated moisture and a low mean annual tem-

* I am at present engaged in preparing a paper on the ancient glaciers of the Rocky Mountains and those farther west, in which their correlations with each other and with the great ice-period shall be more fully treated of.

† Report on Northern California and Oregon, 1857, p. 42, and Pop. Sci. Monthly, 1876, p. 289.

‡ Geological Survey of California, vol. i, 1865.

§ Explorations and Surveys West of the One Hundredth Meridian, 1875, p. 86.

|| Ibid., p. 103.

¶ Ibid., p. 104.

perature. In order to obtain the requisite amount of moisture for the regions where we observe evidence of ancient glaciers, we must necessarily either assume that at the time of their existence the quantity of precipitated moisture was greater, or that the mean annual temperature was lower, than it is at present. If we study the country adjacent to that where we find glacial evidence, we will observe that a by far larger area was at one time covered by water than to-day. The Great Salt Lake extended beyond the boundaries that now confine it, spreading over a wide expanse of country.* Many of the valleys in Arizona, Nevada, and Southern California, that now present nothing but the sterile sand and gravel that rapidly destroy the few streams of these regions, were at that time filled with lakes. Here, then, we have a source of moisture far exceeding, in quantity, that carried eastward at present by the prevailing westerly winds. Near the western coast, where precipitation of water is more abundant than farther inland, we find glaciers still existing in some of the ranges. I conclude, therefore, that the ancient glaciers of Colorado and regions similar to it, both as regards geographical location and orographic construction, owe their former existence mainly to the presence of those numerous sheets of water farther west. These now have disappeared, and incident upon their removal, whatever may have produced that, was the recession and final extinction of the ancient glaciers. Holding this view, I maintain that the lakes formerly filling so many valleys were in existence *before* any glaciers occurred in the Rocky Mountains proper. Whether these lakes were prior, synchronous, or subsequent to the accepted glacial epoch of the North American continent is of no importance in this instance, inasmuch as their presence at any given time would have produced the local effects of glaciation in the regions under discussion. It is highly probable, however, that the period of their greatest magnitude fell into the time of the general glacial epoch, and thus, indirectly, do the local glaciers observed become connected therewith. So far as they are concerned directly, however, I claim for their origin immediate telluric causes causes that were originally the result, perhaps, of cosmic conditions of that character upon which Croll bases his ingenious and acceptable hypothesis. An analogous case to the one under consideration is that regarding the former and present glaciers of Switzerland. Escher von der Linth, the Swiss geologist,† supported by Désor, has explained the gradual diminution of Swiss glaciers in a manner that would fully account for the formation as well as for the disappearance of those formerly existing in the Rocky Mountains and the Sierra Nevada. It is a well-established fact that, in comparatively recent geological ages, the desert of Sahara was in connection both with the Mediterranean Sea and the Atlantic Ocean. It was then essentially an inland sea of enormous dimensions. The time of its greatest extent may be assumed to have been synchronous with that of the greatest development of South European glaciers. One instance may suffice. Proof has been furnished by Captain Bach‡ that at one time the glacier of the Rhine extended northward across Lake Constance, far into the present kingdom of Würtemberg. This was by no means the case at so very remote a period, as the archæological remains found at Schussenried by Professor Fraas§ tend to show. The glacier of the Rhone at that time extended southward

* Report Explorations and Surveys West of the One Hundredth Meridian, 1875, p. 88.
† Allgemeine Zeitung, Beil., No. 9 and 10, 1865.
‡ Wuertt. Jahreshefte, 1869, ii, p. 113.
§ Arch. für Anthrop., tom. ii, 1867.

across the Lake of Geneva, many miles beyond its present limits. Dependent upon the moisture derived from the large expanse of water farther south was the existence of these enormous moving ice-fields. With other words, though indirectly in connection, perhaps, with the general glacial epoch, their perpetuation was directly dependent upon local causes. As the sea of the Sahara receded, the prevailing south-westerly wind (fœhn of Switzerland) became warmer, the mean annual temperature rose, and the size of the glaciers diminished in proportion. According to Ch. Martens,* the mean temperature of Switzerland would to-day require a fall of but 4° C. to permit glaciers to extend once more as far as the city of Geneva.

B. v. Cotta † states, in his clear language, that in the course of time, may it even require millions of years, every lake destroys itself. The water contained in a basin will never rest until it has destroyed such portions, the destruction of which will result in the disappearance of the lake itself. Where changes of niveau do not take place, counter-balancing the transporting power of flowing water, the tendency of all streams emptying into lakes will be to raise the level of its bottom. Thus both erosion at the edges of a lake and a rising of its bed will combine to produce a dry valley where formerly water occupied the region. To these is added the destruction by evaporation, and we have three mighty factors to account for the absence of bodies of water in the numerous valleys of our western country that bear evidence of having at one time contained them.

With the disappearance of these lakes, the recession and eventual destruction of the ancient glaciers was in the most intimate connection. The latter were totally dependent upon the former for their existence, and both came to a termination within a short time of each other.

Though no doubt numerous localities may be found in Southern Colorado, where small glaciers existed, it was impossible, during the time we spent there to study more of them than the ones especially mentioned above. They represent, I think, the most typical occurrences of that section of the country, and present varied features of great interest.

B.

CATALOGUE OF THE MINERALS OF COLORADO.

The subjoined list of minerals was prepared as nearly complete up to date as possible. As a foundation for it, the list published in the Report of 1873 (p. 355) was taken. All available material has been utilized in its preparation. I am indebted for information both through the medium of publications and personal communications to the following gentlemen: Capt. E. L. Berthoud, of Golden, Col.; Prof. P. Frazer, E. M., Philadelphia; Prof. F. A. Genth, of the University of Pennsylvania; Dr. F. V. Hayden; W. H. Holmes; Dr. O. Loew; Prof. E. J. Mallet, jr., of Rosita, Col.; A. R. Marvine; Dr. A. C. Peale; Mr. Peters, E. M., Fairplay, Col.; Prof. J. F. L. Schirmer, United States Mint, Denver, Col.; A. Von Schulz, E. M., Black Hawk, Col., and J. Alden Smith, Territorial Geologist of Colorado.

Among the most interesting minerals of the State the tellurium-com-

* Vezian, Prodrôme de géologie, tom. i, p. 421.
† Geologie der Gegenwart, 1872, p. 357.

pounds will be noticed. Nowhere have these occurred so beautifully developed and in such large quantities as in Boulder and Lake Counties. They have justly attracted the attention of mineralogists both on this and the European continents. Although a considerable amount of work has been done upon them, there is ample opportunity and need of further investigation. As the mines of the districts in which these minerals occur increase in depth, we may possibly be able to obtain some definite knowledge as regards the vertical distribution, in the vein, of minerals that are so highly volatile. Many discoveries have succeeded the first ones made in the Gold Hill district on the famous Red Cloud and Cold Spring lodes. New districts have been organized, and mining is carried on vigorously, producing the high-grade ores that are characteristic of the presence of tellurets.

A number of minerals, such as pyrite, chalcopyrite, galenite, sphalerite, and others, not classed as "ores", occur throughout the entire State. The former more particularly in ore-districts, the latter (feldspars, varieties of quartz, &c.) everywhere. In such a case merely the general locality has been given, without any special localities, unless these contain the mineral in some particular form or association. Since 1873 the number of mineral species found in Colorado has increased nearly 50, showing that by no means all the occurrences are known as yet. Nearly all found in the State, with but five or six exceptions, are primary minerals. After the mines will have been worked for some length of time, we can expect the formation and discovery of epigene species that would be particularly interesting from the telluride regions. Numerous localities have been added since 1873, discovered in part by members of the survey, kindly furnished in part by some of the gentlemen above named.

Glancing over the list, we find that Colorado is rich in minerals that may be classed as "silver-minerals". Many of the species belonging to this group are here represented and occur at a number of localities. Fewer varieties represent the lead and copper minerals. Silicates are found in their chief species, but good crystals of any one of them are rare.

Though comparatively a small list for a State containing such broad expanses of mineral lands, it represents mainly one class of species, those pertaining to mining industries, and the enumeration thereof furnished is sufficiently complete to give an idea of their distribution.

ACTINOLITE.—In radiated form, of light-green color, on station 2 of 1873, on Buffalo and Sopris Peaks, Bergen's Ranch, and Boulder Peak.

ACTINOLITE, CRYSTALLIZED.—Bergen's Ranch, Jefferson County, Colorado.

AGATE.—Cloudy, of white and gray color in the trachytic formations of station 27 of 1873, in various forms at the Los Pinos agency, in South Park, in the Arkansas Valley, and on the Frying Pan, in varieties. Throughout Middle Park, valley of the Gunnison, and adjoining regions. Moss agate below Uncompahgre, near Grand River.

ALABANDITE.—At Quartzville.

ALABASTER.—Mount Vernon.

ALLOPHANITE.—Franklin mine, in Gilson Gulch; Fowler and Wells's branch, Sugar Loaf district.

ALTAITE.—Red Cloud and Cold Spring, at Gold Hill.

ALUM.—Mount Vernon.

ALUMINITE.—Mount Vernon.

AMAZON STONE (ADULARIA).—Elk Creek.

AMBER ?—(One specimen found on head of Cherry Creek).
AMETHYST.—At Nevada and other neighboring localities. On Rock Creek, Clear Creek County. San Juan mines.
AMIANTHITE.—North Boulder Creek.
AMPHIBOLITE.—Buffalo Peak, Montgomery. In small acicular crystals in the porphyritic trachytes. Head of Ohio Creek in volcanic breccia. Along Ohio Creek and Gunnison River.
ANGLESITE.—Freeland Mine on Trail Creek. In crystals at the Horseshoe lead mine, in South Park.
ANHYDRITE.—On Elk Creek. Crystallized at the salt-works in South Park.
ANTHOPHYLLITE.—North Boulder Creek.
ANTHRACITE.—Gunnison River, Southwest Colorado. Anthracite Creek O Be Joyful Creek, in the Elk Mountains. Uncompahgre Cañon (semi-anthracite).
ANTIMONY.—Gold Hill.
ANTRIMOLITE.—Golden, Colorado Table Mountain.
APATITE.—At Fairplay.
APOPHYLLITE.—Station 22 of 1873.
ARAGONITE.—Occurring in the form usually termed *flos ferri*, very beautifully in Marshal's Tunnel, Georgetown, Golden. Table Mountain.
ARGENTITE.—Colorado Central Mine, Terrible, and other mines at Georgetown; in the No Name, Caribou, and others at Caribou; in some mines near Nevada; in the Senator lode of the Hardscrabble mining district; it occurs mostly in small quantities imbedded either in quartz or in the predominating ore; when decomposed, native silver is the result. At the Silver Star, Moose, and other mines near Fairplay.
ARSENOPYRITE.—Priest mine, Fairplay.
ARSENOPYRITE.—(With silver and copper,) Park Lode, Bergen's Ranch, Jefferson County, Colorado.
ASBESTOS.—occurs in small quantities, partly radiated, near Caribou.
ASPHALT is found in the White River region. It occurs in veins, is very compact and brittle. Occurs in springs near the summit of the Book Cliffs; Cañon City. (Loew.)
AVENTURINE FELDSPAR.—On Elk Creek, Jefferson County, Colorado Territory.
AVENTURINE QUARTZ.—Elk Creek.
AZURITE.—In the No Name, together with malachite, the result of decomposition of fahlerz, Caribou; in the Rosita mines in Hardscrabble, on Trail Creek, on Crater Mountains, in the mines around Fairplay, and in the mines of Elk Mountain district, Malachite lode, Bear Creek, Gendhemas lode, Tucker's Gulch.
BARITE.—In yellow tabular crystals, clear in the Tenth Legion mine of Empire, in the Terrible mine, near station 17 of 1373, and on station 46 of 1873; near Cañon City, transparent crystals occur in the arenaceous formations of that locality. In Gilson Gulch, Georgetown. Crystals occur in the limestones around Fairplay, Apishpa River, Colorado. (Amorphous). White, red, brown, Clear Creek Cañon. Montezuma.
BASANITE.—East of the salt works in South Park.
BERYL.—On Bear Creek, Tiffany's Ranch. Stone Dam, Jefferson County, Colorado.
BIOTITE.—On Buffalo Peak and station 64 of 1873.
BISMUTH.—French Gulch.
BISMUTHITE.—In the Las Aminas mine, pseudomorphous.
BISMUTITE.—From the Las Animas mine.

BITUMINOUS COAL.—At several localities along the Front range, at Pueblo and Cañon. On Trout Creek Pass, Trinidad, Golden, and at all the localities where the Post-Cretaceous Lignitic group is developed. In the Cretaceous on divide between Uncompahgre and Cebolla, on Animas, Florida, and La Plata. Near White River.

BRUCITE.—On James Creek.

CALAMINE.—Park County.

CALCITE.—In small crystals, scalenohedra, at the Monte Christo, Central; on station 35 of 1873, camp 32. At Mount Vernon, Bergen's Ranch. Rhombohedral crystals on Cheyenne Mountain; in the limestones of South Park; scalenohedra in Elk Mountain district; fibrous in Trout Creek Park; on Frying-Pan Creek. Brown, rose-colored, yellow, and white, Table Mountains. Golden, Arkansas River.

CALEDONITE.—Freeland mine, Trail Creek.

CAOLINITE.—Camp 42 of 1873.

CARNALLITE.—Salt-works, South Park.

CARNELIAN.—Middle and South Parks. Los Pinos agency.

CERARGYRITE.—Gilpin County lode, Black Hawk. Small compact quantities in the Wade Hampton mine, Argentine, Caribou.

CERRUSSITE.—J. P. Whitney mine; in very small crystals. Central; No Name, Caribou; Caribou mine; Silver Hills mines and Rosita mines, in the Hardscrabble district. Freeland mine, Trail Creek. In the Horseshoe mine it occurs earthy, and is found throughout the mines of Elk Mountain district. Cañon City.

CHABAZITE.—Golden, Col. Table Mountain.

CHALCANTHITE.—On Clear Creek, below Black Hawk, in a deposit, and on several dumps near Central.

CHALCEDONY.—Chalk Hills, eight miles south of Cheyenne Mt. On station 27 of 1873; at the Los Pinos agency. Middle and South Parks. Buffalo Park; Fair Play; Frying-Pan; Trout Creek, &c. Gunnison River.

CHALCOCITE.—Bergen district, near Idaho City. Liberty lode, Bear Creek, Cañon City, Mosquito.

CHALCOPYRITE.—Malachite, Pocahontas lode, Bear Creek. Auriferous in the Bobtail, Winnebago, Dallas, Gunnell, Running, Kansas, California, and other mines at or near Central; mostly occurring compact, and frequently very intimately intermixed with pyrite. It occurs in every paying gold mine in Gilpin County, and the miners seem to think a great part of the "pay" dependent upon its presence. It also occurs in the Terrible, Pelican, Cold Stream, and other mines of Georgetown, as well as in those of Caribou and Hardscrabble. In the gold and silver mines of Fair Play and the Elk Mountain district.

CHLOANTHITE.—Arkansas River.

CHLORITE.—On station 45 of 1873. On Trail Creek; on Sopris Peak.

CHLOROPHANITE.—Bergen district.

CHROMITE.—Massive; Silver Hills and Fair Play.

CHRYSOCOLLA.—Champion lode, Trail Creek, Cañon City.

CHRYSOLITE.—So far as can be determined, the chrysolite associated with the Fort Defiance garnets extends into Colorado. (Compare Lieutenant Wheeler's Annual Report, 1875, p. 105.)

CHRYSOPRASE.—Rare, in Middle Park.

COAL.—*Vide* Bituminous coal.

COLORADOITE, or TELLURIDE OF MERCURY.—A preliminary notice of this mineral was given in October last at the meeting of the American Philosophical Society. It occurs at the Keystone and Mountain Lion mines, Magnolia district, Colorado. Another new telluride of gold, silver, and mercury is found at the Smuggler, Ballerat district, Colorado. For information on these minerals, I am indebted to Dr. F. A. Genth.

COPPER.—Native; arborescent in the Gregory lode. Ward district, Boulder County; Bergen's Ranch.

COPPERASITE.—On the dumps of the Wood Lode and Nevada.

COVELLITE.—Mosquito, Central City, Cañon City. (Loew.)

CUPRITE.—In crystals, from Sacramento Gulch and from the Sweet Home mine, Malachite lode, Bear Creek, Gendhemas lode, Tucker's Gulch.

DOLOMITE.—From the Four-Mile Creek.

EMBOLITE.—Peru district, Snake River, Gold Hill.

EPIDOTE.—In crystals, together with garnet on Gunnell Hill, Central; in crystals, small, on stations 17, 43, 46, 50, and 77 of 1873. A large number of the hornblende-dikes traversing the country contain epidote, either massive or in small crystals. On the summit of Mount Bross, Lake Creek Cañon, Grand Mountain, Elk Mountain Ridge, and all through the foot-hills. On Trail Creek.

FAHLERZ.—Terrible, Colorado Central, Pelican, and other mines of Georgetown; No Name, Caribou, and others at Caribou, station 46 of 1873.

FELDSPAR.—Occurs in the gangue-rock of a large number of mines near Central and Georgetown; crystals showing the Carlsbad twin-system are found in Gregory Hill, Central, in the porphyry, at station 46 of 1873, at Rosita. Twins are also found in the porphyries of Gold Hill, on Elk Creek, and at Idaho. Compare orthoclase.

FIRE-CLAY.—Golden, Ralston, Boulder, &c.

FLOAT-STONE.—Mammoth lode, Central.

FLOS FERRI.—*Vide* Aragonite.

FLUORITE.—Terrible mine, Georgetown, in the light-green cubes; in small crystals and massive, of violet color, on Mount McClellan and Gray's Peak. On Bear Creek; massive, pink and violet in the Sweet Home mine, Clear Creek, and James Creek.

GALENITE.—In narrow seams, fine-grained, Winnebago; feathery in the Dallas mine; coarse-grained in the J. P. Whitney, Running, Monte Cristo, Forks, and other mines of Gilpin County. In the Colorado Central, Equator, Star, Pelican, Terrible, and others it occurs in large quantities. The Cold Stream shows beautiful crystals, combination of cube and octahedron, with rarely the rhombic dodecahedron. The International, at an elevation of about 12,800 feet, has a heavy vein of galenite. The No Name, Fourth of July, and other mines in Boulder County contain the mineral. The Silver Hill mines (fine-grained) and the Rosita Mines in Hardscrabble district; on station 46 of 1873. Hamilton, the mines around Fair Play show crystals; the mines of Elk Mountain district, the head of Iowa and of Empire Gulch, contain galenite. In small, scattering quantities, it is found almost throughout the country. Bear Creek, Guy Gulch.

GARNETS.—Crystallized in rhombic dodecahedra and sometimes icosatetrahedra; found together with epidote in the dike on Gunnell Hill. Closely resemble the garnets from Auerbach, in Germany. In mica schist at camp 14, and at station 22 of 1873. On Trail Creek, Bergen, &c.; Montgomery, Bear Creek, Tucker's Gulch. Near the southwest corner of Colorado, occurring in drift (almandite).

GLAUBER SALT.—Bear Creek, Smoky Creek. At a number of hot springs in Colorado.

GLOCKERITE.—Central City, Idaho Springs.

GOLD.—Native gold in very small and indistinct crystals in the Bobtail, Gunnell, Quartz Hill, near Central. Tarryall Creek, Placer Diggings, near Fair Play, in imperfect crystals and laminæ; in Washington and California Gulches, in the placers of Union Park, and numerous other localities. Occurring as the result of decomposition of the tellurids at Gold Hill. Lately discovered native in great quantities, though very minutely distributed, in the quartz-ledges of the San Juan mining district. At Oro City in rhyolite. Nevada lode in azurite. Placers on San Miguel. Very handsome crystals of gold (small) have been obtained by Professor Schirmer from the Gunnell Lode, Central City. They occur on black sphalerite, and show combinations of cube, octahedron, and rhombohedron.

GOSLARITE.—On the dumps of the Wood lode, Leavenworth Gulch, near Central.

GRAPHIC GRANITE.—Bear Creek, Jefferson County, near Townshend's Ranch. Mount Ouray.

GRAPHITE.—Trinidad Mine, Las Animas County.

GREENOCKITE.—On sphalerite of the Dallas mine, Black Hawk; Running Lode, Quartz Hill, Nevada. In mine of galena on South Boulder.

GYPSUM.—Is distributed very widely throughout the Cretaceous formation of Colorado. Good crystals are rare. Selenite is the usual form of its occurrence, frequently being found in twins. Occurs also in the Upper Carboniferous rocks of Western and in the Tertiary beds of Southern Colorado. In Jurassic along the Front Range.

HALITE.—Salt-works of South Park, along some parts of the Platte River in springs. Found at salt-licks in various parts of the Territory. Cañon City, Sinbad's Valley, Greenhorn Mountains.

HEMATITE.—Bear Creek, Jefferson County, Colorado. Specular on Procer Hill, Central, head of Bear Creek; fibrous and specular in Phillips mine, Silver Hills; in the mines of Elk Mountain district; micaceous on station 65 of 1873; on Sopris Peak. Unaweep Cañon (specular).

HENRYITE.—Red Cloud Mine, Gold Hill. Cold Spring mine.

HITCHCOCKITE.—On copper minerals of the Dallas mine, Black Hawk.

HORNBLENDE.—Occurs in numerous localities in the dikes, so that it would be useless to enumerate them. No good crystals were found. Radiated on station 43 of 1873.

HYALITE.—On stations 33 and 34 of 1873 in trachyte. At the Hot Sulphur Springs of Middle Park. Basalt of North Man. In the trachorheïtes of the Uncompahgre group.

IDOCRASE.—*Vide* Vesuvianite.

IRON.—Native, in the Colorado meteorite found in 1866

ISERITE.—Chug Water.

JAMESONITE.—Sweet Home mine. San Juan.

JASPER.—Green and red, station 33 of 1873; yellow, red, brown, gray, Los Pinos agency. Throughout Middle and South Park. Along Gunnison River (Dakota group). Between Grand and Gunnison.

JET.—Wet Mountain Valley. Trinchera mesa, Southeast Colorado.

LABRADORITE.—Near Golden in the dolerites. Near Fair Play in the trap-rock. In the dolerites of Colorado.

LANARKITE.—(Mine unknown, but probably in South Park.)

LEAD.—Native in Hall Gulch, Summit County. At Breckenridge. An announcement of native lead must always be received with necessary caution. The small specimen owned by Professor Schirmer I have seen, but although it had a very natural appearance I was unable to decide.

LEPIDOLITE.—Station 17 of 1873, in a form resembling the Saxon zinnwaldite.

LEUCITE.—Table Mountain, Golden City.

LEUCOPYRITE.—Spanish Bar.

LICORITE.—North Clear Creek.

LIGNITE.—Mouth of Gunnison. There it retains its wood structure.

LIMONITE.—Near station 17 of 1873; in the Tertiary sandstones west of Plum Creek, near Colorado City; in several localities of South Park. At the head of south fork of Anthracite Creek, west slope of Sangre de Cristo range, above Mosco Pass. Numerous localities in White River region. The "kidney-ores" of Lignitic group.

MAGNESITE.—In small quantities in the Running lode at Black Hawk.

MAGNETIC IRON.—Bear Creek. Ralston Creek, Grape Creek.

MAGNETITE.—In loose nodules on Gunnell and Procer Hills, at Central; in small octahedric crystals in the gneissic rock on station 1; on station 54 of 1873. Occurring in the granites of various localities, Silver Hills, White House, Capitol; in the dolerite rocks generally. At Idaho and Caribou. Mined on Grape Creek, near Cañon City. Occurs near Golden.

MALACHITE.—Is found as the result of decomposition of fahlerz and other minerals at the Dallas, Leavenworth, and other mines near Central; at the No Name, Caribou, Seven-Thirty, Fourth of July, and others, at Caribou; at some of the Georgetown mines; at the Hardscrabble mines, on station 46 of 1873, and other localities; at Crater Mountain, in the mines of Fair Play and Elk Mountain district. Malachite lode, Bear Creek, Gendhema's lode, Tucker's Gulch, Oro City, Cañon City, Pollock, Montezuma.

MARCASITE.—Philipps mine, Fair Play.

MELACONITE.—Occurring at the Gunnell, Briggs, Leavitt, Leavenworth, and other mines, near Central; at the Unknown mine, in Montgomery. Tucker's Gulch, Jefferson County, Colorado. Pollock, Mosquito.

MELANTERITE.—On the dumps of the Wood, Dallas, and Kansas mines, and others, near Central; in the Sweet Home Mine.

MESITINITE.—Black Prince lode, Lump Gulch.

MESOLITE.—Golden, Col. Table Mountain.

MISPICKEL.—Together with pyrite in the Bobtail and other mines.

MINIUM.—Freeland mine, Trail Creek, Georgetown, Central City.

MICACEOUS IRON ORE.—Caribou, Ralston Creek. Unaweep Cañon.

METEORIC IRON.—*Vide* Iron.

MOLYBDENITE.—Leavitt mine, at Central; occurring in thread-like veins in Silver Hills, near Fair Play, Boulder County.

MUSCOVITE.—In good crystals on station 2 of 1873, and in the coarse-grained granite near Cañon City; throughout the granite and partly in the schist rocks.

NAGYAGITE.—Gold Hill.

NATROLITE.—Golden, Col. Table Mountain.

OBSIDIAN.—Porphyritic, in a dike, at station 27 of 1873; Buffalo Peak, Arkansas Valley, and Union Park. Under the trachyte, on Gunnison River (porphyritic and spherulitic).

ONYX.—Middle Park.

OPAL.—Idaho, Aguas Calientes, Gilson Gulch.

ORTHOCLASE.—In crystals in the porphyries of Gregory Hill, partly altered into sanidite. It occurs sometimes in very large pieces throughout the coarse-grained granites of Colorado; in the porphyry dike at Gold Hills, crystals of large size. Jefferson County, Colorado, crystallized. Green, South Park, west of Pike's Peak. Reddish, Elk

Creek, Jefferson County, Colorado. Brown and grey, Central City. The green orthoclase, found in beautiful crystals, on Bear Creek near Pike's Peak, owes its color to less than one per cent. of protoxide of iron. (Wheeler's Report, 1875, p. 111.)

OZOCERITE ?—From head Cherry Creek.

PEGMATITE.—At several localities in the vicinity of Georgetown, on station 2 of 1873. Bear Creek and Gold Hill, in Boulder County.

PETROLEUM.—From the oil-wells in Oil Creek Cañon, to the east of Cañon City. Smoky Creek, 10 miles south of Golden.

PETZITE.—In the gold-mines of Gold Hill, occurring in narrow seams and veins.

PHLOGOPITE.—On station 46 of 1873.

PITCHBLENDE.—Occurs in large quantities; massive in the Wood lode in Leavenworth Gulch, near Central.

POLYBASITE.—In tabular crystals at the Terrible mine, near Georgetown, Clear Creek County.

PRASE.—Middle Park.

PREHNITE.—Fair Play, in some of the mines.

PROUSTITE.—Occurring in the Brown lode, intermixed with galenite.

PSEUDOMALACHITE.—Little Platte River, south of Fair Play.

PSILOMELANE.—Seaton mine, Idaho; occurs in small quantities.

PYRARGYRITE.—In the Colorado Central, Terrible, International, Cold Stream mines, at Georgetown, associated with galenite, fahlerz, and sphalerite. In the Brown lode with galenite. Argentine, Georgetown.

PYRITE.—One of the most widely-distributed minerals in the Territory. As a rule, it is auriferous, occurring crystallized in pentagonal dodecahedra in the Bobtail, Bates, Briggs mines; in cubes combined with the pentagonal dodecahedron at the Winnebago, Mack, Dallas, Kansas, Grand Army, Gunnell, and other mines, all near Central City. In immense bodies it is found in the Mammoth, Briggs, and Leavitt lodes. It is found crystallized in the Terrible, Pelican, New Boston, Cold Stream, and other mines near Georgetown; at the Tenth Legion mine in Empire; in cubes at stations 45 and 46 of 1873. Found also in Silver Hills, crystallized in the mines of Buckskin. Cubes of 4 to 5 inches edge in the Philipps mine; in the Elk Mountain district, on Eagle River; in octahedra on station 65 of 1873. In the mines near Idaho, crystallized and massive.

PYRITE, AURIFEROUS.—Golden, Colo. Octahedral crystals on Anthracite Creek.

PYRITE, RADIATED.—Smoky Hill River. Purgatory, Timpas Creeks, (possibly markasite.)

PYROLUSITE.—Massive at Buckskin and in Silver Hills.

PYROMORPHITE.—Freeland lode, Trail Creek.

PYROXENE.—Near Fair Play. In a number of localities in younger volcanic and metamorphic rocks.

PYRRHOTITE.—Malachite lode, Jefferson County.

QUARTZ, CRYSTALS.—Gunnell lode, Briggs mine, Quartz Hill, and other localities near Central. In the Rosita mines, in some of the Georgetown mines, at station 46 of 1873. On East River, in the mines of Elk Mountain district, Iowa Gulch, Sopris Peak. Head of Anthracite Creek.

QUARTZ, ROSY.—On station 70; camp 39 of 1873; Bear Creek. Near Clear Creek. Near head of Roaring Fork.

QUARTZ, SMOKY.—Pike's Peak; Elk Creek. In the Colorado divide; large crystals on the Upper Platte.

RED CHALK.—(Impure.) S. Table Mountain.

RHODOCHROSITE.—Sweet Home mine, Park County, in very beautiful specimens, and in the Diadem mine.

RIPIDOLITE.—San Juan, Colo. Trail Creek, Clear Creek County, Colorado.

RUTILE.—On the Ute Pass, occurring in quartz.

SANIDITE.—Occurs throughout the trachorheïtes, sometimes in very handsome crystals.

SARDONYX.—In Middle Park.

SCHIRMERITE.—Red Cloud and Cold Spring mine; Gold Hill.

SCHREIBERSITE.—In the Colorado meteorite.

SELENITE.—At various localities, in the shales, station 35 of 1873. Golden, Colo. Table Mountain. Upper Carboniferous of Eagle River. (See Gypsum.)

SEMIOPAL.—At Los Pinos agency.

SIDERITE.—Crystallized in South Park. Gold Hill, Colo.

SILVER.—Native, as wire-silver at the Terrible, Georgetown, at the International on Mount McClellan; as wire-silver in the No Name and Caribou mines, at Caribou. In small nuggets and thin scales near Fair Play, in Washington Gulch, Homestake lode. Sunshine; Gold Hill; Blue River, Montezuma.

SINTER-CALCAREOUS.—See Tufa.

SINTER.—Siliceous, South Park.

SMITHSONITE.—Jones's mine on sphalerite, near Central, Running lode, Black Hawk.

SODA.—Carbonate, from the Hot Springs.

SODA-SULPHATE.—See Glauber-salt.

SODIUM-CHLORIDE.—See Halite.

SPHALERITE.—Occurs in almost every mine; only few exceptions take place. In the lead-silver mines it is more abundant than in the gold mines. It is found in the Winnebago, dark brown, Dallas, Gunnell, J. P. Whitney, Kansas, Wood, California, Running, Bobtail, Briggs (small quantities in these two), Monte Cristo, and numerous other mines in the vicinity of Central. The mines of Georgetown invariably contain it. The Caribou mines show at times large quantities of the mineral. Station 46 of 1873. Sphalerite, containing cadmium, found in several mines near Fair Play.

SPINEL.—Crystal mine, Virginia Cañon.

STEMBERGITE (iron and silver sulphide).—Georgetown. (Loew.)

STEPHANITE.—Colorado Central, Georgetown. Moose mine, near Fair Play, Montezuma, and other localities.

STIBNITE.—Terrible mine, near Georgetown. Boulder County.

SULPHUR.—In a small crystal on galenite from the Clifton mine, near Central; found in the Middle Park. Pagosa Springs.

SYLVANITE.—In the Red Cloud mine of Gold Hill, occurring in foliated masses and thread-like veins.

TALC.—In fine scales among the gangue-rock of the Bobtail and Kansas, near Central. In light-pink scales in the Silver Hills and Barton mines, Hardscrabble district.

TELLURITE.—At the Smuggler, in Ballerat, and the John Jay, in Central district, Colo. Tellurite, with the formula $Te\ O_2$, is one of Dr. F. A. Genth's new species, and I am indebted to him for the opportunity of publishing at this date both name and composition.

TELLURIUM, NATIVE.—At the Red Cloud mine of Gold Hill, in crystalline masses, belonging to the hexagonal system.

TENNANTITE.—Crystals in Buckskin Gulch. Geneva district, Park County.

TETRAHEDRITE.—Crystals in Buckskin Gulch.
TORBERNITE? (URANITE) found by Captain Berthoud on Lyden Creek.
TOURMALINE.—In the quartz of Gunnell Hill, Central, of Running Hill, Black Hawk. On Guy Hill and at Nevada, Station 64 of 1873. Crystals with both terminations at Montgomery, Ralston Creek, Jefferson County, Colorado.
TREMOLITE.—Smith's Fork of the Gunnison.
TUFA.—Calcareous, Currant Creek, Roaring Fork, and Frying Pan. Springs in White Earth, Wagon-wheel Gap, Pagosa, Animas, Uncompahgre Park.
TURQUOISE.—Southern Colorado, doubtful.
URANINITE.—On the dumps of the Wood lode in Leavenworth Gulch.
VESUVIANITE.—In large crystals of simple combinations on Mount Italia, station 64 of 1873.
VULCANITE.—Quartz Hill?
WAVELLITE.—Golden, Colo. Table Mountain.
WHEELERITE.—Described by Dr. O. Loew in vol. iii of the report surveys west one hundredth meridian; probably also occurs in the lignitic coals of Colorado. Its existence in each particular case, however, can only be determined by analysis, on account of its physical resemblance to other resins occurring in the same manner.
WILLEMITE.—Jones's mine, Central.
WOLLASTONITE.—Near Fair Play, in the limestones.
WULFENITE.—Park County, Boulder County, Gold Hill.
ZINCITE.—Jones's mine, Central.
ZIRCON.—Bear River, Middle Park.
ZINKENITE.—Sweet Home mine, small crystals.

REPORT OF WILLIAM H. HOLMES, GEOLOGIST OF THE SAN JUAN DIVISION, 1875.

LETTER TO DR. F. V. HAYDEN.

WASHINGTON, D. C., *December* 30, 1876.

SIR: Herewith I submit my report on the geology of the district examined by the southwestern or San Juan division during the season of 1875.

Our party, consisting of George B. Chittenden, topographer, T. S. Brandegee, assistant topographer and botanist, and myself, together with two packers and a cook, took the field at Denver on the 7th of June. By written instructions from you we were directed to survey the area which is "bounded on the west by 109° 30′, on the south by 36° 45′, on the north by 37° 50′, and on the east by Mr. Wilson's work of 1874." In this area there are about 6,500 square miles. In addition to this, Mr. Chittenden was instructed to finish out the edge of map 83 from latitude 39° 15′ to latitude 38° along the meridian 104° 30′. This work Mr. Chittenden completed as we marched south, without interfering with the progress of the party.

In order to reach our district in the southwest, a distance of some 350 miles had to be traversed. On the 12th we reached Pueblo; passing south from this, we reached and ascended the Huerfano River and entered San Luis Park by way of Mosca Pass. On the 19th we arrived at Del Norte. A portion of our supplies had been forwarded to this point by freight, but as nothing had arrived and no word came of their approach, I effected an exchange with a merchant of the place by which we were enabled to push forward without delay.

From Del Norte we passed up the Rio Grande for some 60 miles. Leaving the river 10 miles above Antelope Park we crossed the ocean divide by way of Weminuche Pass and camped in the upper valley of the Rio Piedra, a tributary of the Rio San Juan. Finding no trail near the base of the mountains and not wishing to descend so far as the crossing of the old Spanish trail, we decided to move directly westward, so as to cross the headwaters of the Pinos and Florida Rivers. At first very rough traveling was encountered, but by the middle of the second day we reached a lovely parked country and soon found a trail which led out to the Spanish trail at the point where it crosses the Florida. By the latter trail we reached the Rio Animas, and, on the 29th of June, the eastern border of our district. During this three weeks of travel we had been passing through the districts surveyed by Mr. Wilson and Dr. Endlich in the years 1873 and 1874; and having with us their map, which reached to meridian 108°, we had no great difficulty in beginning work. The wagon-trail which now leads from the Animas Valley to the La Plata mining camp, crosses our eastern line in latitude 37° 15′, and our first station was made near this, on the divide between the Rio La Plata and the Animas, midway between the northern and southern boundaries of our district, and about 12 miles south of the southern base of the La Plata Mountains. Of the 7,400 square miles assigned, 5,000 are in Colorado, 1,000 in Utah, 1,000 in New Mexico, and 400 in Arizona. This area includes parts of three Indian reservations, Ute, Apache, and Navajo. Formerly the Weminuche Utes occupied the entire county of La Plata, but by the recent San Juan mining purchase they have lost all but a strip 15 miles wide on the south and 20 miles wide on the west. There had been considerable dissatisfaction among them in regard to the boundaries of their reservation, as restricted by the purchase. They had threatened to prevent the laying down of the objectionable lines by the Government and we were apprehensive of trouble. In 1874 Mr. Wilson's party had been ordered back by them, and as they were probably at this season expecting the surveying parties to arrive on the ground, I thought it best to take immediate measures to avoid serious molestation, and, if possible, to secure their good-will and co-operation. Through a very fortunate circumstance I was enabled to secure the assistance of Captain John Moss, of the La Plata mining district, whose influence among them is very great. By a messenger he sent word to the principal village, which is located about 30 miles below, that our party was not engaged in the survey of lines and that it would be to their advantage to let us pass through undisturbed. The Indians seem to have regarded this advice, as they gave us no trouble whatever. There were at this time no white settlers in the district excepting the small party of miners under Captain Moss and one ranchman who did farming on the Rio Mancos for the camp at La Plata.

The published maps of the San Juan Valley were found to be very incomplete, giving as they do only the principal stream-courses, and these in a number of cases incorrectly; the various Government parties who had visited it having simply passed through, observing, or at least recording, but little beyond the route of travel.

Our quartermaster, Mr. Charles Aldrich, had been sent forward with supplies to the Mancos ranch, but as the road crosses the range by way of Abiquiu and Tierra Amarilla, New Mexico, he could not reach that destination before the middle of July. Having still three weeks' supplies with us we decided to make our initiatory trip by passing down the Rio La Plata to the San Juan, thence to the west along our southern border, and finally returning by way of the Rio Mancos. The swollen condition of the San Juan made it impossible for us to cross into the southwest corner, we therefore turned about and ascended the Mancos, zigzagging sufficiently to complete the Mesa Verda and portion of the Late Mountains. On the 14th we reached the Mancos ranch, 45 miles above the junction of the Mancos with the San Juan, but found the place deserted and no word from our quartermaster.

As we had still some six days' supplies, we passed on to the northeast and completed the western half of the La Plata Mountains and part of the Upper Dolores region. On returning to the Mancos on the 20th, we learned that Mr. Aldrich had arrived at the La Plata camp with supplies, and also that Mr. Jackson, of the photographic party, had come in.

On the 22d, in company with Mr. Jackson, who was on his way to the Moqui country, we set out for a four weeks' trip in the southwest. Crossing the Mancos again we visited Ute Peak and worked up the region drained by the McElmo, Hoven-weep, and Montezuma Creeks, and on the 25th camped on the San Juan near the Utah line. Here Mr. Jackson left us, setting out for the Moqui towns.

On the night of the 28th, while encamped near our western line, our entire herd of stock was stolen by Indians, but by the prompt action of our chief packer, Thomas Cooper, all were recaptured and returned safely to camp before morning.

It was now ascertained that the San Juan could be forded with ease; we therefore crossed and pushed our investigations into Arizona, spent a week about the Sierra Carriso, and returned to La Plata again by way of the Mancos Cañon, giving a little additional time to the study of the very interesting ruins that occur there.

As we approached the La Plata camp on the 30th, we were much surprised to encounter the parties of Mr. Gannett and Mr. Gardner, which, while working in the region between the Abajo and La Sal Mountains, near our northern line, had been attacked by Indians and forced to relinquish further operations in that region. It is quite probable that these Indians, as well as those who made the raid on our herd, belong to the outlawed band of Utes, Pai-Utes, and Navajos, who, under the lead of Pah-ghe-nob-i-gant, infest the cañons of Southeast Utah, and acknowledge no tribal or other authority.

It was, under the circumstances, thought unsafe, with so small a party, to attempt to visit or survey the country to the west of the Dolores; but, having been joined by Mr. Gannett, Dr. Peale, Mr. Pearson, and Mr. Atkinson, we set out for a short trip to the northeast and north. In the course of three weeks we visited the Upper Dolores, the inter-Dolores Plateau, and the San Miguel Mountains, also the cañon of the Dolores, and the dry sage-plain north of the Late Mountains.

By September 8, the regular field-work of the season was completed. As there were some points in connection with the geology of the southeastern corner of our district which needed further attention, and, having in view the prospect of discovering additional ruins, I took a small party and passed through that way, coming out by way of Tierra Amarilla and Conejos, while the main part of the outfit, in charge of Mr. Chittenden, returned to Denver by way of Silverton and Del Norte. In company with Dr. Peale and Mr. Aldrich I visited the region of the Lower Animas, and followed up the cañon of the San Juan to the crossing of the Spanish trail; thence we crossed into New Mexico, visited Abiquiu and Ojo Caliente, and examined the interesting ruined pueblos near those places, and finally, on the 5th of October, arrived in Denver.

Very respectfully, your obedient servant,

WM. H. HOLMES.

Dr. F. V. HAYDEN,
United States Geologist-in-charge.

GEOLOGICAL REPORT ON THE SAN JUAN DISTRICT.

CHAPTER I.

GENERAL REVIEW OF THE DISTRICT—OROGRAPHIC FEATURES.

On descending from the Weminuche Pass we come out, at an elevation of 8,000 feet, upon the border of a vast broken plain which, to the south and west, seems almost limitless; but not until we have reached the banks of the Rio Mancos, 50 miles farther west, and have passed the La Plata Mountains, the last of the high promontories of the Colorado or Park Mountains, do we obtain a full view of the plateau region.

To one who has been long among the great highland regions of Central Colorado the name plateau seems almost a misnomer when applied to the lowland country about the valley of the Rio Colorado; but when considered in reference to the sea-level it becomes indeed a plateau quite grand in dimensions, although broken into a thousand fragments by the labyrinth of cañons. I have in a measure become accustomed to think of the numerous groups and chains composing the Rocky Mountains in Colorado as so many remnants of a great plateau—a continental-divide plateau of great width which has been encroached upon and cut down by the waters of the two oceans until only a small number of widely scattered summits remain to index a former general level of at least 14,000 feet. North and south along this remarkable collection of remnants the continental divide runs, meandering a belt 100 miles in width from east to west. On the east and west this plateau falls off quite abruptly to the level of 7,000 feet, or one-half of the depth to the sea-level. On the east the descent is quite regular and complete, there being no great promontories or outlying masses. On the west the line is decidedly irregular; a few groups extend far to the west, and many isolated patches of highland occur. Of the promontory groups, the Sierra San Juan, the Elk Mountains, and the White River Plateau are the principal. Alternating with these are four great bays, so to speak, into which the approximately horizontal strata extend. This is well shown in the accompanying diagram, Plate XXXIV. It will be plainly seen by reference to the figure, that Colorado consists of three distinct belts, topographically as well as geologically—a belt of highland chiefly metamorphic, two belts of lowland chiefly sedimentary. If we consider the metamorphic belt only, and its relations to the horizontal sedimentaries, the two middle bays become one, as the western extension of the Elk Mountains is but a group of volcanic masses resting on and in and protecting the horizontal beds which belong to the eastern border of the Colorado-Plateau region. Considered alone, however, in reference to the actual arrangement of the highlands and lowlands, there appear along the western border three well-defined promontories and four great bays. Each of these great bays possesses a system of drainage of its own. These systems are represented by the San Juan, the Gunnison, the

Grand, and the Green Rivers. We may think of these streams as originally sweeping out at right angles to the trend of the metamorphic highland and connecting with the main drainage-course of the Rio Colorado, which runs from north to south. It is useless to speculate as to what geologic horizon formed the surface of the plain upon which these drainage-systems were first laid down; it was doubtless, however, high in the Tertiaries.

At the present time there remains no longer a great plain, but in its place we have a grand skeleton only. The main water-course of the Colorado has cut its way down through almost the entire thickness of the sedimentary strata, and the four subordinate streams have scored out huge cañoned valleys in whose sides are exposed the rocks of all periods from the Tertiary to the Archæan. Such enormous quantities of the strata composing the upper half of the plateau have been removed along the main drainage-course that the outcropping edges of the higher strata have retreated far to the east, and the Upper Cretaceous and Tertiary rocks are only to be found along the base of the mountains or in particularly protected spots.

The district which I have examined is a fragment of this skeleton plateau which includes a large portion of the drainage-system of the San Juan, and which extends from the base of the mountains to within thirty miles of the Rio Colorado. The rocks exposed are chiefly Mesozoic It is a region of exceptional interest and unusually well calculated for geologic study.

GENERAL SECTION, ETC.

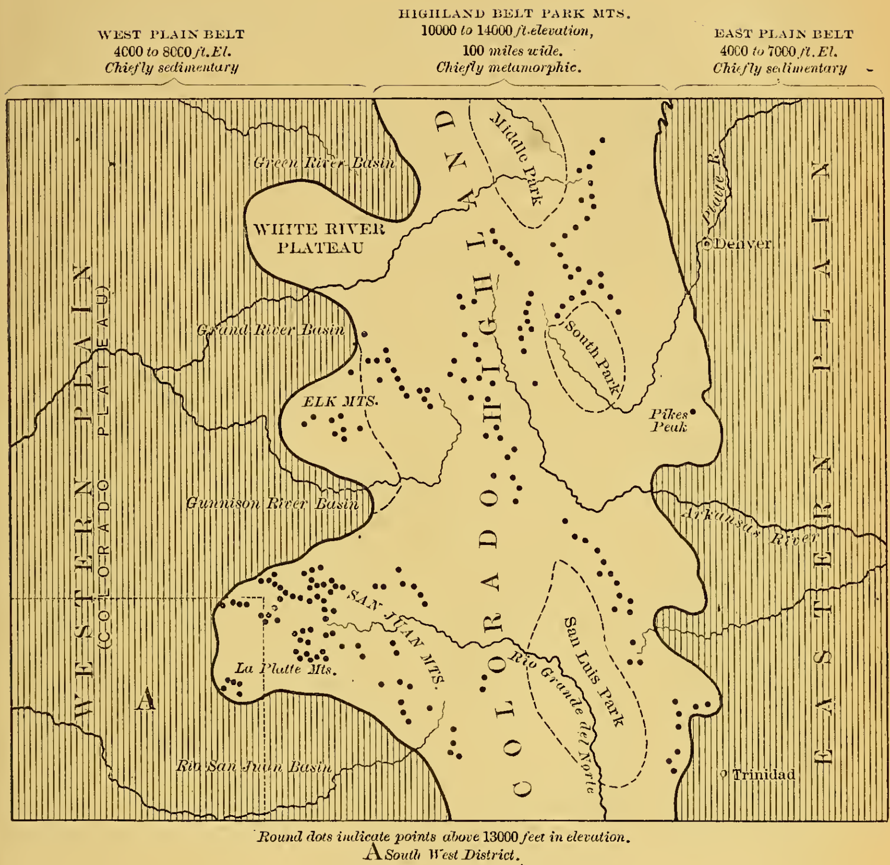
I give in this connection a general section of the strata exposed in my district so that there may be no difficulty in identification. In most cases I have given characteristic local names to the more marked groups, giving at the same time such correlations with other sections as are clearly established.

The entire exposure of sedimentary rocks is not far from 9,000 feet, 2,000 of which are classed as Tertiary, 5,000 as Cretaceous, and 1,500 as Jura-Trias. A considerable exposure of rocks of Upper Carboniferous age occurs in the La Plata Mountains, but so changed by metamorphism that nothing definite can be made out. The Cretaceous formations occupy the major part of the district, and are the only series that I have been able to thoroughly identify from the fossil remains.

The section given in Plate XXXV, was made principally along the banks of the Rio San Juan, beginning in the cañon near the mouth of the Rio Pinos and ending in Utah, on meridian 109° 30′. The dip is so slight that in this distance of 100 miles only these 9,000 feet of strata rise to the surface; the fall of the river in the same distance being a little over 1,000 feet.

Notwithstanding this slight dip the succession of strata is quite easily made out and measurements are easily made, on account of the tendency to break off in steps. Each group of hard strata is carried west in a long, gentle slope until a break occurs, when a precipitous descent is made across the outcropping edges, and so on throughout the section. It will be seen by the section that there are six of these well-marked layers of firm rock, in all cases of sandstone, with a corresponding number of soft beds, chiefly shales. There are, therefore, six well-marked steps observable in descending the river; the compact groups forming each a floor and an escarpment and the soft groups a slope and talus.

Frequent reference will be made to this section throughout my report,



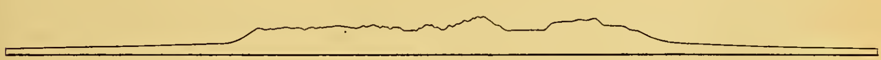


PLATE XXXIV
General Orographic Features of Colorado

and numbers and names corresponding to these will be used on all the detailed sections.

The group numbered 10 in the section is the typical Dakota Sandstones of Dr. Hayden.

Groups 10 and 11 together, probably constitute the complete Dakota Group; *i. e.*, the Lower Cretaceous of Dr. Newberry, and the Henry's Fork Group of Major Powell.

Group 9 is the Cretaceous shales (Cretaceous Nos. 2, 3, and a part of 4 of Hayden,) the Middle Cretaceous of Newberry, and the Sulphur Creek of Powell.

Groups 8, 7, 6, 5, and 4 Cretaceous Nos. 4 and 5 of Hayden, the Upper Cretaceous of Newberry, and the Salt Wells of Powell.

Group 3 is probably the Lignitic coal group of the eastern slope, the Laramie Group of King and of Hayden, and the Point of Rocks of Powell.

Groups 1 and 2 probably correspond to the Wahsatch Group of Hayden and White, and the Vermillion Creek Group of King.

Groups 12, 13, 14, and 15 are a series of rocks called by some Jurassic, by others Triassic, and by still others Jura-Trias.

The Lower Cretaceous sandstones are the most easily recognized and by far the most uniform and persistent of the whole section. There is, however, considerable difficulty in defining their vertical extent, resulting from the scarcity of fossil remains. The division between these sandstones and the shales above is never obscure. In many localities which I have examined the line is well marked both by fossils and strata; but it is very difficult to decide what portion of the strata beneath to include in the group. Ordinarily there are about 250 feet of sandstones and conglomerates about which there can be no dispute (these are group 10 of the section), but beneath these is a series of variegated marls and sandstones, which have frequently been placed in the Jurassic (the upper part of group 11). In Eastern Colorado this series is so distinct from the more massive beds of the Dakota group that I have always been inclined, in the absence of proof, however, to class it as Jurassic; but certain geologists, Dr. Peale, Mr. Howell, and Dr. Newberry, have found Cretaceous fossils, or what are recognized as such, in a series of sandstones that come in at the base of the marls, and into which the marls grade. If we include these formations in the Lower Cretaceous down to the horizon in which these fossils were found, that is from 400 to 600 feet below the top of the Dakota Sandstones, it seems that we will have to include in the Cretaceous section the entire group of marls and sandstones. These occur here, without a break, to the thickness, by barometric measurement, of 600 feet. This gives a thickness of at least 800 feet of Lower Cretaceous strata. I prefer to divide this into two parts, for convenience of description as well as mapping. The upper part always forms a plain floor or the upper stratum of a table-land, and the broken faces give universally an escarpment-line, while the lower and softer group outcrops on a gentle declivity or is hidden beneath the *débris* of the talus. Group 12 consists of brownish and purplish laminated sandstones, generally less than 200 feet in thickness. This is the fossil-bone bed of Dr. Newberry,* which is thought by him to be Triassic. Group 13 is the well-marked bed of massive white and pinkish sandstone. This is succeeded by a laminated series, and this by red sandstones. The more important parts of the section will be given in detail farther on.

* Expedition to the junction of Grand and Green Rivers, Capt. J. N. Macomb, 1859; page 91.

There are three distinct groups of coal-bearing rocks, two being undoubtedly Cretaceous, and the other belonging either in the top of No. 5 Cretaceous or in the lower part of the Laramie Group. The Middle Coal Group is between the two escarpments of the Mesa Verde, and the Lower in the upper part of the Dakota Sandstones, extending up into the Middle Cretaceous shales.

Besides the sedimentary formations there are in this district five distinct trachytic areas. These occur in small mountain groups which are scattered over the Cretaceous plain. They are the San Miguel, the La Plata, the Late, the Carriso, and the Abajo groups. The structure is somewhat obscure, although not greatly complicated, and is much alike, so far as can be determined, in all cases. The intrusive matter has been forced up through crevices in the superincumbent sedimentary rocks, encroaching as it rose upon the less firm rocks, sending out wedge-like masses between the yielding strata, and finally resting, so far as can be observed, in greatest bulk among the easily-yielding strata of the Middle Cretaceous.

In most cases there has been a slight elevation of the surrounding sedimentary beds, which effect is probably produced partly by the intrusion of sheets and wedges, and partly by the upward movement of the fluid or plastic mass. The structure of these trachytic mountains is fully illustrated in Plates XXXVI, XLV, and XLVI.

The distribution of these groups, as well as the positions of all the important topographical features, the mesas, the cañons, and stream-courses of our district, is clearly shown in the accompanying bird's-eye view (Plate XXXVI). I have taken pains to give all the features in considerable detail.

The point of view assumed is in New Mexico, south of the most southerly bend of the Rio San Juan, and at an elevation of a few thousand feet above the plain. In looking to the north from such a point a fine view of the plateau border region would be obtained. The San Juan River and the Carriso Mountains would appear in the foreground. The Mesa Verde, the La Plata, and Mancos Valleys, and the La Plata and Late Mountains in the middle distance, and the Rio Dolores, the San Miguel, the Abajo, the La Sal, and the Henry Mountains in the distance. The appended sections will be understood at a glance. I have preferred not only to give the sections across my district, but also to give, on a reduced scale, their continuations to the east, west, north, or south, as the case may be, through the districts examined by Dr. Peale, Dr. Endlich, Mr. Gilbert, and others. The sections are, as far as possible, drawn through the more important points. The lines along which they have been made are laid down on the accompanying map (Plate XXXVII.)

In this part of Colorado there are comparatively few well-marked folds. The only one of importance that crosses my district extends from the base of Sierra La Plata down into New Mexico, maintaining in general a southwest direction. It is essentially monoclinal in character, the depressed side being to the east and southeast.

I have found it convenient, in reviewing the general surface geology of the various river-basins, to give in the same connection such topographic and other details as seemed especially worthy of record.

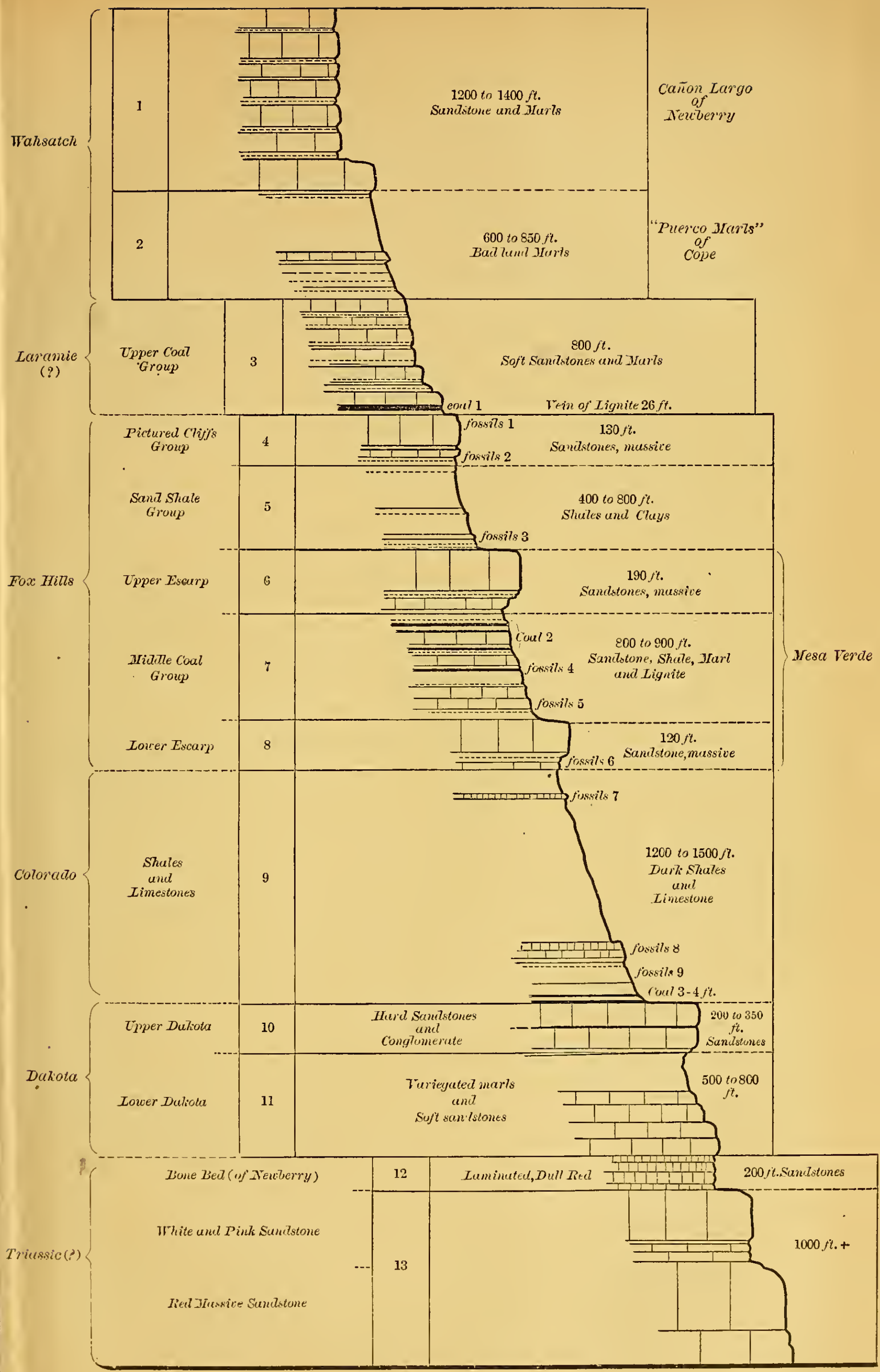
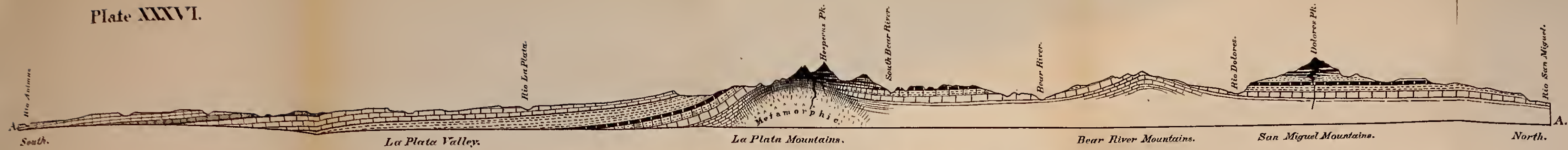
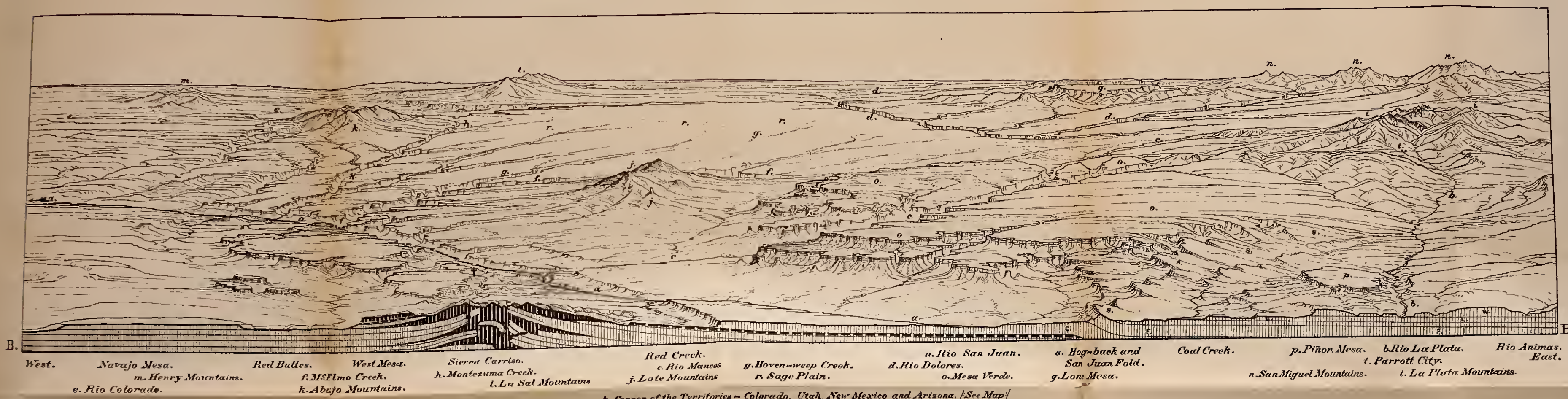


PLATE XXXV
General Section
Valley of the Rio San Juan

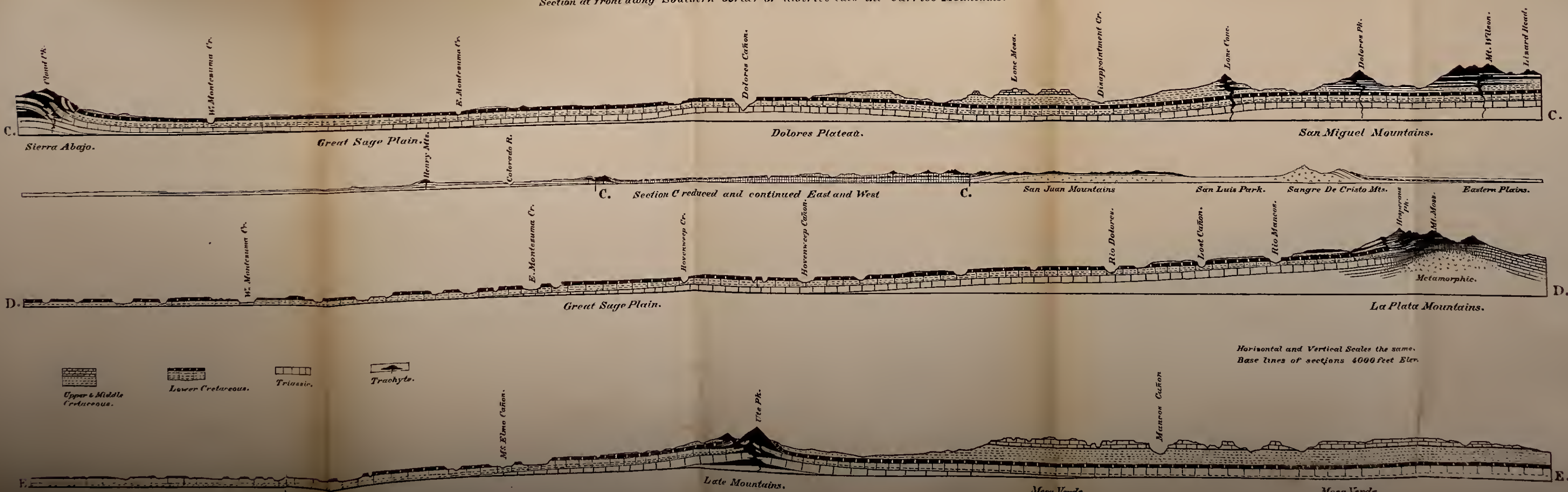
Plate XXXVI.

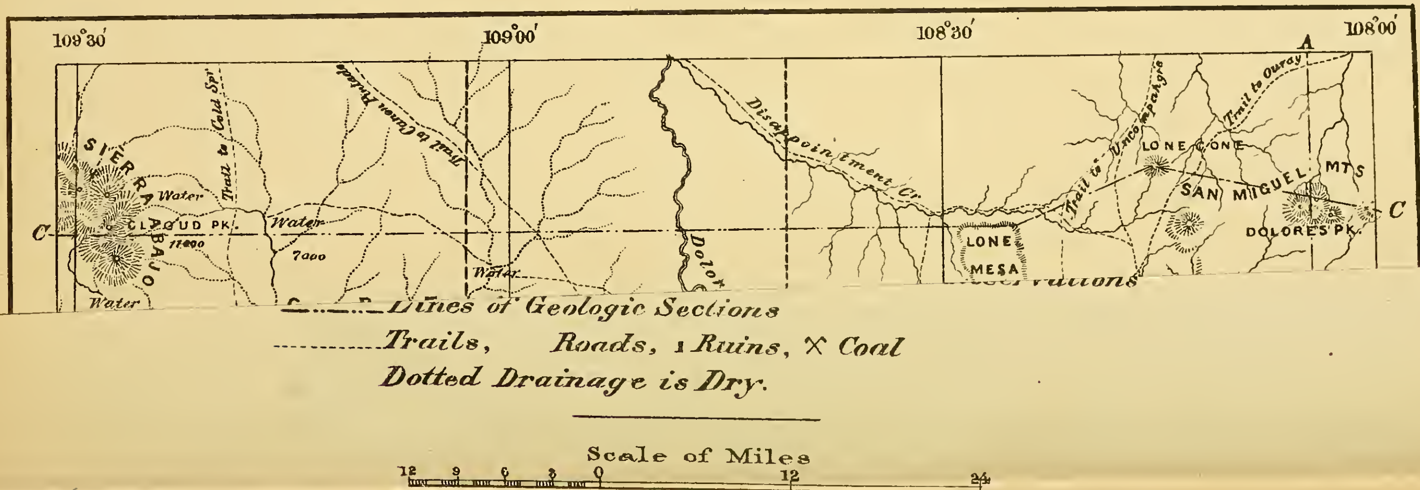


Section North and South from the Rio San Miguel through the San Miguel and La Plata Mountains to the Mouth of the Rio Animas.



Birds Eye View of the Middle Portion of the San Juan Valley looking North.
Section at front along Southern border of district cuts the Carrtso Mountains.





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Trail to Uncompahgre
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SAN MIGUEL MTS
DOLORES PK.
Trail to Ouray
Lines of Geologic Sections
Trails, Roads, Ruins, X Coal
Dotted Drainage is Dry.
Scale of Miles
12 9 6 3 0 12 24

AM. PHOTO-LITHO CO. N.Y. (OSBORNE'S PROCESS)

Plate XXXVII

MAP

of SOUTH WEST COLORADO *with parts of* UTAH, NEW MEXICO *and* ARIZONA.

- - - - - *Boundaries of Territories and Indian Reservations*

—..—..— *Lines of Geologic Sections*

.............*Trails, Roads, ι Ruins, ✕ Coal*

Dotted Drainage is Dry.

Scale of Miles

12 9 6 3 0 12 24

CHAPTER II.

LA PLATA VALLEY.

The Rio La Plata, although a small stream, is one of the most important in the southwest. It takes its rise in the rich mining-district of the La Plata Mountains, and in its middle course flows through considerable areas of tillable and pasture lands. Its entire length is 60 miles. For 8 miles of the upper course it is in a deep mountain-valley. Below Parrott City it runs some 4 miles through a flat valley occupied by placer-bars. On leaving this it cuts its way through a ridge of Upper Cretaceous sandstone and enters a broad, shallow valley. The upper part of the latter valley is occupied by a fine system of terraces. Of these there are a number of distinct levels, the higher occupying the divide between the La Plata and Lightner's Fork of the Animas. In the vicinity of the road-crossing this is nearly 300 feet above the bed of the La Plata and upward of 1,200 above the bed of the Animas. West of the river they are not so well marked.

Cherry Creek is the only considerable tributary of the La Plata, and gathers the drainage from the southwestern spurs of the La Plata Mountains. It has its eastern source within a mile of the La Plata at Parrott City. From this point it runs west inside or north of the northeastern wing of the Mesa Verde. From Thompson's Park it cuts its way out through the sandstone wall to the south and enters the broad valley of the La Plata. It joins the latter stream just midway in its course and in the center of the valley. The conformation of this broad valley is the result of what would at first appear to be quite unimportant geologic conditions. It occupies the space between two slight monoclinal folds. One of these extends west from the La Plata Mountains and dies out in the Mesa Verde; the other crosses the country nearly 20 miles farther south, and sweeps off to the southwest. Along the northern border the former fold has upturned the Upper Cretaceous beds, producing a rim of sandstones. The dip of these sandstones is at first from 5° to 10°, but as we pass south through the valley we find that they flatten out and descend almost with the fall of the river. On reaching the second fold a gentle dropping occurs on the south or, more properly, southeast, by which the Bad Land Group (2, general section) is brought to the river-level, and the sandstones of the Upper Coal Group (3, general section) form a low hogback facing the north, which gives a low southern rim to the valley. Slight as the dip seems to be on the floor of this valley between the folds, a considerable thickness of beds, consisting of the upper strata of the Mesa Verde Group, disappears, although few outcrops are seen.

The second or outer fold just mentioned is one of the most important features in the geology of the San Juan Valley. I shall therefore call it the San Juan fold. It seems to begin along the base of the mountains east of the Animas River, and is first noticeable in the increased dip it gives to the outcropping strata of the Lower Cretaceous. This increased dip was noticed by Dr. Endlich in 1874. My attention was first drawn to this fold while on Station 1, from which point it appears to flex outward toward the south, as plainly indicated by a line of hogbacks. It is these hogbacks that form the southern rim of the basin just described. By reference to the map it will be seen that this outcropping line of harder beds has turned the river considerably to the westward, and that a number of long washes run parallel with the strike of the strata.

Station VI was made on the highest point of a small group of hills that lies on the line of the fold about 8 miles east of its intersection with the river and some 15 miles southwest of Station 1. The hills are capped by a massive white sandstone, 25 or 30 feet thick. On the summit of the hill on which our station was made we observed large heaps of cinders. I am led to attribute their presence to the burning of coal-beds which at one time probably occurred on the upper surface of the sandstones. In numerous localities, both east and west, I have encountered portions of strata that had the appearance of having been burned as in a kiln, and I have noticed that in every case the phenomenon occurs in coal-bearing strata, and also that coal is locally absent in all such places. Dr. Newberry observed a similar condition of coal strata in Arizona, and Dr. Peale and others in Colorado. Beneath the sandstones in the bluff faces a considerable thickness of soft clay and sandy shales is exposed. These are probably some hundreds of feet in thickness, and seem to rest upon a group of yellowish sandstones which outcrop in the river bluff a few miles to the west, and from which I obtained a few imperfect fossils, which resemble those of No. 5 Cretaceous in the region about Greeley. If these are really Upper Cretaceous fossils, the probabilities are that the coal-bearing horizon of Station 5 corresponds with the so-called Lignitic horizon of the Eastern Colorado region. The greater part of the formations in this part of the valley are obscured by terrace deposit, and the absolute identification of the isolated outcrops cannot easily be made. Near Station 6 the river cuts across the gently tipped strata of Upper Coal Group (3, general section), exposing a very good section. In descending the river we observe in the bluff a whitish massive sandstone, the same as that of Station V, which has a thickness of nearly 100 feet; following this are about 150 feet of brownish sandstones, with interbedded shale and marl which seem to have been reddened by heat. A little farther on, where a deep side gulch has notched the bluff, a coal-seam upwards of 13 feet in thickness is exposed. The quality of this coal is by no means good, and seams of clay and shale are so numerous as to make up nearly half of the thickness. On the opposite side of the stream a similar outcrop occurs. Above the coal, that is to the south of the coal outcrop, is a series of brown sandstones several hundred feet in thickness, in which are seams of lignite and dark carbonaceous shale, also gray and purplish shales. These all belong to the Upper Coal Group (group 3 of the general section) and have a very marked general resemblance to the Lignitic Coal-Measures of Golden City and the Boulder Valley. The white sandstone at the base is probably identical with the Pictured Cliffs Group (4 of the general section). The dip of the sandstones of the Coal Group varies from 4° to 10°, and the strike at the river is nearly northeast and southwest. The San Juan fold crosses the river with these strata, and is the cause of the increased dip. The coal strata are succeeded by a heavy thickness of sand and clay shales and marls (the Bad Land Group of the general section), over which the river runs to its junction with the San Juan. Since leaving the base of the mountains the river has gradually changed from a sparkling mountain torrent to a slothful, slimy stream, which has hardly enough vitality to clear a way for itself through the encroaching alluvium. The bright meadows and the heavy verdure of the headwaters have been replaced by sage and cactus and yellow earth, yet the valley is less a desert than might at first be suspected. The alluvial bottoms in the second or Bad Land valley are really rich, and the Weminuche Utes are cultivating crops of corn and vegetables. The fertile-looking upper valleys are quite useless for agriculture, on account of the high altitude.

After leaving the mountains the river has ascended, geologically speaking, through the entire Cretaceous section, but the exposures are rather meager and measurements not reliable.

Below the Indian farms a broad valley opens out to the right and left, eroded from the soft formations of the Bad Land Group. It extends far to the northeast, following the strike of the strata, and to the southwest opens out in a low passage-way to the San Juan. For nearly 10 miles the river follows this depression, but instead of following it through between the Piñon and Verde Mesas, it turns to the left and cuts directly through the former, forming a shallow cañon, in the walls of which the sandstones of group 1, general section, appear. In the valley above, the river is bordered by a fine system of terraces, which extends over many square miles and shows a number of well-marked levels; the highest rises to 200 or 300 feet above the river. On a subordinate terrace, near the river, I discovered the ruins of an ancient village. Plans and descriptions of this are given elsewhere.

The greater part of the Piñon Mesa lies to the west of the La Plata. It rises gradually from the river toward the western angle, where it terminates in a high promontory. It covers an area of some 40 square miles and is capped with a massive yellowish or light-brown sandstone, which has a thickness of from 60 to 100 feet. On the west this stratum breaks off in a line of bold and picturesque cliffs. On the east side of the river this stratum of sandstone lies at the base of a considerable thickness of massive sandstones, which constitute group 1 of the general section.

Beneath the sandstone capping of the mesa are the Bad Land formations (group 2, general section). They outcrop all around, but only on the west and south faces are the Bad Land forms well developed. Here the richly-colored, soapy-looking clays are weathered into a thousand fantastic shapes, and broad areas have neither rocks nor vegetation to break the peculiarly monotonous waste. This group I have identified with the "Puerco marls" of Cope.*

Passing down to the west over this belt we reach the depression or puerta that separates the Piñon Mesa from Mesa Verde. Here are broad flat spaces covered with grass and sage, beyond which are the scattering outcrops of the Coal Group (3, general section). First, there are a number of outcrops of yellow and rusty sandstone, and following these the outcrop of the white sandstone which lies at the base of the Coal Group. This outcrop, which is still tipped up at a higher angle than the other beds by the San Juan fold, may be traced to the point where it crosses the La Plata at the Indian farms and beyond to Station V, while to the south it can be followed to the San Juan, where it falls off to the horizontal and forms the Pictured Cliffs (group 4, general section). West of this line of outcrop we cross another low belt and then begin to rise on the slope of the Mesa Verde, and soon encounter the cañon-cut sandstones of the Upper Escarpment

*See report of Chief of Engineers for 1875, page 1012.

Group (6, general section). In the depression between the two mesas we have therefore the following section:

1. *Escarpment of Piñon Mesa, lower stratum of group* 1........ 80 feet.
   Soft, yellowish, coarse-grained, cross-bedded sandstone, containing layers of large pebbles of quartz and other rocks. Very slight dip to the east.
2. *Bad Land formation, "Puerco marls," group* 2.............. 800 feet.
   Principally soft sand clays and marls, highly colored with reds, yellows, and purples, growing gray below and containing masses of soft sandstone and at the base grading into the next group.

Upper Coal series, group 3.................................. 800 feet.
Four hundred feet of greenish clay with beds of brown sandstone; 200 feet of shale with beds of brown sandstone; 250 feet of shale and shaly sandstone bearing a heavy seam of soft, brown lignite, apparently about 30 feet in thickness. The dip here rises to 20°.

Pictured Cliff sandstone, group 4.............................. 130 feet.
Thirty feet white sandstone, followed by 100 feet of brownish and yellowish sandstones and shales. Dip 20°; strike somewhat irregular.

Sand shales and bedded sands, group 5........................ 350 feet.
Dip falls again to 3° or 4°. These are followed by the sandstones of the Mesa Verde.

Mesa Verde, Upper Escarpment sandstone, group 6 .... 140 feet.
One hundred and forty feet of yellowish, fine-grained sandstone, bearing a few seams of shale. This is the strongest stratum, excepting, perhaps, the sandstones of the Dakota group, in my entire section, and where it remains is a governing element in the topography of the country; rising at a gentle angle from the low country of the La Plata valley, it reaches the upper level of the Mesa Verde and flattens out forming the floor, or rather the capping stratum of that mesa. The sloping eastern face has been cut by a number of sharp, deep cañons, which drain out to the La Plata and San Juan. In these the strata of the Middle Coal Group are exposed.

Mesa Verde, Coal Measures, group 7 .... 500 feet.
Following the escarpment sandstones are 200 feet of strata in which lignite and carbonaceous shale seem to predominate; bedded irregularly with these are many irregular seams or masses of soft sandstones. There is no single seam of coal above a few feet in thickness, and there is probably no workable seam in the whole series.

There is a remarkable lack of persistency in individual strata, and sections taken a few rods apart across corresponding horizon would resemble each other only in the most general features. Beneath the coal bearing series are about 300 feet of irregularly stratified sandstones, clays, and shales. In the entire section no fossils sufficiently well preserved for identification were found excepting the ordinary *Halymenites*.

VALLEY OF THE SAN JUAN.

The Rio San Juan is one of the most important tributaries of the Rio Colorado, and joins that stream, according to Professor Powell, in Utah, 85 miles west of the Colorado line and 12 miles north of the northern border of Arizona. It is some 200 miles in length, and flows in a general westerly direction. In its middle course it bends south into New Mexico, but soon enters Colorado again at the extreme southwest corner, and thence crosses into Southeastern Utah. The area drained by it will probably not fall short of 20,000 square miles. This area is divided between four Territories, and consists mostly of the dry plain country of the eastern border of the Colorado Plateau. On the north are five important tributaries, all of which have their sources in the high mountain region to the north. Of these the Animas is the largest, being at its junction with the San Juan fully two-thirds as great as that stream. For some distance above the junction both streams are in cañons, formed of Upper Cretaceous and Tertiary rocks, but at the crossing of meridian 108° they enter wide terraced valleys, bordered by low bluffs. These bluffs are composed of the sandstones of the Piñon Mesa Group and outcrops of the Bad Land marls occur in the slopes. The immediate borders of the stream are rendered very attractive and beautiful by the growth of cottonwood trees which line the banks, and frequently extend back over the river bottoms. On the borders of these groves are dense growths of bushes and broad meadows of fine grass. Throughout its entire lower course the river is marked by these verdant borders. In the upper and middle course it is clear and sparkling for many months of the year, but farther down passes through wide belts of friable rock, and becomes clogged with sediment, and abounds in treacherous quicksands.

Station 9 was made on the higher of two small buttes that lie between the La Plata and Animas, and about 6 miles from the junction of the former with the San Juan. The strata forming these buttes are the yellow sandstones of the Piñon Mesa Group. At the base is the heavy stratum of sandstone that forms the escarpment of the Piñon Mesa on the west, and which immediately overlies the Bad Land Group. This sandstone stratum is at the base of a very extensive series of sandstones, which have alternating bands of gray, greenish, and pinkish marls. These sandstones, as I afterwards found, in passing up the San Juan, reach a thickness of some 1,500 feet, being always massive, whitish, and yellowish, frequently coarse, almost a conglomerate and slightly compacted, while the marls, although unimportant as to thickness, alternate very regularly at intervals of from 5 to 25 feet, giving in the weathering of the high cliffs a heavy laminated appearance. The formation does not seem favorable for the preservation of fossils, and I was unable to find anything that could be identified. It seems, however, to correspond to the Lower Eocene sandstone of the Nacemiento Mountain region described by Cope in the Report of the Chief of Engineers for 1875. Its stratigraphical relations appear to be the same as those of the Wahsatch Group as it occurs in the valleys of the Grand and Green Rivers.

The little butte on which Station 9 was made, as well as two or three others of corresponding height in the vicinity, seem to be the remnants of a former terrace, as the tops are leveled off and covered with a heavy bed of drift; bowlders of the harder crystalline rocks occur a foot or more in diameter. The height above the present river-level is by barometrical measurement upwards of 900 feet. Station 11, some 10 miles farther down the valley, was made on a butte of slightly inferior height, which was also covered with quantities of similar drift. The lower terrace-levels are more distinctly marked, and cover a great number of square miles in this part of the valley. Generally they seem to have but little drift deposit, and are simply the soft sandstones and marls leveled to a succession of flood-plains. Occasionally large bowlders occur, and in a few cases small pebbles of Carboniferous limestone containing Coal-Measure fossils were found.

At the mouth of the La Plata the river has encroached upon a subordinate terrace, and a sharp bluff is formed in which there is exposed a stratum of compact massive sandstone. This stratum seems to occur in the lower part of the Bad Land Group, and can be traced by a pretty continuous line of outcrop all along the slope south and southwest of the Piñon Mesa; beneath it are the Coal Group outcrops, which show a predominance of soft, yellow sandstones interbedded with clay and sand shales. These beds occupy the valley from the mouth of the Rio La Plata to the outcrop of the white sandstones of the Pictured Cliffs, 15 miles below. The dip is to the east, at a very slight angle. Before reaching the Pictured Cliffs, in descending the river, a large remnant of one of the lower terraces appears on the right, a considerable space above and to the right being reduced to the flood-plain of the river. All along the south face of this remnant are outcrops of the Coal-Measures, and near their base a coal-seam, 26 feet in thickness, of light brown lignite, is exposed. Beneath this a sharp bluff of massive grayish-white sandstone rises from the water-level, and after following the river for a short distance circles around to the west and north. The trail passes up over the low promontory formed of this sandstone, descends again to the river-bottom, and follows for a while the base of the bluff. The sandstone stratum is quite massive, and breaks down in great smooth-faced blocks. On these thousands of fantastic figures have been engraved, recording, perhaps, the history of some former occupants of the valley. Beneath the massive stratum are several layers of brownish sandstone. To the group I gave the name suggested by the picture-writing. On the upper surface of the Pictured Cliff sandstone, and not more than 30 feet below the great bed of lignite, I discovered a heavy bed of fossil-shells, in which were a number of forms having Upper Cretaceous fasces. They were quite similar to the forms found beneath the coal on the Cache la Poudre and Platte Rivers. One specimen of *Corbula* was all that could be preserved, as they were extremely fragile. From the first I have been very much inclined to consider this horizon the top of the Cretaceous, and I am well convinced, after carefully comparing my sections with those made by Doctors White and Peale in Northwestern Colorado, that my Upper Coal Group occupies a place in the section corresponding to that of the Laramie Group in theirs.

In New Mexico Professor Cope observed a similar group of sandstones occupying the same relative place in the section, but did not attempt to place it either with the Cretaceous rocks which lay beneath, or with the well-identified Tertiary strata which came above. Prof. C. A. White has recently made the suggestion that this group of rocks be classed as Post-Cretaceous until sufficient proof can be gathered to decide the question of age.

Beneath the massive sandstones of the Pictured Cliffs, and about 100 feet below the first fossil horizon, I obtained from a hard fine-grained chocolate-brown sandstone a number of poorly preserved fossils. They included *Tellina scitula*, *Scaphites Warrenii*, and unidentified species of *Cardium* and *Actæon*.

West of the Pictured Cliffs the river runs through a broad valley that opens out to the north and south; beyond this an immense hogback ridge composed of Upper Cretaceous sandstones crosses the valley at right angles to the river's course. The space between the Pictured Cliffs and the Great Hogback or "Creston," as it is called by Dr. Newberry, is occupied by a group of sands and clays, group 5 of the general section. The dip at the base of the Pictured Cliff is not above 2°; midway between this and the Great Hogback the beds fall to the horizontal and remain nearly so until turned abruptly up against the sandstones of the hogback. The upper part of group 5 is composed of clays, argillaceous shale and sands, greenish toward the base. In the lower part there are thin layers of sandstone, and near the base a stratum of rusty limestone, in which I obtained specimens of *Inoceramus*, *Lucina*, *Baculites*, and *Anisomyon*. The detailed section of the strata exposed on the San Juan down to the Great Hogback is as follows:

Piñon Mesa sandstones, group 1 .... 1,200 feet.
Chiefly coarse, yellowish sandstones, alternating with thin beds of variagated marls.

Bad Land formation, group 2 .... 600 feet.
Variegated marls containing, toward the base, layers of yellowish sandstone.

Upper Coal series, group 3 .... 700 feet.
Soft, yellow sandstones, interbedded with sands, clays, and shales; one seam of lignite near base, 26 feet exposed.

Pictured Cliffs, group 4 .... 140 feet.
Forty feet of white sandstone; 60 to 80 feet yellowish-gray sandstone. Beneath these 30 to 40 feet of brownish laminated sandstones. Fossil horizon No. 1, on upper surface of the white sandstone. Fossil horizon No. 2, in the brownish laminated sandstones.

Sands, clays, and shales, group 5 .... 600 to 900 feet.
Sands, clays, and shales grayish in color and having near the base a bed of brown limestone. This is fossil horizon No. 3.

THE GREAT HOGBACK.

The Great Hogback is composed of the Mesa Verde Group (groups 6, 7, and 8 of the general section.) It crosses the river at right angles, having a trend nearly north and south. North of the river it rises abruptly to the height of 500 feet, and extends in an unbroken line northward until it joins the Mesa Verde. (See Fig. 1, Plate XXXIX.) South of the river it has been planed down by the water, nothing appearing above the terrace-levels for a mile or more but isolated remnants. Farther south it rises in a line of grand ridges which can be traced for many miles across the plain country. These ridges are visible from the La Plata, the Late, and Carriso Mountains. On the north side the ridge is really double, the main eastern crest being formed from the sandstones of the Upper Escarpment Group, and the western and subordinate ridge of the sandstones of the Lower Escarpment Group. Between these two ridges is a sag eroded from the yielding strata of the Middle Coal Group. The dip at the river is 40°. As we go north the dip rapidly decreases, and as a consequence the two ridges become considerably separated. The slopes become gentle on the east, and break off abruptly on the west. The depression between becomes a shallow valley, and the drainage from it passes out through breaks in the western ridge. The dip finally falls off to 5° and less and the various members of the Hogback may be seen connecting on with the corresponding members of the Mesa Verde. The main eastern ridge becomes the Upper Escarpment, the western the

Lower Escarpment, and the Coal Group series occupies the slope between.

The section of the Mesa Verde Group as exposed in the Hogback just north of the river is as follows:

Upper Escarpment sandstone, group 6 .... 200 feet.
Yellowish-brown massive sandstone, with impressions of *Halymenites.*

Middle Coal-measures, group 7.

90 feet clay shale and shaly sandstone.

8 feet orange-colored sandstone.

8 feet sandy shales.

16 feet sandstone, with seams of clay and lignite.

10 feet arenaceous clays and shales.

30 feet lignitic beds, containing many seams of fire-clay, shale, and sandstone.

100 feet calcareous sandstones, with thin seams of limestone and beds of iron concretions.

375 feet greenish, purplish, and gray clays, containing many irregular seams of sandstone, shales, and concretionary seams of iron ore and limestone; also, some coal indications.

5 feet sandstones, containing fossil leaves.* *Fossil horizon No.* 4.

40 feet clays and calcareous shales, with stratum at base, containing fossil leaves. *Fossil horizon No.* 5.

30 feet beds of shale, with thin coal seams.

30 feet sandstones, with seams of clay shale.

Lower Escarpment sandstones, group 8 .... 180 feet.

100 feet massive fine-grained sandstone, whitish above.

80 feet yellowish sandstones, alternating with shales, containing *Inoceramus Barabini*, *Tellina scitula*, and *Trapezium truncatum. Fossil horizon No.* 5.

Beneath this comes the great series of Middle Cretaceous shales.

Before completing this section I became impressed with the seeming correspondence between certain of its members and portions of the section farther up the river. I immediately set to work to determine, if possible, whether or not a displacement and consequent duplication occurred. As this is a matter of considerable interest and has an important bearing upon the vertical extent and distribution of the strata, I shall give here all the more important facts bearing upon it. If a fault occurs, it is certainly along the axis of the San Juan fold, which fold I have traced entirely across my district without being able to detect a displacement. The exposures of the strata are more than ordinarily complete, and there is no place between the mouth of the La Plata and the gateway through the Great Hogback, in which the strata cannot clearly be traced. A sudden change of dip occurs along the east base of the Hogback, (see Fig. 1, Plate XXXVIII), but it is apparently not associated with any dislocation. Yet there is a marked similarity between the outcrops east and west of this fold, sufficient at least to cause one to suspect that a fault may have occurred having the downthrow on the west as is indicated in Plate XXXVIII, Fig. 2, by which there would be a double outcrop of the Mesa Verde Group. The Lower Escarpment Group (8) resembles the Pictured Cliff Group (4), and beneath each is a bed of brown sandstone containing fossils; a few species are common to both horizons. Above each of these sandstone groups is a group of coal-

*Described in Report of United States Geological and Geographical Survey of the Territories for 1874, page 360.

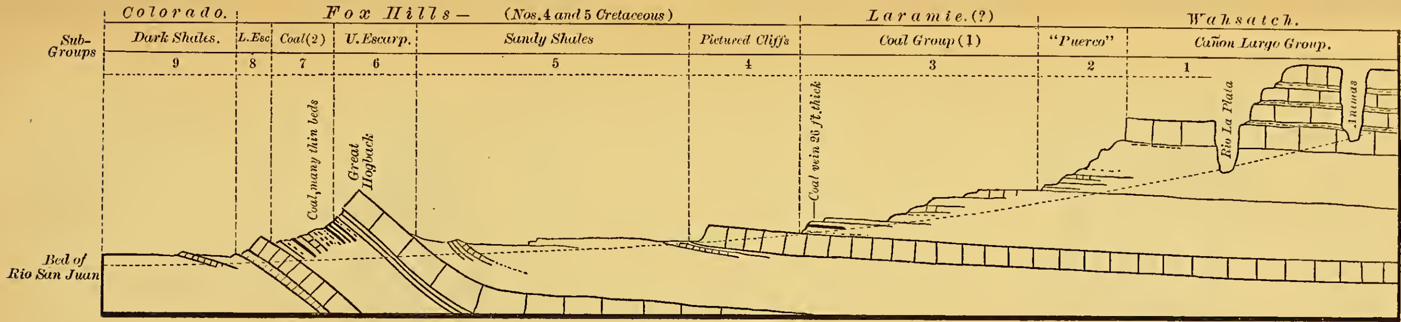


Fig. 1.

Section on the San Juan

Extending from the mouth of the Animas to the Great Hogback.
Names and figures same as on General Section.

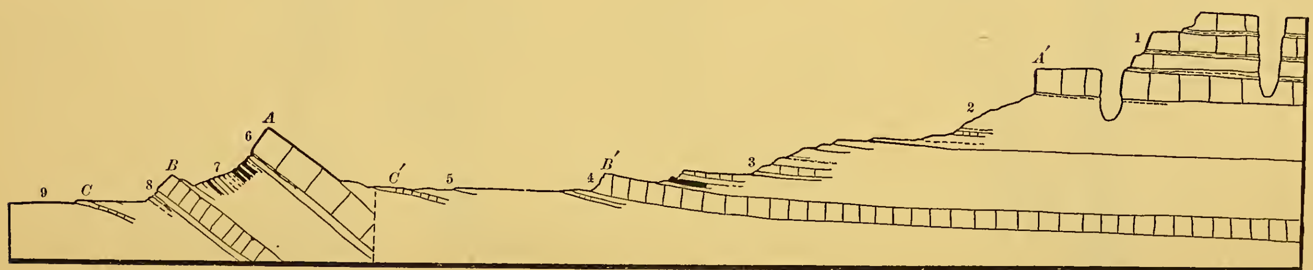


Fig. 2.

Section showing apparent duplication of Strata

and location of the supposed fault, by which A would be the same as A′, B the same as B′ and C the same as C′. Figures are the same as in Fig. 1.

PLATE XXXVIII.

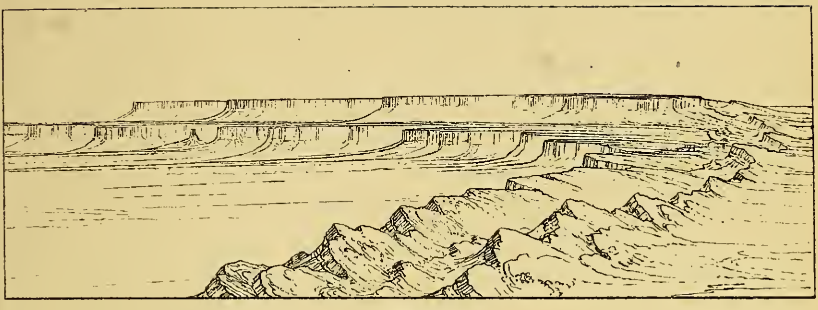


Fig. 1.
The Great Hogback and the Mesa Verde.

Plate XXXIX.

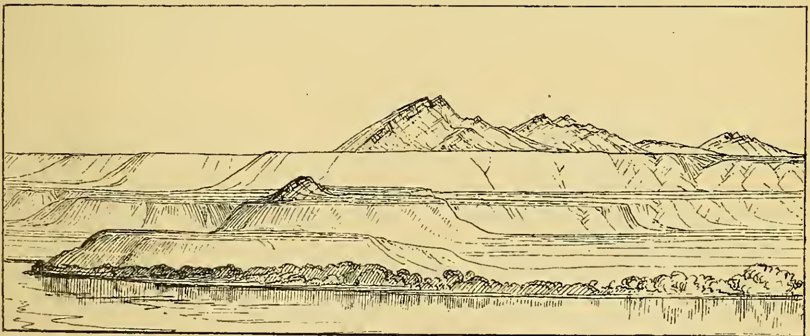


Fig. 2.
Terraces at the Great Hogback.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

bearing rocks, and above these two groups of sandstone, the Upper Escarpment and the Piñon Mesa Groups (6 and 1), which are somewhat alike; also, the fossil-bearing limestone, which occurs near the base of group 5, is apparently repeated in a bed of rusty limestone (9) that occurs beneath the Lower Escarpment and in the upper part of the Middle Cretaceous shales. The displacement or throw indicated by these facts would be about 1,500 feet, and if proven to exist would change my section so as to place group 1 immediately upon group 7, and the 1,500 feet between would drop out of the section. But the evidences against the existence of such a displacement are very strong, if not conclusive. The Coal Group of the Hogback (group 7) is totally unlike the Upper Coal Group (3). In group 7 the entire thickness is only 800 feet, and the strata are chiefly sandstones and shales, which, toward the top, have a number of seams of coal; farther west and north, in the Mesa Verde, the sandstones predominate. In group 3 the coal occurs in a heavy seam at the very base, the mass of the strata being yellow sandstones, which bear no coal toward the top, while group 2, the bad-land marls, has no place or corresponding group in the section of the Hogback. These differences are constant throughout the area examined by me. The section on the La Plata has the same succession of groups as this on the San Juan. Dr. Endlich has the same near the Rio Florida, and Messrs. Dwire and Hendrickson observed the same succession of strata, the same arrangement of the coal groups and corresponding thicknesses of beds on the Animas. In all of these cases the exposures are so complete that a fault could hardly exist without being detected. Dr. Newberry, who passed up the San Juan in 1859, states that a fault or rupture occurs in the region of the Great Hogback, but he seems to have observed no evidence of it except the apparent duplication of strata.

In Plate XXXIX I present a sketch of an interesting system of terraces that occurs on the south side of the river. They cover a large area about the Great Hogback, and seem to have uniform levels both east and west of it. Portions of the Hogback have been planed down to the level of the upper terrace, more limited portions to the level of the second, a few buttes of outcropping strata protruding above, and a very narrow belt to the lower level, while the river has cut a passage barely wide enough for its own accommodation.

MESA VERDE.

As already mentioned in the preceding pages, the San Juan fold begins along the south base of the La Plata Mountains and extends in a southwest direction to the San Juan River, which it crosses at the Great Hogback. East of the fold the Eocene (?) formations occupy the surface of the country; west of it we have nothing but Cretaceous rocks. The heavy sandstones of the Mesa Verde group rise to the surface along the axis of the fold and in a comparatively gentle slope reach a level more than 1,000 feet above that occupied by the same beds east of the fold; afterward they flatten out and form the Mesa Verde (see bird's-eye view, Plate XXXVI). This table-land is one of the grand features of this part of the great Colorado Plateau, which, although rising so gradually on the east, presents a magnificent series of cliffs on the north, south, and west. Over the greater part of the area, which comprises some 90 square miles, the general level is well sustained by the massive layer of sandstone of the Upper Escarpment, not as an unbroken mass of block of strata of course, for the erosive forces have invaded it on all sides and the edges are scalloped by a thousand cañoned gorges. Not only have the destroying forces encroached from the edges on all sides, but the mesa has been entirely severed by the cañon of the Rio Mancos, which cuts through it from north to south. This cañon sends out a multitude of side cañons and gorges, which seem literally to have honeycombed the interior of the table-land; indeed, when we come to look more closely there seems only the skeleton of a plateau remaining; this is well shown in the contour map (see atlas of Colorado). The relation borne by the Rio Mancos to the mesa has an interesting bearing upon the past history of this region. Between the mesa and the La Plata Mountains there is a broad irregular passage-way, eroded from the Middle Cretaceous shales. The river is formed on the western slopes of the mountains, crosses this low belt and cuts directly into the northern face of the table, which presents massive cliffs nearly one thousand feet in height, notwithstanding the fact that a natural passage-way opens out both east and west between the mountains and table-land. It is evident that the river could not have taken this course with the present relations of surface-rock. It has in all probability been "superimposed" upon the present face of the country by having been first laid down upon a surface of uniform character. Such a condition of surface may easily have existed when the sandstones of the Mesa Verde group (or of any higher group) extended back to or overlapped the trachytic masses of the mountains. It is probable that when the bed of the river, in its descent through the successive formations, reached the shales, the cañon-walls were continuous from source to mouth, and consisted of the massive sandstones of the Upper Cretaceous and Tertiary formations. These formations would probably first be penetrated along the base of the mountains where considerable uplifting and breaking up of strata had occurred. The eroding forces on reaching the soft shale-beds at a given point would be greatly aided by a process of undermining by which the cliffs would break down and retreat to the right and left, forming side valleys, and these in time would meet similar lateral valleys from the McElmo and La Plata Cañons. It thus seems clear that the course of the Rio Mancos was laid out at a very early period and that the formation of the transverse valley separating the mesa from the mountains is of comparatively recent date.

At the entrance of the cañon on the north the cliffs are capped by the sandstones of the Lower Escarpment, which are highest at the northern edge and slope off toward the interior of the mesa; beneath this are exposed 700 or 800 feet of the Middle Cretaceous shales. The dip to the south is so much greater than the fall of the river (see section, Plate XL) that ten miles below the shales disappear, and the sandstones of the Lower Escarpment outcrop along the river-banks, while the Coal-Measures occupy the middle slopes, and the Upper Escarpment sandstones cap the cañon-walls. The general height of these walls remains quite uniform, being measured generally by the thickness of the Mesa Verde Group, which varies from 1,000 to 1,200 feet.

Midway in the cañon the Coal Group descends to the river-bed, but below this the dip decreases and the river cuts down into the shales again. Throughout the portions of the cañon in which the firm strata of the Mesa Verde Group only occur, the walls are steep and close.

The Coal series is always prominent; the dark lines of the outcrops appear everywhere int he middle portions of the walls. The preponderance of sandstones is very noticeable, and beds of great thickness appear in all parts of the section. These beds are exceedingly variable,

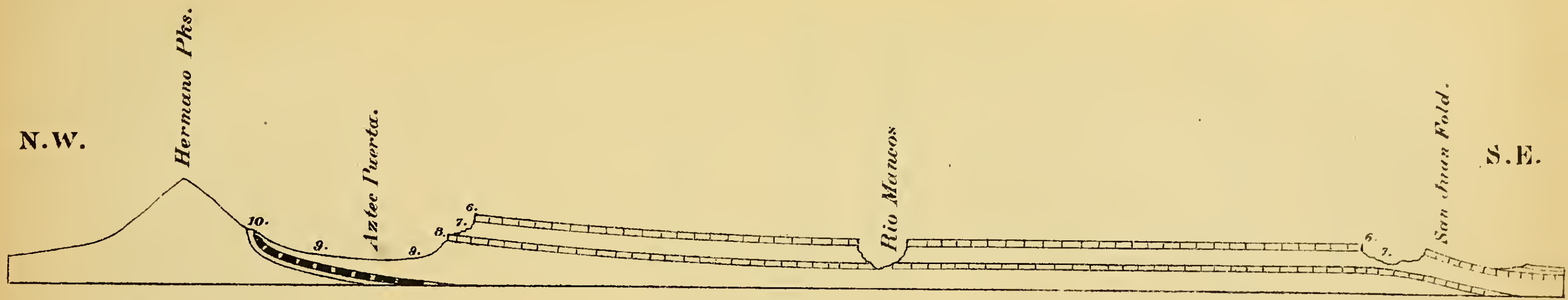
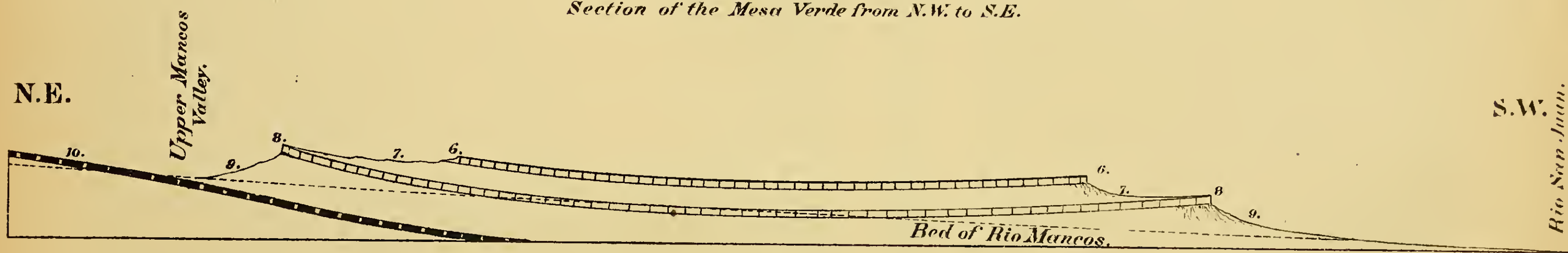


Fig. 1.

Section of the Mesa Verde from N.W. to S.E.



AM. PHOTO-LITHO CO N.Y. (OSBORNES PROCESS)

Fig. 2.

PLATE XL.

Section of Mesa Verde as exposed in Mancos Cañon.
Horizontal scale 4 miles to 1 inch.
Vertical scale 5000 feet to 1 inch.

however, and have no great horizontal extent. As compared with the section in the Great Hogback on the San Juan, the sandstones are doubled in quantity. In one locality I found a number of fossil leaves which correspond closely to those found near the same horizon in the Hogback section. Midway in the cañon and in the neighborhood of the two-story cliff-house (see map) Mr. Brandegee procured the following section. Beginning with the Upper Escarpment, we have—

200 feet sandstone; massive, reddish and yellowish. Beneath this is the *Coal Group* (7, general section).
6 feet black shales. (The niches which contain the cliff-houses are eroded from this.)
50 feet light-colored sandstone, massive and soft.
1 foot black shale.
100 feet sandstones, soft, yellowish.
20 feet shale.
10 feet sandstone.
75 feet sandstone, argillaceous.
10 feet sandstone.
30 feet blackish clay shale.
10 feet sandstones.
2 feet shales.
4 feet sandstones.
6 feet black shale.
6 feet sandstone.
6 feet coal shale, containing small seam of good coal.
3 feet sandstone.
150 feet shale alternating with sandstone.
10 feet coal and coal shale, 2 feet of good coal.
160 feet sandstones and shales alternating.

It appears by this that the sandstones occupy at least three-fourths of the entire section, whereas in the San Juan Hogback they are scarcely half.

The scenery throughout the cañon is quite striking. The bold cliffs of the Upper Escarpment fairly overhang the valley and the projecting angles are sentineled with tottering crags and half-poised masses of rock.

The trail is in many places a difficult one to follow, and the tourist who may be tempted to visit this locality for the purpose of studying the works of the ancient inhabitants will find it no holiday task to work his way through the mazes of fallen rocks and sharp-cut gulches. In many places the river washes the bases of the cliffs, and forces the trail back up the rocky slopes. The fringe of tangled underbrush that borders the stream, the deep ditch-like channel and the quicksands of the bed, make it next to impossible to cross from side to side.

Lower down, the shales of the Middle Cretaceous appear again, the cliffs retreat to the right and left, and narrow sage and grass covered flats border the river. Still lower, the Upper Escarpment falls back out of sight from below, and the cliffs of the Lower Escarpment are deeply indented by the side-cañons, so that in looking down the valley one sees nothing but a series of bold promontories.

At one point within five or six miles of the foot of the cañon the upper line of cliffs approachs the river-front on the east side. This point, on which Station 25 was made, commands a fine view of the southern and western borders of the table-land as well as of the Late and Carriso Mountains and the valley of the San Juan. In Plate XLI, I present an outline sketch of the view to the north and west from this station.

In the foreground are shown the west walls of the Mancos Cañon The upper and steeper portions are composed of the Lower Escarpment sandstone, and the slopes and base of the shales of the Middle Cretaceous. The Coal Group and the Upper Escarpment sandstones have been removed by erosion, so that the mesa-top is a smooth floor, formed by the upper surface of the Lower Escarpment beds. This floor, although unusually firm, seems to be yielding very rapidly to the eroding forces. Many side-cañons are eating their way into the very center of the mass, and large fragments have already been entirely or partially severed. These fragments or outliers are always interesting and picturesque objects, and may here be seen in all stages of formation and decay. Some still retain their table-like caps and are a number of square miles in area; others stand as majestic columns, whose vertical sides are fantastically carved and colored; others are so far reduced that they are mere needles that totter over their slender bases, while innumerable piles and heaps of earth mark the sites of those from which the capitols and columns have long since fallen. Beyond the cañon-cut mesa is the group of mountains which, on most of the old maps, is called the Sierra Late. It is a small group of low trachytic summits that stands quite alone, and with its rounded and conical forms presents a very striking contrast to the flat, square-cut table-lands that surround it. Between the Mesa Verde and this group of mountains, as may be seen in the drawing, there is a wide, deep puerta eroded from the Cretaceous shales. This depression connects the valleys of the San Juan and Lower Mancos with those of the McElmo and Dolores.

From this station the line of Upper Escarpment cliffs extends southeast to the point where the mesa connects with the San Juan Hogback, a distance of nearly 20 miles. The line of Lower Escarpment cliffs is nearly parallel with the Upper, and is a few miles farther south. This line is very much broken by deep indentations, and a large number of isolated buttes lie to the south. The cliffs, however, are quite precipitous, and cannot be ascended at any point without great difficulty. Between the base of these cliffs and the Rio San Juan there is a low, smooth plain, eight to ten miles in width, which is quite barren.

The Mancos River, on emerging from the cañon, turns to the westward and flows obliquely across this low belt. The exposed rocks are, throughout, the shales and shaly limestones of the Middle Cretaceous or Colorado group. The section given in Fig. 2, Plate XL, will show the relations of the cliffs of the Mesa Verde to the valley of the San Juan.

West of the Mancos the cliffs have their southwestern termination in a sharp angle. From this they extend to the north in a gentle curve, and finally sweep around to the point at which the Mancos enters the cañon on the north. This part of the mesa, viewed from the west, is very imposing. In many places the greater part of the Mesa Verde Group (including both escarpments and the Coal Group between, the latter being chiefly sandstone here) comes forward together, forming a series of bold cliffs upward of a thousand feet in height. Beneath these are exposed nearly a thousand feet of the shales of the Colorado Group. These weather into most fantastic forms. They are soft and homogeneous, and the water from the occasional rain-falls carves out innumerable little sinuous washes, which, in descending, come together, forming deep gullies. These keep on, joining others, until the main drainage-course of the valley is reached. Between this net-work of washes are corresponding ridges, which, in a favorable light, give to the mesa-face the appearance of an elaborate and very artistic piece of ornamental carving.

a. a. a. Slopes of Mesa are of Middle Cretaceous Shales.
b.b.b. Capping of Mesa Lower Escarpment Sandstones.
c. c. Remnants of Coal measures.

d. Jackson Butte. e. Ute Mountain.
f. Hermano Peaks.
g. Sentinel Rock.

Plate XLI.

The South Western Border of Mesa Verde and the Sierra el Late.

Looking west across Mancos Cañon.

From Station 25 it could be plainly seen that, although the Upper Escarpment sandstones hold their place on the summit of the western border of the mesa, they are much broken in the interior, and especially along the line of the Mancos Cañon. There is a slight upward dip westward from the cañon, so that the drainage has in no case been to the west, while a multitude of cañons head very close to the western border and open out into the Mancos. Indeed, there seems to be a slight dip inward from all sides of the mesa, and this no doubt accounts for the rather remarkable fact that from without we get the idea of an unbroken and well sustained table-land, while from within we discover only a skeleton—a sort of rude wheel, which might be described as having pretty well defined tire and spokes, but no hub.

On the divide between the head of the McElmo and the Upper Mancos a high promontory extends far out to the north. It is capped by the Lower Escarpment sandstones, beneath which are the shales.

East of the Mancos there are two great fragments almost severed from the main eastern mesa, by cañons which have cut down through the mesa sandstones and exposed the shales throughout most of their courses.

The more easterly of these, reaches north along the divide between the Mancos and Cherry Creek, and ends in a high promontory which overlooks the beautiful valley that lies between the mesa and the La Plata Mountains. At Cherry Creek the mesa proper ends, and the Mesa Verde group of strata extends eastward in a long ridge, or hogback, at first quite flat, but at the crossing of the La Plata at the base of the Parrott City bar the dip rises to five or six degrees.

A clearer notion of the character and surroundings of the Mesa Verde can be obtained from the bird's-eye view, Plate XXXVII, than from any word description, however detailed.

MIDDLE CRETACEOUS ROCKS.

The Middle Cretaceous rocks, which include numbers 2 and 3 of the ordinary classification, have an average thickness of nearly 1,400 feet, and throughout the district examined are chiefly shales, dark in color, and usually homogeneous. They occupy considerably more surface-area than the Upper Cretaceous rocks. At the south they first rise to the surface at the base of the Great Hogback; from this point they extend to the base of the Sierra Carriso, a distance of nearly 25 miles. The dip to the east is very gentle, so that the San Juan flows 22 miles to the westward in descending through 1,400 feet of strata. The actual descent of the bed of the stream in this distance is only 200 feet. After passing the gateway in the Hogback the river enters a broad valley which extends to the base of the Mesa Verde on the north, far away to the south in a stretch of smooth, grassy plain, which has not been fully defined. The monotony of this plain is somewhat broken by a continuation of the Great Hogback, which crosses indefinitely to the southwest. The one remarkable feature of this part of the valley of the San Juan, however, is known as the "Needles," a mass of volcanic rock which rises abruptly from the plain and terminates in a cluster of needle-like points or spires, which presents from the distance at which we were compelled to view it, the appearance of a gigantic cathedral. Its height is said to be nearly 1,800 feet. It is located some 10 miles south of the San Juan, and nearly opposite the opening of the Mancos Cañon. It is a great landmark and visible from many distant points.

Along the course of the river there are occasional terraces which rise to the height of 20 or 30 feet. The only considerable bluff occurs some 20 miles below the Hogback, and consists of the firm shales and impure siliceous limestones which contain such quantities of fossils—including *Baculites*, *Scaphites*, *Ostrea*, &c. A short distance below this the sandstones of the Dakota group rise to the surface. The section of the Middle Cretaceous strata, as exposed on the San Juan, will be about as follows:

Beginning at the base of the Hogback, we have—

200 feet of sandy shales, gray and yellowish.

10 feet of ferruginous, shaly limestone, containing bed of *Inoceramus*.

700 feet of shales, sandy, argillaceous, and calcareous.

12 feet of siliceous limestone, containing many well-preserved specimens of *Scaphites Warrenii*, *Inoceramus Barabini*, and *Baculites ovatus*.

400 feet of shales bearing heavy deposits of *Ostrea* and *Gryphea*. Near the base a considerable seam of coal occurs. This group of shales rests upon the Dakota sandstones.

The bed of siliceous limestones correspond to a group of fossiliferous limestones that occurs everywhere along the eastern base of the mountains, and which is usually considered a part of No. 2 Cretaceous. In this valley it is the only stratum belonging to the Middle Cretaceous which has sufficient firmness to produce a line of well-marked bluffs.

Near the river these bluffs rise to the height of 30 or 40 feet; on the south side they form the east banks of Red Creek, which are in places nearly 200 feet in height. North from the river they may be traced to the Mancos River and beyond, around the west base of the Late Mountains. The section of Middle Cretaceous rocks on the Mancos does not differ greatly from that of the San Juan.

North of the Mancos the shales do not reach west beyond the San Juan, but in a number of places cap the bluffs on the east side. They surround to a great extent the trachytic masses of the Late Mountains, and occur on the higher parts of the table-land that lies between the lower McElmo and the San Juan. In many places they appear to be tipped up against the bases of the Late Mountains, and large fragments of shales are carried high up on the trachytic summits. The low puerta between the Late Mountains and the Mesa Verde is occupied entirely by the shales, and the ancient village which lies at the highest part of the puerta and on the divide between the Mancos and McElmo has been constructed chiefly of the fossil-bearing siliceous limestone mentioned in the last section. In Figure 1, Plate XL, is given a profile of the western face of the mesa, the Late Mountains, and the puerta between.

Along the northwest face of the Mesa Verde the shales occupy a belt from four to six miles in width. The greater part of the series outcrops along the steep slope of the mesa. Between the headwaters of the McElmo and the Mancos, extending northward from the mesa promontories, are a great number of rounded buttes composed of dark shales. About the bases of these buttes great quantities of Grypheas and Oysters may be seen. They are weathered out and lie about in heaps.

As has already been stated in the preceding pages, the long, narrow puerta or pass which separates the La Plata Mountains from the Mesa Verde, and connects the valleys of the Mancos and La Plata Rivers, is eroded from the Cretaceous shales. The La Plata gold bar has been deposited on the upturned edges of the shales and the fossil-bearing limestone passes beneath Parrott City. Between the town and the La Plata River a low ridge, composed of this limestone, appears above the bar level, and pretty full outcrops of the same limestone and the black shales beneath may be seen in the steep banks of the river. Along the trail between Parrott on the Mancos the shales appear on all hands, and in many places extend high up the mountain-slopes. The Dakota sandstones are exposed where erosion has been deepest. On the western faces of the La Plata Mountains the shales are found high up, and are in many cases interbedded with the trachyte of the summits. The Mancos River above Merritt's ranch has cut down through the shales and exposed 200 to 300 feet of the Dakota sandstones. Between the Mancos and Lost Cañon the formations sink again almost to the horizontal, and the shales have nearly all been carried off, leaving a smooth floor of the Dakota sandstones. The same may be said of the extensive sloping plain that extends far out to the west between the McElmo and Dolores Rivers. Patches of the shales remain in the more protected localities, and frequently where the shales have been entirely removed, quantities of Gryphea and Oyster shells lie about on the hard sandstone floor. North of the Dolores, on the high plateau regions which separate that river from the Rio San Miguel, large areas of the Middle Cretaceous formations remain. In the small mesas west of Lone Cone the entire series of shales has been preserved, the caps of the mesas being of the Mesa Verde sandstones, Lower Escarpment group. In the San Miguel Mountains the shales have been preserved by the flows of trachyte, with which they are now interbedded.

LOWER CRETACEOUS FORMATIONS.

The group of sandstones that immediately underlies the shales is, apparently, in the southwest the most important members of the Cretaceous formations. Although it does not comprise as great a thickness of strata as either of the other grand divisions, the superior compactness of the rocks has been the means of retarding and almost arresting for a time the progress of degradation. I imagine that upon close examination the strata comprising it would not be found to possess a much greater degree of firmness than the sandstones of the Mesa Verde group, and they are certainly less massive; but when we consider that the former group rests upon a series of moderately compact rocks, while the latter are underlaid by 1,400 feet of exceedingly friable strata, and, further, that these firm rocks yield more by undermining and breaking down than by actual disintegration, we can understand the reasons for such successful resistance.

Over hundreds of square miles these sandstones lie comparatively unbroken, while the loose series of shales above have been swept off like so much dust from a great floor. This condition of things is especially noticeable in the region of the Great Sage Plain between the Dolores and the Lower San Juan. It has, where remaining in its undisturbed horizontal position, only been penetrated in the deeper parts of the cañons of the San Juan and Dolores Rivers. In these cañons the Red-Beds are exposed. Along the bases of the La Plata and San Juan Mountains it has been turned up against the slopes, and generally where outcropping forms a prominent hog-back ridge.

At the exit of the Rio La Plata from the mountains, less than a mile above Parrott City, it outcrops in the river banks, and dips away from the mountains at a high angle. Here as elsewhere it contains near the top one or more seams of coal. The quality of this coal is always good, but is not known in Colorado to reach a thickness above 3 or 4 feet.

West of the Rio La Plata the sandstones of this group may be seen lying against the steep slopes north of the Mancos trail. Farther around to the west, about the sources of the Rio Mancos, they pass beneath the black shales and the masses of trachyte, and are only seen where the cañons penetrate deepest.

West of the Mancos, where the conditions of the strata are so uniform, it will not be necessary to speak in great detail. I shall, therefore, describe them briefly in connection with the several valleys in which they occur.

On the San Juan, at the mouth of Red Creek, the Dakota sandstones come to the surface and rise with a slight inclination toward the Sierra Carriso. At the mouth of the Mancos, eight miles below, they crop out in the high bluffs. The section at this point consists of about 200 feet of sandstones, apparently of less compact structure than usual; many beds of shale appear, and some irregular seams of coal.

The Rio Mancos, after entering the alluvial valley of the San Juan, flows for some distance along the base of a steep bluff, in the lower part of which there is an exposure of brilliantly colored beds, consisting of shales, marls, and many thin seams of hard clay-slate and fine-grained purple quartzite.

From the mouth of the Mancos to the western border of our district, a distance by way of the river of some forty miles, I found the upper beds of the Dakota sandstones capping the bluffs on all sides. There is no perceptible dip, and I was somewhat astonished to find that the difference of level between the upper surface of the sandstones at Station 56, near the Mancos, and Station 45, on our western line, was only 200 feet, the western one being that many feet higher. The dip to the east, therefore, amounts to 200 feet in 40 miles. The river in that distance descends 500 feet, so that there are 500 feet of additional strata exposed.

The section taken at Station 45 is as follows: beginning with the upper stratum of the outstanding butte on which the station was made, and nearly on a level with the surface of the Great Sage Plain which lies to the north, we have first 60 to 80 feet of yellowish, moderately hard siliceous sandstone, changing into a massive, closely compacted conglomerate at the base. Following this are 200 to 300 feet of variegated shales and marls, with thin seams of argillaceous slate and concretionary layers of impure limestone. At the base, these thinly laminated beds are replaced by soft sandstones, and following these is a series of rocks some 500 feet in thickness that presents many curious characters. Sandstones, marls, clays, shales, and conglomerates are thrown together without apparent regularity. A massive sandstone, 20 or 30 feet in thickness, will often be found, if followed a few yards horizontally, to change suddenly into an uncompacted mass of most uncertain composition, that weathers into a thousand fantastic forms and presents the colors of the rainbow. The color, composition, and style of weathering seem to change with every turn in the river.

Beneath these beds come a series of laminated sandstones about 200 feet in thickness. They have generally a dull purplish hue, and are very impure and coarse. There seems to be a very regular alternation of hard and soft layers, so that from top to bottom there is a succession of prominent edges and deep grooves. These beds lie upon a massive red or pinkish sandstone, which extends to the river-bed.

The upper member of this section is the strongest layer of the almost universally recognized No. 1 Cretaceous. The variegated series which succeeds it I at first felt inclined to call Jurassic, since it resembles so closely the variegated beds that on the eastern slopes of the mountains have usually been credited to that age. I observe, however, that, although it has the same appearance and the same relations to the well known Dakota sandstones as the eastern variegated beds, it is not followed by the same well-known Jurassic strata. On the contrary, the heavy thickness of peculiar beds which underlie it seem not to be represented farther east, and are certainly developed to a greater extent here than at any other point, so far as I can learn, west of the mountains.

In Middle Western Colorado Dr. Peale has found Cretaceous fossils in a stratum of sandstone some three or four hundred feet beneath the bed of conglomerate, and also beneath a series of variegated beds that resemble these in this section. Considering these facts, I cannot do better for the present than class this entire series of rocks from the level of the Sage Plain to top of the purple laminated beds as Lower Cretaceous. Altogether there is a thickness of nearly nine hundred feet, only about two hundred feet of which can with absolute certainty be said to belong to the Dakota sandstones. These 200 feet occur at the top, and are so distinct from the group beneath that I shall, for convenience, hereafter distinguish them as Upper and Lower Dakota. The former consists of two or three beds of massive sandstone or conglomerate, separated by thin layers of shale or marl, that may generally be found, where present in a plain country, capping table-lands and forming long lines of perpendicular cliffs, or, if in the neighborhood of mountains or abrupt folds, occurring in lines of prominent hog-backs. The latter, in the valley of the San Juan, outcrops in the sloping sides of the valleys and cañons or in the faces of prominent table-lands, and may be distinguished by the total lack of uniformity in weathering, composition, and color.

There is a slight rise in the strata north and south from the San Juan. From the mouth of Red Creek to Station 45 the river-bed seems to be in the shallow trough of a synclinal fold. On the south side the dip toward the river amounts to from one to three degrees. On the northeast side of the Carriso Mountains the Dakota sandstones rise in an unbroken slope to the base of the mountains, where they disappear beneath the masses of trachyte. Along the east base, where there has been considerable uplifting of the formations, the upper and lower members of the Dakota group have been penetrated, and the red rocks of the Jura-Trias are exposed over a considerable area.

West of the valley of Navajo Creek, which has its sources in the central part of the Sierra Carriso and reaches the San Juan just below the mouth of the Mancos, the Dakota sandstones form an extensive sloping table-land, lowest along the San Juan and the highest facing the Carriso Mountains. It is separated from these mountains by a wide deep valley, which connects the middle portion of the valley of Najavo Creek with the open country to west about Gothic Creek and the De Chelly. Erosion at Navajo Creek has barely reached the laminated purplish sandstones, but a little farther west, in the depression occupied by Arido Creek, the red-beds are exposed. West of Arido Creek there are three or four isolated buttes of red sandstones which present most remarkable examples of the "cross-bedding" structure.

The southern face of the sloping mesa which overlooks this valley is very regular and continuous, being broken only by the cañon of Arido Creek which cuts through it to the San Juan, but the northern border which faces the San Juan is extensively broken. The slope to the north has turned the drainage all that way, so that a great number of long, deep cañons reach from the San Juan far back into the table-land. On the west this table-land terminates with the valley of Desert Creek, as also do the Cretaceous formations, if perhaps we except a few low buttes of marly sandstones that appear on the west side of the valley. On one of these buttes Station 46 was made.

We are here in Southeastern Utah and in a country that, with the exception of a very slight growth of grass, in a few favorable places, is an unadulterated desert. The surface is composed either of loose sand or smooth, bare rock. The dry beds of the streams are generally at the bottom of deep, almost impassable gorges, and a more desolate and perplexing country to travel can hardly be imagined. The low country surrounding the Sierra Carriso, northwest and south, is almost all of this character. Near the north base of the mountains on Navajo Creek there are a number of good springs, and about these there is a belt of very fine pasture-land. Here we found a couple of Navajo villages. The people of these villages keep large herds of sheep, and in the damp patches of ground about the springs raise grain, vegetables, and melons.

Close under the north base of the mountains and extending around to the west, a belt of Lower Cretaceous strata remains. These strata are composed of the Lower Dakota sandstones and marls, which generally yield rapidly to the eroding forces, but in this case have been preserved by masses of trachyte that have been poured out over or forced in among them. They are now found along the faces of the lower slopes, beneath masses of trachyte, and seem to have undergone neither metamorphism nor uplifting.

Extending west from West Mesa (see Plate XLVIII), between the valleys of Arido and Desert Creek on the north and Gothic Creek on the south and west, is a low ridge which connects with a long flat mesa. This mesa is composed principally of the Lower Dakota sandstones, but is surrounded by a red sandstone desert. The structure of the Carriso Mountains will be dwelt upon in another chapter.

On the north side of the San Juan, west of the Rio Mancos, there is an area of fully 3,000 square miles, tributary to the San Juan, in which there is not during the summer season a single stream of constantly-running water. It is essentially a plain country, there being only two small groups of mountains, the Sierra Late and the Abajo or Blue Mountains, which are 60 miles apart. About the bases of these there are a number of springs.

The surface rock is generally the Upper Dakota sandstones, and the deepest cañons in no place penetrate more than 300 feet below the base of the Lower Dakota group. It seems, therefore, that a greatly-detailed description of this region is not necessary.

There are two principal drainage systems, the McElmo and the Montezuma. The former has two main branches, the McElmo proper and the Hovenweep. The McElmo heads chiefly in the Cretaceous shales between the Mesa Verde and the south bend of the Rio Dolores, and passes directly west past the north base of the Late Mountains. The Hovenweep heads up against the Rio Dolores and runs southwest, joining the McElmo in Utah about three miles west of the Colorado line and within 14 miles of the San Juan. It comprises a multitude of cañons, most of which head upon the upper surface of the Dakota sandstones and extend to the south and southwest, cutting down only partially through the Lower Dakota rocks.

The McElmo, at the north base of the Late Mountains, cuts down to the red beds. There has been a slight arching of the sedimentary strata here, the result, probably, of the uplifting of the trachyte of the mountains. It is in cutting through this arch that the red beds are exposed.

The section made here is almost identical with that made on the San Juan near Station 45. The Upper Dakota Group seems somewhat more fully developed, showing upward of 200 feet of sandstones in the bluff face. The Lower Dakota Group shows considerably more sandstone and there is much more persistency in individual beds. The red and pink sandstones are very massive. They outcrop for two or three miles along the river, and on the north side of the valley, opposite Ute Mountain, sweep back in a great amphitheater. In the more massive beds there are weathered many deep caves in which the ancient inhabitants have built their rock shelters. On the lower McElmo there are exposures of Lower Cretaceous rocks only.

Between the McElmo and Hovenweep, in that part traversed by the trail to Hovenweep Castle, there is a large area from which the Upper Dakota sandstones have been more or less completely removed. Here the harder layers of the variegated group beneath are broken up into numberless little blocks, which are covered with a black, lustrous coating of some mineral that makes them look like iron-ore. The coating is very thin, and is probably black oxide of manganese. I have observed the same phenomenon in other localities, notably in New Mexico, between El Rito and Abiquiu. Dr. Loew, on page 1020, Report of the Chief of Engineers for 1875, gives an analysis of the same material.

The Montezuma occupies a system of cañons somewhat more complicated and considerably more extensive than the McElmo. The upper branches reach far out to the north, ramifying the Great Sage-Plain in a most remarkable manner. From Ute Peak on the east I looked out over this desolate region, and afterward from the Abajo on the west, but the network of cañons was quite unintelligible. Gorges and broken precipices and impassable walls of rock followed each other in such quick succession that no portion of the plain country seemed to be left. So far as I could learn there is no running water during the summer excepting near the east base of the Abajo Mountains; but the growth of cottonwoods, willows, and grass along the lower course indicates that there is considerable moisture most of the year and running water, probably, during the winter and spring. The Dakota sandstone everywhere forms the summits of the cliffs and the level tops of the tablelands, while the Lower Dakota Group outcrops in the slopes. In the West Montezuma cañon, nearly midway, the Red Beds are exposed for a short distance, but not to any considerable thickness. The cañon walls are upward of 1,000 feet in height.

REGION OF THE RIO DOLORES.

The Rio Dolores may well be regarded as one of the most interesting and remarkable rivers of the Colorado Plateau region, while at the same time it is certainly the least known. Having its origin in the San Juan Mountains, it flows toward the south and southwest for upward of 30 miles, and then turns abruptly to the northwest and afterward to the north, passing to the east of the Abajo and Salt Mountains, and joining the Grand in Utah 100 miles below the south bend. In describing the area drained by this stream I shall have to deal principally with the sandstones of the Dakota group, as they govern the entire surface erosion and give shape to all the principal topographic features. On a line drawn east and west through Ute Peak to the Montezuma on the west and the Rio Mancos on the east, the upper surface of these sandstones will average about 6,000 feet altitude. The general dip is to the south, at a gentle angle, so that in going north from this line we rise on a gentle slope which continues, with but little variation, to our northern line, a distance of 40 miles, where it will be found that the upper surface of the Dakota sandstones has an altitude of from 7,000 to 8,000 feet. The actual surface of the country varies but little from this plane. Some remnants of the Middle Cretaceous occur on the north edge, and the various cañon-beds are sunk to considerably varying depths beneath the surface.

Now the peculiar relations of the Rio Dolores to this plane may be easily understood by an examination of Plate XLII.

On leaving the mountains in the northeast corner (*a*), which is considerably higher than the northwest (*b*), the river flows at first in a cañon over 2,000 feet in depth. In its southward course its angle of descent is so much less than that of the surface of the plane that it rises in the geologic scale from the Red Beds to the upper part of the Upper Dakota sandstones. When, however, it is within one hundred feet or less of the upper surface of these sandstones (*c*)—which form the upper stratum of the confining walls throughout the entire course—it suddenly changes its course, turns to the north, and cuts back into the plane, and descends through the geologic scale in a gradually deepening cañon which, at the northern edge of the plane (*b*), is 2,000 feet deep.

Why this stream should thus stop midway in a great slope, which presents no obstacle to its continuous flow southward to the San Juan, and turn back upon itself against the slope, is an interesting question. At the extreme southern bend (*c*), as will be seen by the diagram, the bed of the stream is within a few feet of the surface. So rapid is the descent of the plane to the south from this point, that if the stream could be carried one mile farther south it would reach the surface of the sandstone which confines it, and would then assume its natural relations to the present configuration of the country, and become a tributary of the San Juan, since from the point *c* to the San Juan there is an unbroken slope which descends more than 2,000 feet in 45 miles.

With the last-mentioned fact in view, it will readily be seen why the many-armed cañons, tributary to the San Juan, reach up to the very brink of the cañon of the Dolores, and also why the direction of all the northern tributaries of the Dolores is to the south; it is the natural drainage of the country as regulated by the *present* position of the surface strata.

During the outlining of the main channel of the Dolores, however, we will have to suppose conditions which are not now evident; conditions which have governed the course of the main channel but not the course of the less important drainage, or at least that the latter has in a great measure conformed to the new conditions.

Let us suppose that the course of the river was originally determined while the sedimentary rocks were in a horizontal position over this area, or, perhaps better, that there was a gentle dip to the northwest. The waters accumulating on the highlands to the east have encountered the bodies of trachyte which at one time doubtless extended westward over the Dolores Plateau, and have thus been turned to the southwest, encountering in turn the belt protected by the La Plata trachytes; when finally the open country has been reached the unimpeded waters would turn to the northwest and descend the even slope. Such conditions may or may not have existed. It does not matter whether the course was determined in this way or in some other way; I wish only to give the

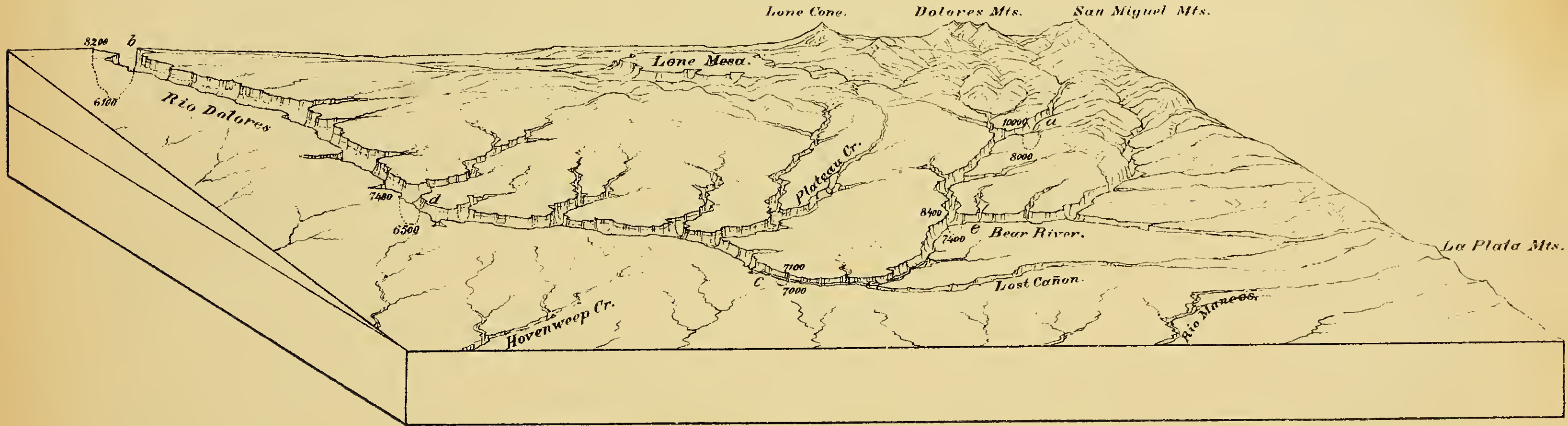


Diagram Showing the Relations of the Rio Dolores to the Inclined Plane.

Cañon 2000 feet deep at a; 1000′ at e; 100′ at c; 900′ at d; and 2100′ at b.

Plate XLII.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

river its present course in the simplest manner, and then make out, if possible, the subsequent changes that would be necessary to produce the present extraordinary condition. Having the river once laid down in its present course, we have but to suppose a gradual elevation to the north and northwest—an elevation not so rapid as to turn the river back upon itself and cause it to seek an outlet in another direction, but nearly so—and we overcome the greatest difficulty. The problems of the sloping plain and the unequally apportioned drainage are easily solved.

While this gradual change of level was taking place, and the river, with strong volume of water, was succeeding in cutting its bed down as fast as the fold rose, the tributaries, with very weak erosive powers, were undergoing a gradual but important change. The southward-flowing streams would constantly be increasing in length and importance, owing to the assistance given to the degrading influences by increased slope, while the northward-flowing ones, which were doubtless originally equal to the southward, would be constantly losing ground on account of decreased slope. Thus on the divide between the Dolores and San Juan, which was doubtless originally midway between the two streams, an unequal war would be waged. As the slope increased the southern streams grew stronger and the northern weaker, so that the divide would be driven to the north with constantly accelerated rapidity. But it is evident that a more marked inequality would take place when the first hard stratum of the Dakota sandstones was reached. The southern tributaries of the Dolores, as will be easily seen by the sections in Plate XLIII, would first encounter these compact beds on the very brink of the river, and thus the already weak eroding forces would almost cease to act, for however much of the friable shales might be disintegrated and sink into the stream-courses, the constantly-rising edge of sandstone along the river-bank would act as a dam to prevent its being carried into the river. Meantime the tributaries of the San Juan, still flowing in the shales, would keep on deepening and increasing in slope; would keep on driving the divide to the north until they had swept the great sloping plain clear of softer deposits, left it a smooth surface of solid rock, and wrested it entirely from the tributaries of the Dolores up to the very brink of that river.

From the summit of Ute Peak a very complete view of this region is obtained. In the foreground, at the very base of the mountain, is the cañon of the McElmo. Opening into it from the north are a great number of deep, precipitous side cañons, which reach back 8 or 10 miles into the sage-plain. At this distance they become shallow, and finally fade out; so that next to the Dolores there is a long, smooth slope. Beyond the Dolores this slope continues, as previously described. Along this slope the cañon of the Dolores can be distinctly traced, apparently first descending from the northeast to the great bend at the south, and then ascending again to the northwest.

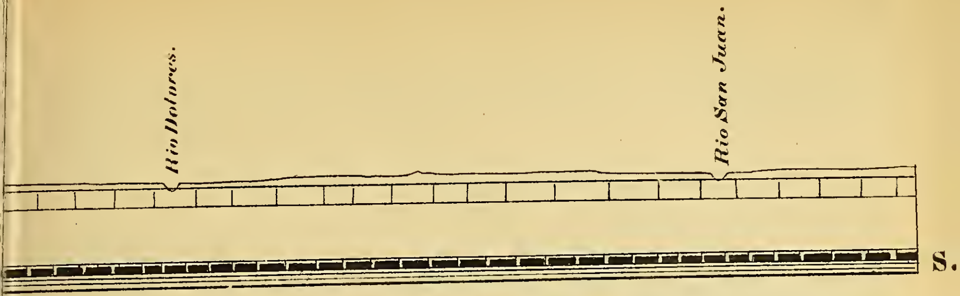
The various branches can be traced back to the north and east (see Plates XXXVI and XLII). The northern branch drains the southern faces of the San Miguel Mountains. The south fork, or Bear River, drains the high divide region between the San Miguel and La Plata Mountains, including the Bear River Mountains, and the Lost Cañon comes down from the western slope of the La Plata Mountains. These are the only tributaries of the Dolores in this region. It has no other tributary between the Lost Cañon and the San Miguel, a distance of 75 miles. Far to the northwest a great notch can be seen in the sky-line where the Dolores, in its northern course, cuts through the northern edge of the plateau. Beyond this notch the river flows for a long distance through a low red-sandstone country. At the southern bend of the river the Lower Cretaceous sandstones are exposed—about 150 feet of firm sandstones, with 40 or 50 feet of variegated beds at the base. Ten or twelve miles farther up, the Red Beds are exposed in the lower part of the cañon-walls, almost to the base of the Sierra San Miguel. There they pass beneath the Cretaceous formations, which constitute the bulk of the mountains. At the mouth of Bear River there are 1,000 feet of strata exposed or partially exposed. Forming the upper part of the cañon-walls are 200 feet of the Upper Dakota sandstones; beneath these are some 700 feet of the Lower Dakota Group but partially exposed, and at the base are about 100 feet of white, pinkish, and red massive, cross-bedded sandstone. As we ascend Bear River these lower sandstones rise gradually until at the entrance of the La Plata branch, 11 miles above, they occupy the greater part of the cañon-walls.

Beyond this they rise more rapidly, and extend high up on the Carboniferous slopes of the San Juan Mountains, while the Cretaceous formations scarcely appear at all between the forks of the Bear. The extreme head of the northern branch of the Bear River is in the eastern end of the San Miguel Mountains, near the curious needle-like summit, called by Mr. Wilson "Lizard's Head," and within about three miles of San Miguel Lake. This is in the Cretaceous formations. Farther down, under the east base of the Bear River Mountains, it penetrates to the Carboniferous sandstones. This region was visited by Dr. Endlich in 1874. The La Plata branch rises in the trachytes and Cretaceous shales on the northern slopes of the La Plata Mountains, and also appears to penetrate to the Carboniferous sandstones. The walls of Lost Cañon contain nothing but Cretaceous rocks.

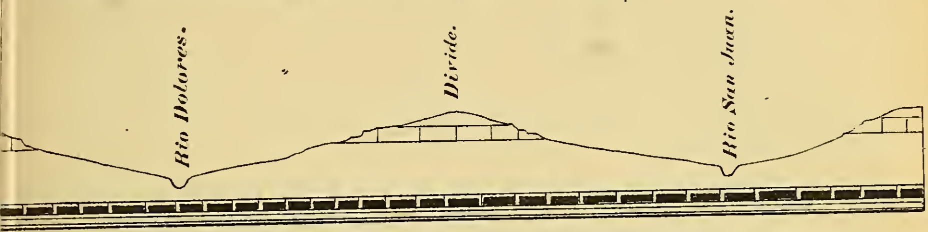
Below the great bend of the Dolores the river-bed sinks rapidly into the red series, but about fifteen miles farther down turns so much to the southwest that it cuts back again into the base of the Lower Dakota Group. On turning to the north again it sinks into a great cañon, which has as yet never been fully explored.

The Inter-Dolores region, called on our maps the Dolores Plateau, still retains a large area of the Middle Cretaceous shales, and a portion of the highest part, called Lone Mesa, retains a capping of the Upper Cretaceous sandstones. This mesa rises to 10,000 feet above the sea, and covers an area of not less than 40 square miles. It is separated from a similar fragment to the north by the cañon of Disappointment Creek. Here there are complete exposures of the Middle Cretaceous strata, and lower down there are exposures of the Dakota sandstones. South and west of Lone Mesa are a number of high conical and flat-topped buttes, from which the Upper Cretaceous sandstones have been removed. On the summits of these I observed numbers of rounded basaltic bowlders. The western and southern borders of the plateau are swept pretty clear of the shales. Forests of pine and fine meadows abound.

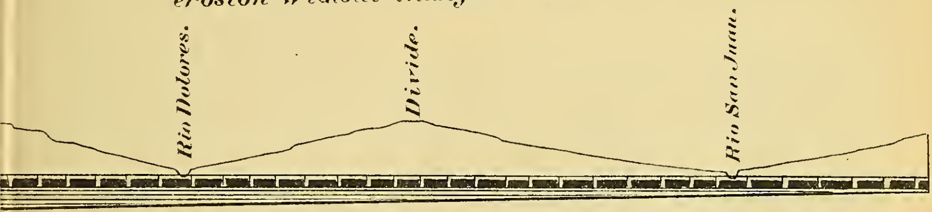
The cañon of the Dolores is, throughout the course, as far as examined by our party, very narrow and precipitous. The alluvial bottoms are seldom wide enough to admit of a trail, and only at the southern bend are there sufficient areas to admit of agriculture. Here there are some beautiful spots. Cottonwood-groves and many varieties of bushes and vines line the banks, and a rich growth of grass covers the alluvial flats. On the borders of the cañon below there is a pretty heavy growth of piñons, cedars, and pines; and above, on the various branches about the headwaters, there is a combination of forest and meadow, of pine



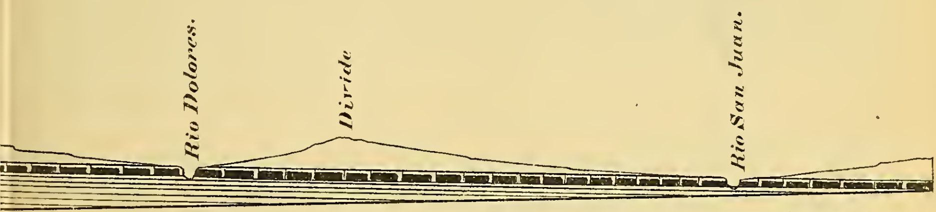
Probable character of surface when the Streams were laid out.



Showing symmetrical profile – the result of advanced erosion without change of level.



Unequal erosion produced by slight elevation to the north.



Section after long period of erosion, erosion on northern slopes retarded, on southern, accelerated.

Section as at present. Floor of hard rock swept clear of the frible shales. Divide on the south bank of the northern stream.

Sections showing the relations, past (?) and present of the San Juan and Dolores Valleys.

Plate XLIII.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

and aspen groves, and rich, grassy parks, that is lovely beyond comparison. It is a paradise within a day's walk of a desert, and its beauty is much enhanced by the contrast.

JURA-TRIAS AND CARBONIFEROUS ROCKS.

The areas occupied by Jura-Trias and Carboniferous rocks call for nothing more than a mere mention, as they are quite limited in extent, incomplete in exposures, and totally without fossil remains. In the La Plata Mountains there are exposures both of Red Beds and Carboniferous sandstones; but they are to a great extent metamorphosed beyond recognition. About the sources of Bear River there are also exposures of the rocks of these ages, but I was not enabled to examine them. In the Dolores Cañon, in the McElmo at the north base of Ute Peak, in the Montezuma Cañon, and on the Lower San Juan, there are slight exposures of the purple laminated beds and of the pink and red sandstones. On three sides of the Carriso Mountains there are outcrops of the Red Beds, but these are mostly beyond our district. From the summits of the Carriso Mountains I obtained a comprehensive view of the tract of country about the valleys of Gothic Creek and the Rio de Chelly; nothing but red and white sandstones appear. A white or slightly pinkish sandstone is in this section peculiar to the upper part of the heavy sandstones of the Jura-Trias.

A few miles west of Station 45, on the San Juan, there appears to be a fold crossing the river and extending toward the Abajo Mountains on the north, and far into Arizona on the south. A very noticeable feature of this fold is a long regular line of white and pink hogbacks, which can be seen from many points far to the east. Mr. William H. Jackson, on his way to the Moquis towns, passed down the San Juan, through the series of rocks brought up by this fold, and his descriptions, assisted by a number of characteristic photographs, make it almost certain that the entire series of Jura-Trias rocks are exposed, and very probably a portion of the Carboniferous. At the mouth of the De Chelly there are exposures of limestones; beyond this the strata again become approximately horizontal.

CHAPTER III.

METAMORPHIC AND ERUPTIVE AREAS.

LA PLATA MOUNTAINS.

In many respects this is a very remarkable group of mountains. Occupying an area not more than ten miles square, and being situated in the remote southwest, almost isolated from the great mountain-chains, it yet has a number of lofty summits which fall but little short of 14,000 feet elevation. A cluster of these, which lie just north of the head of the La Plata River, are among the most rugged and picturesque mountains in Colorado. The geologic conditions are interesting and peculiar, and the mines of silver and gold give promise of very considerable richness.

The La Plata River heads a little north of the center of the group, and occupies a great cañoned valley, which opens out to the south. On either side of this valley are two great wings or spurs, on which there are several high points. These spurs come together around the head of the valley and connect with the spire-like summits of the central mass. Extending northwest from the principal cluster of summits, between the two branches of the West Mancos, is a short, narrow, crested ridge, which terminates in the highest summit of the entire group. To this we have given the name Hesperus, on account of its being located farther west than any other high mountain in Colorado.

Of the central summits there are two sections—one that is in plain view from the valley of the La Plata below, and another a mile or more farther north. The latter has two fine crests; the one nearest Mount Hesperus seems quite inaccessible, and looks from the west like a great bundle of needles or splinters, so deeply scarred are its vertical sides and so sharp its thousand spires. I have named it Mount Moss, after the indomitable Capt. John Moss, of Parrott City.

From this peak one great spur extends to the north between the West Mancos and the south branch of Bear River, and another to the east, between the La Plata and South Bear. The latter ridge divides, and sends out one branch between the Bear and Animas, another extends to the east between Hermoso and Junction Creeks, and the third and main spur extends south, and forms the east wing, the La Plata Mountains.

In making out the general geologic features of Colorado, as illustrated in Plate XXXIV, I included the La Plata Mountains in the metamorphic belt, because the central portion of the group, as exposed by the deep-cut valley of the La Plata River, is highly metamorphic, and is composed principally of uplifted and altered sedimentary rocks. But there are associated with these to a very considerable extent eruptive rocks, and very great complication of structure is the result. In considering the metamorphic character of this group, I find that it is associated with the great metamorphic group, which lies to the northeast about the Animas, and seems to be a prolonged spur or offshoot of that mass, locally developed by causes which have operated only over a small area. These causes are not easily ascertained, unless we conclude that the intrusion and outflow of the great masses of trachyte would be sufficient to produce all local peculiarities.

Against attributing any great amount of change in the sedimentary rocks to the presence of the trachyte, is the fact that in the neighboring groups of mountains of trachytic origin there is little or no metamorphism apparent. At the same time there are examples all along the western border of metamorphism by contact with masses or sheets of trachyte, notably in the Elk Mountains. In the group under consideration, there are many localities where it is clearly evident that great changes have been produced. It is very probable, however, that the main part of the elevation of the sedimentary strata belongs to the period of the general elevation of the quartzite group to the east, and that the elevating influence of the trachytes is in no case of very great importance.

The metamorphic core as exposed by the deep-cut valleys would probably be included in a circle six or seven miles in diameter. In passing up the La Plata River from Parrott City, we find at the opening of the cañon, that is, where the river issues from the mountains, that the Lower Cretaceous sandstones dip away from the mountains at an angle of from 20° to 40°, and that these lie upon the red sandstones. We notice, however, that these beds have been considerably changed and are quite dark. A little farther up, the beds that were red below become gray, and soon lose in a great measure their bedded character, so that within a mile of the opening of the valley all appearance of structure is lost. High up toward the summit of the western ridge, however, where the trachytes have not obscured the outcrops, the bedded character, and even the color in places, are preserved. From Comstock Gulch to the mouth of Lewis Creek, a distance of five miles, approximately, there is not the slightest trace of bedded structure, and so complete has been the obliteration of all the sedimentary characters and so intricate is the net-work of mineral veins and porphyritic dikes, that an analysis of the geologic structure is out of the question. Having crossed this area, we again encounter the red sandstone, probably Carboniferous here, at first hardly recognizable, but farther on, near Basin Creek, recovering their original bedded character and color.

In the central part of the altered area the metamorphic mass probably extends up to and includes the Red Beds, but the higher portions are so obscured by trachytic outflows that nothing was determined. All along the western slopes of the mountains, as far as I examined, the trachytic rocks are associated with the Middle Cretaceous shales. On the eastern side, according to Dr. Endlich, they rest upon the Carboniferous. On the north and south, in a number of cases, they are in contact with the Lower Cretaceous and Jura-Trias rocks, but it is hard to say whether the masses which now cap the summits were poured out over the already eroded surfaces, or whether they have been intruded among the sedimentary rocks so that their present positions on the summit regions is the result of their tendency to retard erosion over the area where their bulk is greatest. Be this as it may, it is at least evident that the channels or vents by which the volcanic materials reached their present resting-places are within the La Plata Mountains themselves. To this the positions of the various outlying masses attest, as they increase in number and importance as we approach the main mountain mass. Also the dikes, such as were observed, seem to extend out into the surrounding rocks from the same mass.

In the vicinity of Mount Moss, a vast number of sheets and masses of trachyte have been forced into the yielding and nearly horizontal Cretaceous shales. The sheets in most cases follow approximately the planes of bedding. The heavier masses, which may in some cases be outflows from vertical dikes, are often thrust at greatly varying angles through the strata. On the Mancos, at the west base of Hesperus Peak, there is a heavy mass exposed, on the upper surfaces of which the shales lie—somewhat bent and distorted, but not greatly metamorphosed. South of this, and probably connected with it, is a great sloping mass of trachyte, the relations of which to the surrounding strata I could not make out, excepting that it rests in and on the shales. It probably connects more or less directly with the trachyte mass of the mountains. On the high spur which extends southwest between the East and West Mancos is a high, bald point, named Helmet Peak, capped with trachyte, which probably belongs to the same flow that caps the high ridge between the East Mancos and the La Plata, as it is on nearly the same level. The ridge that extends north from Mount Moss has a capping of trachyte which spreads out over a large area between the Mancos and South Bear River and rises occasionally into sharp buttes. The intrusion of sheets and wedges, however, is most strikingly illustrated in Mount Hesperus. Between timber-line and the summit there is an alternation of trachytic sheets with the shales, in such regular succession that, until closely examined, I imagined the whole to consist of the sandstones of the Upper Cretaceous. In the upper 1,500 feet there are twelve distinct layers of trachyte (see plate XLIV), some having a thickness of from 30 to 40 feet, others of not more than a few inches. Between these the shales, which ordinarily are soft, black, and friable, are reduced to a hard gray slate that weathers into angular fragments, and frequently into symmetrical slabs and blocks. In these the fossils are still preserved, but much crushed and often nearly obliterated.

Lower on the mountain-slope, ledges of trachyte occur at intervals, indicating that the entire mountain has been thoroughly penetrated by the intrusive matter. On the west slope, by way of which we approached the summit, a narrow shoulder occurs, produced by a mass of trachyte that seems to have been thrust up from beneath, probably as a dike, as the outcrop can be traced down the side of the mountain into the valley. The sheets which occur in the body of the mountain, however, evidently radiate from the region of the Mount Moss group, which is three-fourths of a mile to the east. From the sentinel gap at the head of Boren Gulch, I obtained a fair view of the south face of Hesperus or Banded Mountain, and could see plainly the interleaving of the trachyte with the shales. (Plate XLV, Fig. 1.) A succession of wedges of the former penetrate Mount Hesperus, while the included layers of shale extend into the west walls of Mount Moss. There is a sort of dovetailing produced that might be illustrated by setting together two combs so that the teeth should alternate. The ends of the shale layers are much distorted, and so highly metamorphosed where they approach the mass of trachyte that it is difficult to say how far they extend, but the sheets of trachyte in the shales are perfectly defined, contrasting with the shale both in color and style of weathering. The sketch I present is not as good as I would like, as the mountain was so enveloped in clouds that the details could not be thoroughly studied. The north side of the mountain presents the same phenomena, and a low mountain to the east, and immediately north of Mount Moss (*b*, Plate XLIV), has the same structure; indeed, the various sheets of trachyte here seen may be simply the con-

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Hesperus or Banded Mountain from the West.

Sheets of trachyte interbedded with Cretaceous shales.

a. Hesperus Mtn. *s. Shales* *b. North spur of Mt. Moss.*

c. Sentinel Rock. *t. Trachyte* *d. Contact of trachyte mass with sedrimentary beds.*

Plate XLIV.

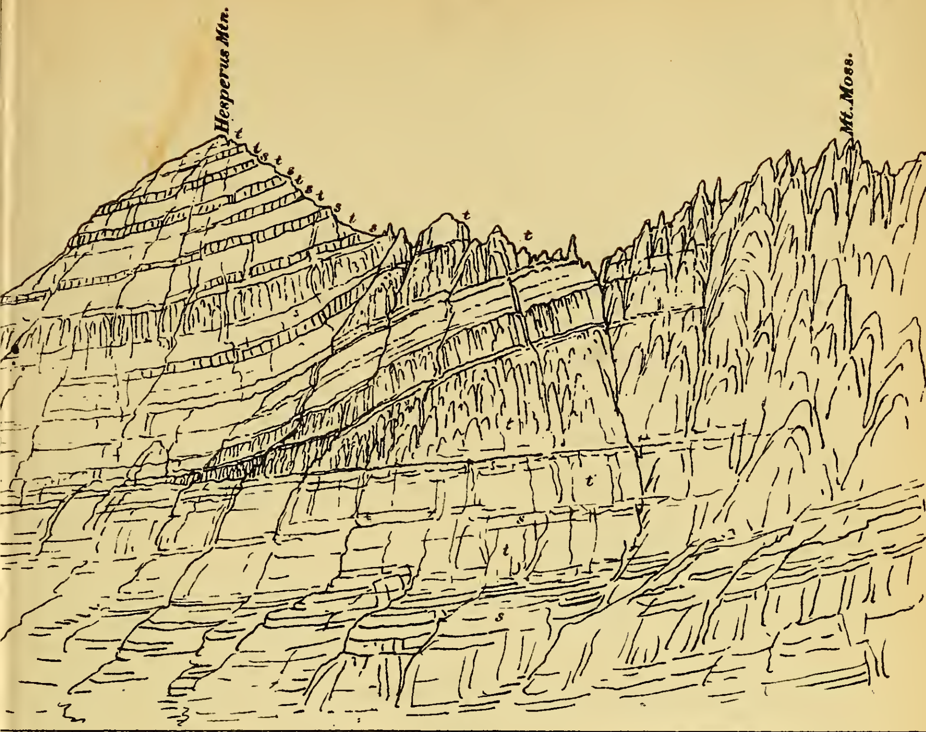


Fig. 1.

Hesperus Mountain from Sentinel Rock.

Showing wedges and sheets of trachyte intruded into the shales from Mt. Moss.

Plate XLV.

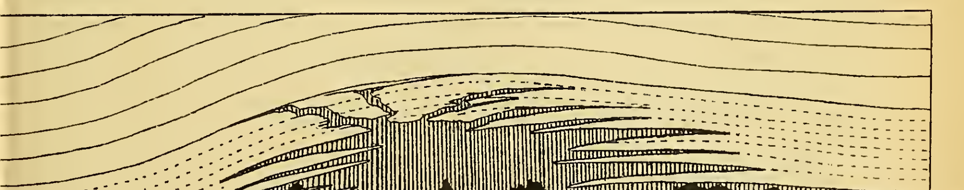


Fig. 2.

Ideal Section of the La Plata Mountains.

Showing the supposed method of intrusion of trachyte.

a.a. Is the present profile, which cuts Hesperus Mtn. and Mt. Moss.

tinuation of those in Hesperus. In many cases the interleaved sheets conform very closely to the planes of bedding, and it is difficult to imagine how a molten material should distribute itself with such nice regularity, but there are a number of examples of oblique intrusion, and in some cases a sheet of trachyte changes from one horizon to another by breaking through the strata in the manner illustrated in Fig. 2, Plate XLV. This extensive intrusion of sheets undoubtedly tends to arch the surrounding strata considerably. In Hesperus Mountain, for example, one-half of the entire thickness is of intruded rock, and it is hardly possible that metamorphism and pressure would be sufficient to reduce the thickness of the shales one-half. In Fig. 1, Plate XLV, a very fine example of the arching or elevating of strata by the intrusion of a wedge of trachyte is shown.

One of the best examples of metamorphism by contact with volcanic rocks found in these mountains is on the west face of the first mountain south from Hesperus (at *d*, Plate XLIV). A mass of sedimentary rocks, chiefly metamorphic shales, abuts directly against, or, perhaps, more properly, is welded to, the trachytic face of the mountain. The exact point of contact cannot be determined, as the metamorphism has been so complete that the shales seem to change gradually into trachyte. At the point where the bedded structure is last detected, the weathering and color are identical with the weathering and color of the trachyte. Farther out, they gradually assume the appearance of massive grayish-yellow quartzites, and a mile or more from the place of contact begin to assume their shaly character and dark color.

On the La Plata side of the ridge to which this mountain belongs, about the head of Boren Gulch, the trachytes of the summits are in contact with Jura-Trias rocks, which still partially retain their character and color. The metalliferous veins here seem to pass indifferently through both metamorphic and volcanic rocks. Farther eastward, beyond the Mountain Moss group, on the Animas side of the mountains, the red sandstones reach nearly to the summits of the mountains, the capping in all cases being of trachyte. The typical trachyte is gray in color, moderately fine-grained and exceedingly compact. It is composed of a light gray crystalline paste which contains very numerous crystals of white oligoclase. There are also acicular crystals of hornblende distributed throughout the mass. These characters become less strongly marked as we approach the outer borders of the mass, and the rock gradually becomes a crystalline aggregate, next a highly metamorphosed slate, and finally an unchanged shale.

The metamorphic core of the mountains, where exposed by the cutting of the valley of the La Plata, is penetrated by a great number of mineral veins, many of which carry silver and gold. So far as I could ascertain they are not arranged according to any system, but seem to have been formed in the irregular faults and crevices produced during the period of uplifting and intrusion. In a number of cases they were found to extend beyond the metamorphic into the easily recognizable sedimentary rocks. In the scoring out of the valley by the river, assisted probably by glaciers, the mineral-bearing rocks have been exposed, worn down, and carried out and distributed over the low country. The bars of loose gravel near the mouth of the valley contain considerable quantities of gold. A portion of the principal bar has been occupied and to a limited extent worked by Captain Moss and his associates. The water-supply is insufficient at present to carry on extensive work, but a large ditch is being constructed which, when finished, will afford better means for carrying on mining operations.

Until the summer of 1875 but little was done toward the exploration of the localities from which the ore-bearing gravel came. During that summer many hundreds of claims were located on lodes both of gold and silver, and since then considerable work has been done. But little however is known, up to the time of this writing, of the value of more than a very few of the lodes. The Comstock, which occurs near the foot of the valley on the very border of the metamorphic area, shows some very fine silver ore.

Accompanied by Dr. Peale I visited as many of the located lodes as my time would permit, and made such observations as were possible in their unworked state. The observations were necessarily fragmentary, and speculations as to the character and richness of lodes based upon such meager facts would be manifestly useless. The small extent of the mineral-bearing district may seem to indicate that it cannot prove very rich, but a number of the lodes show considerable persistency, having been traced many thousands of feet. These show fair prospects throughout. A number of lodes are extremely wide and show but little ore. In some cases a number of veins run side by side. A town has been built, and it is hoped that increased facilities may enable the sluicing to go on with good profit. The locality is one of the most enchanting in Colorado, and although at too great an altitude to admit of agricultural pursuits, it is within easy reach of the rich agricultural valleys of the Animas and Mancos Rivers. It is accessible to wagons by way of Tierra Amarilla only, and hence labors in this respect under considerable disadvantage. The settlement is surrounded by a fine grass country, at least for summer range. The mountains abound in good timber, and there is an inexhaustible wealth of coal on all sides.

SIERRA EL LATE.

Twenty-five miles southwest of the La Plata Mountains, and just beyond the western border of the Mesa Verde, is the small eruptive group known as Sierra el Late. It is in the extreme southwest corner of Colorado and totally isolated from other highlands. (See Panorama, plate XXXVI.) The area occupied by this group is not more than 40 square miles and the highest summits do not reach 10,000 feet. Viewed from all sides it appears to be a cluster of rounded, and, for the most part, gently-sloping hills, from which rise two or three steeper cone-shaped points. At the southern end is a double-topped mountain 9,000 feet in height, to which we have given the name Hermano Peaks. At the northern extremity is a steep symmetrical cone that rises to 9,900 feet. This is known by the La Plata miners as Ute Peak. It is the highest point within 25 miles, and from all parts of the San Juan basin is a prominent landmark. The entire group is pretty well covered with vegetation; considerable forests of piñons occupy the lower and middle slopes, and clusters of spruces occur about the summits. Grass is found in favorable localities about the bases, but sage and bad lands occupy most of the lowland. Water is found in many of the gulches throughout the summer season.

The bulk of the mountain mass is composed of trachyte, of which there are a number of varieties. Ordinarily it is composed of a dark-gray micro-crystalline, feldspathic paste, with many acicular crystals of hornblende and a little sanidite, porphyritically imbedded. All the specimens collected were found to contain considerable magnetite. A specimen collected near the summit of Hermano Peaks, differs considerably from this. It is composed of bluish-gray paste with large crystals of oligo-

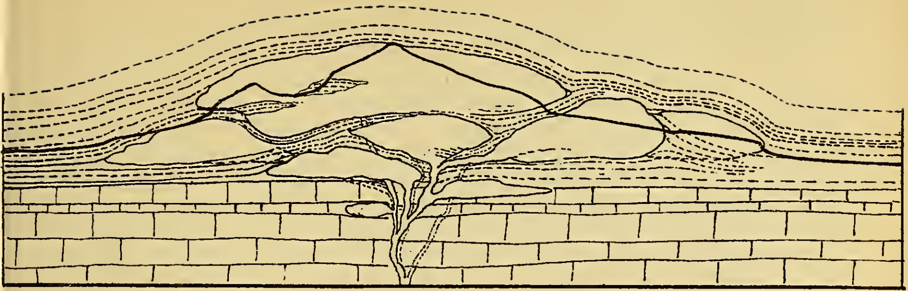


Fig. 1

Section showing probable method of intrusion of masses of trachyte.

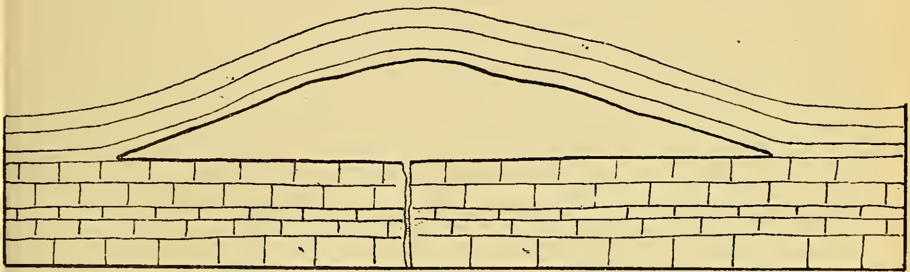


Fig. 2.

Arching of strata produced by intrusion of single mass uniformly destributed.

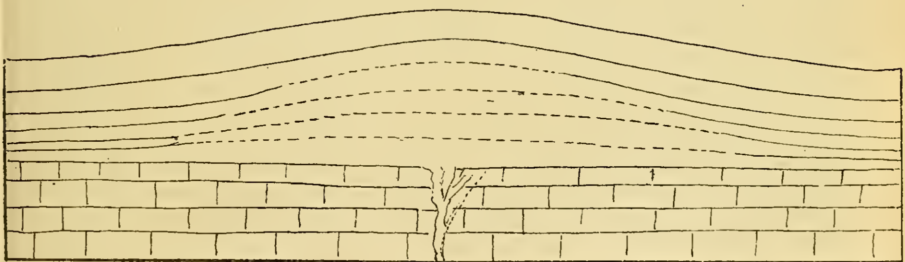


Fig. 3.

Degree of arching really produced by the irregular intrusions.

Intrusion of masses of Trachyte.
Sierra el Late.

Plate XLVI.

clase; crystals of sanidite are very minute and rare; small crystals of quartz are scattered through the mass. Next in frequency to the oligoclase is a green mineral—probably some variety of amphibole. Bits of metamorphosed rock are found in many of the specimens.

When viewed more critically, this mountain group does not seem closely compacted, as if formed of a single mass of trachyte, but rather as if formed of a number of distinct bodies that had reached their present horizon through closely associated vents. That the various masses of trachyte came from sources located directly beneath is evident from the fact that the sedimentary rock are frequently bent up at a high angle around the borders. The upturned strata include the lower part of the Middle Cretaceous shales and portions of the Dakota sandstones.

It is a fact worthy of notice that in all parts of the trachytic mass there are fragments of the Cretaceous shales which have been caught up in the rising mass and distorted and methamorphosed, but that no other rock appears similiarly situated. This fact would seem to have an interesting bearing upon the question of the manner in which the volcanic matter reached the position now occupied by it. It does not seem possible that any considerable bulk of pasty or even fluid matter could rise through the sedimentary crust without carrying up quantities of fragments. The absence of all fragments excepting of the shales goes to prove that the ascent of the molten material up to the base of the shales has been through narrow, firm-walled crevices, and that the lateral spreading and consequent stoppage of the great bulk took place when the horizon of the yielding shales was reached. So far as my observations go, the trachyte does not seem to have been deposited as a single compact mass, as though on reaching the shale horizon it had opened for itself a great cavity, with the firm sandstones as a base, and an unbroken arch or dome of the entire series of superincumbent strata above, but rather as though it had broken irregularly into the yielding shales, pushing them back upon themselves, penetrating them first in one direction and then in another, with a sort of irregular radiation of masses from the mouths of the vents—not at once, perhaps, but with a rapidity depending upon the size of the vents and the character of the forces beneath. By such a method of intrusion numerous masses of the shales would be surrounded and held suspended in the mass of plastic material, or sandwiched between masses proceeding from distinct flows. In no case did I notice any symmetrical arching of strata over the trachytes, but my observations all tend to show that there has been a sort of absorption, so to speak, of the shales, and that at least half of the space through which the trachyte is distributed is occupied by the crushed and metamorphosed fragments of shale. As a consequence, the height of the arch—such as may once have existed—would not be equal to the height of the trachytic mass, as only the higher layers of shale extend entirely over it, the lower layers having been absorbed by it and really forming a part of it. The three figures given in Plate XLVI will assist in making my meaning clearer.

Figure 1 illustrates the manner in which the molten matter seems to have been intruded among the shales. If the entire mass had at once been intruded between the strata at a given horizon arching those above, the result would probably be as represented in Figure 2. Figure 3 will illustrate the combined arching and absorption as ordinarily exhibited in this group. On the north side of Ute Peak a large vertical dike cuts through the Jura-Trias and Lower Cretaceous sandstones, and connects, apparently, with the trachytic mass of a northwest spur. (See Plate XLVII.) On the north face of Ute Peak there is a heavy horizontal bed of trachyte that falls off in rounded bluffs. It seems to be interbedded between the Dakota sandstones and the Middle Cretaceous shales, and rests upon the upper surface of the former.

SIERRA CARRISO.

In the extreme southwestern corner of our district and chiefly in Arizona is the interesting group of mountains known as the Sierra Carriso. Its structure is somewhat more clearly defined than that of the Late group, as the intruded trachytes occur in larger and more compact masses and the surrounding sedimentary rocks are but slightly disturbed. It is a typical example of the eruptive groups of this part of the Colorado Plateau. It stands alone, an island in the midst of a sedimentary sea. It has a nucleus of its own, and so far as the surface is concerned is independent of all other eruptive masses. The masses of trachyte were not poured out over the surface of the country but lodged between the sedimentary strata, producing a more or less symmetrical doming of those beds that were not penetrated. Beyond the immediate vicinity of the trachytic masses the strata remain comparatively undisturbed.

The trachytes are now found chiefly in contact with the Lower Cretaceous and Jura-Trias rocks, for the reason that the Middle Cretaceous shales, in which a large part of the trachytes were originally deposited, have been completely carried away, leaving only small fragments imbedded in the faces and upper surfaces of the trachyte. The opportunities for study are unusually fine, but my time was very limited, and I will not attempt a closely detailed analysis of the group. The trachytes occupy an area of nearly 100 square miles. The higher points rise to an altitude of about 9,000 feet above sea-level, and some 2,000 feet above the general level of the country. The northeast, north, and north west faces are drained by the San Juan and its tributaries, including Red Creek, Navajo Creek, Arido Creek, Gothic Creek, and the Rio De Chelly. In appearance it is a rather striking group, and rises in the eastern and central portions into a number of rugged irregular ridges and peaks, but on the north and west is bordered by remnants of a high table land. (See sketch, Plate XLVIII.) There is nearly everywhere a sparse growth of piñons and pines. Good pasturage is found about the bases as well as on the interior highlands. Water is unusually scarce. We observed no living streams, but there are a number of good springs along the north and east bases.

In the central part of the group is a high summit to which we have given the name Pastora Peak (c, Plate XLVIII), from the fact that it overlooks the highland meadows in which the Navajo shepherds keep their sheep. This peak is composed of a brownish-gray trachyte, and in common with a number of other high points belongs to the main central trachytic mass of the mountains. Distinct from this mass and lying along the northern and western flanks are two high table-lands (a and b), capped with massive sheets of trachyte. It will be seen by reference to the sketch that these masses of trachyte rest upon a heavy series of sandstones, and do not connect with the central trachytic mass in any way, but are separated from it by the series of sandstones. The remarkable feature is that portions of the sandstones are apparently arched over the central trachytic mass, as may be seen at g in the sketch, and that the massive sheets of trachyte that cap the two mesas are also flexed with the sandstones and appear as if they might at one time have formed part of the arch. Unfortu-

Ute Mountain from the Mc. Elmo Cañon.

a. Trachyte. *c. Fragments of Cretaceous Shales.*
b. Vertical Dike. *d. Lower Cretaceous Sandstones.*

AM. PHOTO-LITHO CO. N.Y. (OSBORNE'S PROCESS)

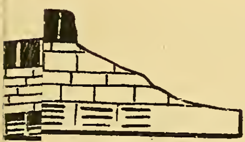
Plate XLVII.

rachyte.

"

Catrata between

rachyte.



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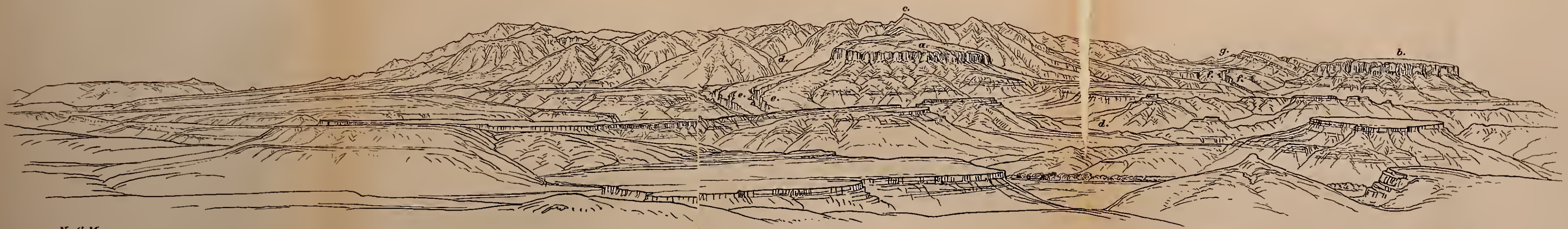


a. North Mesa.
b. West Mesa.
c. Pastora Peak.
d. Navajo Creek.

Fig. 1.

The Carriso Mountains from the North.

e. Cañons cut in trachyte.
f. " " " "
g. Cretaceous Strata between beds of trachyte.

Plate XLVIII.

Fig. 2.

Section in Cañon of Navajo Creek.

Fig. 3.

Section through North Mesa.

Fig. 4.

Section through West Mesa.

AM. PHOTO-LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS)

nately my observations could not be carried to the southern and southeastern slopes of the mountains, and it is impossible to say whether the arch has been continuous and symmetrical or not. On the north these two remnants seem to be all that is left of the outer sheet, unless a small fragment of trachyte observed resting on a southwestern space may belong to the same. It does not appear to me that the beds of sandstones that occur in the arch between the inner mass and the flexed sheets are of uniform thickness. Between the capping of the North Mesa and the inner mass the sandstones are nearly pinched out. They are so obscured by *débris* that I could not determine their precise relations. On the east side of the North Mesa the bed of Navajo Creek has cut down through the sandstones and exposed in the walls of three or four deep, sharp cañons (*e*, *e*) a large body of trachyte, which would seem to belong to the mass which in the center of the group rises into the high summits east of Navajo Creek. West of the North Mesa this lower mass of trachyte is exposed in the cañons of the west branches of Navajo Creek, (*ff*), and is very evidently connected with the central mass.

East of North Mesa, in the faces of the deep valley of Navajo Creek, there is a heavy stratum of red sandstones, interbedded with the trachytes and dipping away from the interior mass at a high angle. The red sandstones appear also in a number of places in the midst of the higher summit regions of the eastern part of the group, interbeded with sheets of trachyte. In figure 2, plate XLVIII, I give the section exposed on the east side of the upper valley of Navajo Creek. The conditions here suggest the idea that possibly the trachyte exposed at *e*, *e*, *f*, *f*, on the east and west flanks of North Mesa, may also be the upper surface of a sheet which domes over the Postora group, and in turn is succeeded by layers of red sandstone.

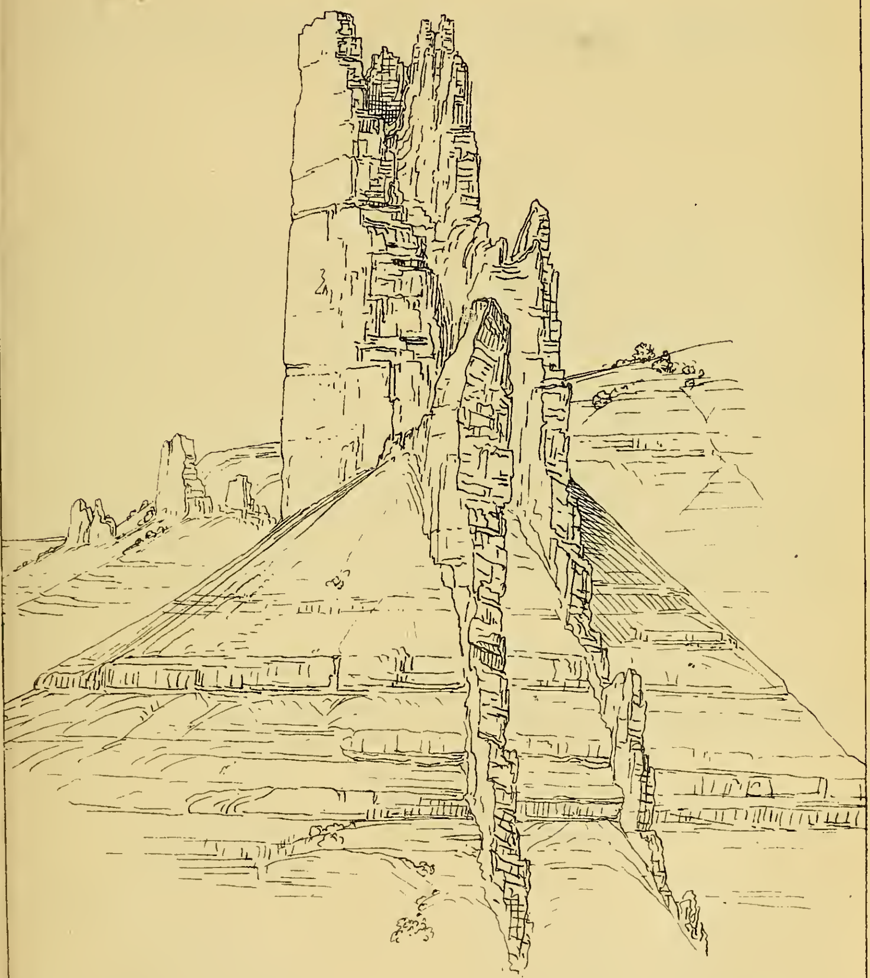
In East Navajo Creek a third bed of trachyte appears, followed by a second stratum of red sandstones. This suggests the possibility of a sort of dome within dome structure, such as would be produced by the uplifting of a series of beds in which there had been horizontal intrusions of trachytic sheets, or even by the intrusion of such sheets into a series of already uplifted sedimentary strata.

I am not inclined to think, however, that the movements of the volcanic matter have been systematic or the results highly uniform, as accidental causes—such as unevenly yielding strata, diversity of dips, and presence of previously deposited volcanic matter—must often greatly influence if not totally govern the direction of the flows, the thickness of the sheets, &c. At the same time there doubtless are laws that in general govern the movements of the volcanic products and tend to produce uniform results, but I shall not attempt their discussion here.

A specimen of trachyte from West Mesa is found to resemble closely in appearance and composition the trachyte of other groups of the southwest. It has a bluish white paste, which contains the following minerals porphyritically imbedded: fine crystals of translucent oligoclase, minute crystals of sanidite, frequently directly associated with the oligoclase, small crystals of biotite (rare), and a few small inclosures of quartz.

In Plate XLIX, I present a sketch of a remarkable dike that occurs on the eastern branch of Navajo Creek at its exit from the mountains. It rises vertically through the horizontal sandstones of the Lower Dakota group. It is over a mile in length, is quite straight, and has a north and south strike. A very remarkable feature of this dike is that it is in places double. Two parallel walls of trachyte (?) rise through the strata, leaving the sandstones to the right and left and between the walls in their undisturbed horizontal position. The sandstones where in contact with the dike-rock seem to be somewhat metamorphosed. On the outer faces of the walls, which are in places from 30 to 40 feet high, are the impressions of strata which have long since been carried away. A specimen collected from one of the walls near the creek-bed consists of a dark grayish-green paste, with numerous small crystals of brownish mica, which are sometimes collected in small round or oval masses. A specimen very similar in appearance to this was collected from a little conical butte between the San Juan River and the Mesa Verde, about 10 miles west of the Great Hogback. It has an olive-green micro-crystalline paste, that contains indistinct crystals of some triclinic feldspar, and exceedingly numerous crystals of brown mica (biotite?) dispersed throughout the entire mass. The rock is evidently an intruded one, analogous, perhaps, to dolerite, which, however, has taken up quartz, various silicates, and lime from the strata through which it passed.

There still remain undescribed two volcanic groups, the Sierra San Miguel and the Sierra Abajo, but as the former was not thoroughly studied in 1875, and the latter not even visited until 1876, I prefer to leave them both to be treated in the report for 1876, which will shortly be published.



Double Dike on Navajo Creek.

Plate XLIX.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

GEOLOGICAL REPORT OF B. F. MUDGE.

NOTES ON THE TERTIARY AND CRETACEOUS PERIODS OF KANSAS.*

PRELIMINARY NOTE.

The State of Kansas is about 400 miles long from east to west and about 200 miles (three degrees) in width from north to south. Its average altitude above the level of the sea, by the List of Elevations by H. Gannett, United States Geological Survey, Miscellaneous Publications No. 2, is not far from 1,780 feet. The lowest point is at the junction of the Kansas and Missouri Rivers, and is 750 feet. The highest is in Cheyenne County, about 4,000 feet. The altitude of Monotony station of the Kansas Pacific Railway, on the west line of the State, is 3,792 feet. The Atchison, Topeka and Santa Fé Railway station at Syracuse, Arkansas Valley, also near the west line, is 3,425 feet.

By inspection of the map of the State, it will be seen that the rivers drain the country in a southerly and easterly direction. As there is not a waterfall on any of the streams 7 feet in height, the descent is gradual, averaging 7½ feet to the mile. The State is so well drained, that there are very few valleys with stagnant ponds, and there is not a peat-swamp of fifty acres within its boundaries.†

I.—STRATIGRAPHICAL GEOLOGY.

A general vertical section of all the formations seen in Kansas would be in descending series as follows:

I.—Quaternary system:

- Alluvium.
- Bottom prairie.
- Bluff or loess.
- Drift.

II.—Tertiary system:

- Pliocene.

III.—Cretaceous system:

- Niobrara.
- Dakota.

[* Reprinted, with much additional matter, from the Bulletin of the Survey, Vol. ii, No. 3, pp. 211-221. June 5, 1876.—Ed.]

† There has been no State geologist during the past ten years, and the information embodied in this sketch was nearly all obtained while engaged in other duties. In relation to the classification of fossils, I have consulted the works of Lesquereux, Meek, Marsh, and Cope.

IV.—Carboniferous system:

Permian.
Upper Carboniferous.
Coal-Measures.
Lower Carboniferous.*

In this paper we propose to describe only the Tertiary and Cretaceous deposits, as they are a part of the formations first described in the reports of the United States Geological Survey under Dr. F. V. Hayden. It will be seen by inspection of the map that they occupy the western two-thirds of the State. The outlines of the formations cannot be given in detail where the scale is so small. But one feature must be kept in mind. It is this: The dip of the strata in all parts of the State is so slight, averaging about 5 feet to the mile, that, as you travel to the northwest, the more modern strata, or deposits, are always seen first on the tops of the hills, and gradually descend into the lower grounds, and disappear under the still more recent deposits. Thus, on the border of the Pliocene Tertiary and Cretaceous there is a belt about 20 miles in common, where the former occupies the higher and the latter the lower portions of the country. In this way the Tertiary covers about 9,000 square miles of Kansas, consisting of 6,000 covering the entire northwest part of the State and 3,000 interspersed with the Cretaceous along its southeastern boundary. This interlocking of the two systems is best seen on the North Fork of the Soloman in Phillips and Norton Counties. At first the whole valley, excepting the tops of the highest hills, is Cretaceous; but in ascending westerly the Pliocene expands, from toward the river, gradually covering the Cretaceous and narrowing its outcrop, till near Spring City, in Norton County, the latter formation is seen in the lowest ravines, near the river, and soon entirely disappears, and the Pliocene covers the entire country. So gradual is the disappearance of the Cretaceous in this valley, that it requires over 40 miles to accomplish the change thus described, where no hill is more than 300 feet above the river. It should be noted that the river runs about half way between the dip and strike of the formations.

The Cretaceous holds its buff, chalky character to the last, and as the Tertiary is siliceous, the physical features as well as the fossils of both formations are in strong contrast.

The same features of the disappearance of the Cretaceous under the Tertiary is seen on the branches of the Smoky Hill River, and less strikingly on the Saline, in Trego County.

II.—TERTIARY SYSTEM.

Pliocene.

This geological area has been but little examined, and consequently our knowledge of its local features is quite limited. Professors Cope and Marsh have both, in their visits to the Cretaceous, made some casual notices of the southern portion, without spending time in searching for its fossils.

During the summers of 1874, 1875, and 1876 we spent much time along the line of its union with the Niobrara, and thus became acquainted with its outlines and a few of its fossils. The line of demarkation, at most points, is very clear and well defined. In numerous places we have found the fossil bones of the Mammalia of the Pliocene within 10 vertical feet of the marine shells and vertebrates of the Cretaceous;

* The Lower Carboniferous is but slightly represented in Kansas, and the line between it and the Coal-Measures is obscure.

and in slides we frequently found them intermingled. The contrast was remarkable, as hardly a single type was common to both.

The material of the Pliocene deposits consists of sandstone of various shades of gray and brown, occasionally whitened by a small admixture of lime. The lower strata are usually composed of finer sand than the upper, and much more loose and friable in their texture. The overlying beds are of coarser ingredients, consisting of water-worn pebbles of metamorphic rocks—quartz, greenstone, granite, syenite, and sometimes fragments of fossil wood from an older formation. These portions of the deposit when crumbled and the finer parts washed away, have much the appearance of drift, and have been mistaken for it. This formation, down to a recent period, must have covered the whole of the Cretaceous, as we find the coarser pebbles scattered, to a greater or less extent, over the western half of the State. It must have been subject to later movements of water-currents, as it assumes the form of altered drift, and sometimes includes remains of the mastodon and elephant, of the later Quaternary age.

The sandstone is usually friable, crumbling on exposure to the atmosphere. When more compact, its mechanical construction is so irregular as to render it almost entirely unfit for a building-material. When firmly consolidated, it forms the hill-tops of the table-like eminences along the line of the boundary of the Pliocene and Cretaceous formations.

At Breadbowl Mound, Phillips County, it is about 200 feet above Deer Creek, and at Sugarloaf Mound, in the western part of Rooks County, it is about 300 feet above the Solomon River. In these hills, as in many others, the upper strata belong to the Pliocene, while the bases are of the Niobrara. Farther west it forms the whole of the visible outcrop, and the mounds are not so prominent.

On Prairie Dog Creek, in Norton County, it is 400 feet in thickness, and in the extreme northwestern part of the State we have reason to believe it is still thicker. The various strata are not clearly defined or regular in line of deposit, and the continued thickness cannot be easily discovered. The formation, like all others in the State, appears to dip slightly to the northwest. It is conformably, or nearly so, upon the Cretaceous.

In the southern portion of the Pliocene, in the vicinity of Fort Wallace and Sheridan, the hill-tops are covered with a stratum about 8 feet in thickness, very hard and siliceous. The material varies from coarse flint-quartz to chalcedony. The latter mineral shades from milk-white to transparent, sometimes presenting a semi-opal appearance. The so-called moss agate is found in the upper few inches of the stratum. This cap rock is interesting to the mineralogist by showing the moss agate in its various stages of formation. The lower portion of the 8 feet indicates an imperfect chemical solution of the silica and black oxide of manganese, therefore the crystallization of the latter is imperfect. As we examine the stratum from the bottom to the top, we find the chemical conditions more favorable and complete, so that the distinct quartz, chalcedony, and manganese of the bottom become more commingled toward the upper inch or half inch, where the silica must have been sufficiently fluid to allow the manganese* to assume the form of sprig crystals. This peculiar deposit is common on all the high hill-tops of Wallace County, but the best locality is the cap-rock of the two buttes, two miles southwest of Sheridan, and half a mile from the line of the Kansas Pacific Railway. They form a notable landmark to travelers.

*On a chemical test by Prof. W. K. Kedzie, some iron was found with the manganese.

Over a considerable portion of the Pliocene no fossils are to be seen; but at other points they are somewhat abundant. They are of modern type, represented by bones of deer, beaver, a large animal of the ox kind, two species of the horse, less in size than small Indian ponies, a wolf, ivory from the elephant or mastodon, bones of the rhinoceros and camel, and also remains of undetermined character. In addition to these mammalia, we find the bones and carapace of a large fresh-water turtle 5 feet in length, beside several species of a smaller size. Also a few species of Mollusca of fresh and brackish-water types.

All the bones are firmly fossilized, and many of them changed to a hard, compact silica. The most interesting of these is the ivory. In the process of petrifaction, the tusk must have been so softened as to admit the intermixture of black oxide of manganese in solution, which then crystallized in delicate sprigs. The ivory was next silicified into nearly pure quartz, with the usual hardness of that substance. Thus we have the ivory converted into the so-called moss agate. Some fragments could not be detected, by the ordinary observer, from the usual specimens of that gem.

This ivory is found in fragments in the extreme upper portion of the deposit, and we were at first inclined to call it Post-Tertiary; but the peculiar fossilization, similar to some of the other bones, induces me to think that it belongs to the close of the Pliocene.

The remains of the horse are apparently the most common, the teeth and jaws being found from Smith County to the vicinity of Ellis, in Ellis County. One is a species of the celebrated three-toed horse having three hoofs coming to the ground. In the northern part of Ellis County, our party, in 1875, found the feet, with the three toes in excellent preservation. In most cases the bones are badly broken, and much of the skeleton missing. The mastodon bones were rather frequent. My attention was recently called to the fragment of one, on the farm of Mr. S. Decker, near Spring City, Norton County, where it was associated with the vertebrates above named and several species of brackish-water shells. On searching the outcrops within half a mile I found the fragments of three other individuals, represented by ribs, vertebra, teeth, and tusks. All these were geologically in the lowest part of the Pliocene, and within 40 vertical feet of the Cretaceous limestone. In Trego County, in the Saline Valley, I obtained a few bones from two other mastodons, in the same geological horizon, and within less than 20 feet of the Cretaceous. These were all so low that, if it should be proved that there is any Miocene in Kansas, they must be credited to that epoch.

All the six specimens were so fragmentary that it was difficult to decide the species. But one femur was nearly entire and was strongly like *Mastodon giganteus*. Had I found it in the alluvium, I should have had no hesitancy in assigning it to that species. Its great age, however, induces us to expect it to be of a different species. These bones were fossilized with lime and consequently not nearly as hard as those of the later portion of the Pliocene, near the moss-agate beds.

A full and careful examination of the Pliocene of Kansas will undoubtedly furnish some valuable fossils, illustrating the mammalia of the period, and give to science some new species.

The Eocene and Miocene have not yet been discovered in Kansas, unless the specimen of the three-toed horse, found in Ellis County, should prove to be the *Anchitherium* of the Miocene. It was imbedded in the lowest part of the deposit, within 10 feet of the Niobrara limestone. Further examination of this formation is desirable.

III.—CRETACEOUS SYSTEM.

1.—NIOBRARA.

2.—DAKOTA.

The Cretaceous in Kansas covers an area of over 40,000 square miles, or more than half of the surface of the State. The Pierre and Fox Hill groups of Hayden, and all equivalents of those periods, are entirely wanting. The Benton group also appears to be absent. The Cretaceous is, therefore, represented in Kansas by the Niobrara and Dakota only. The line of demarkation between the Pliocene and Cretaceous, though presenting a very irregular line, is well defined and sharp. Adjoining the Permian easterly, it is not so clear; yet some recent examinations, made in company with Prof. O. St. John, show that the boundary is not difficult to trace. We have never been able to find any fossils of the Jurassic or Triassic, the beds of the Cretaceous resting conformably or nearly so on the Permian.

That portion south of the Arkansas River has been little examined, either by myself or others, but appears to be represented by the Fort Hays and Dakota groups.

1.—NIOBRARA.

a.—Niobrara.

b.—Fort Hays.

The Niobrara of Hayden, or its equivalents in time, is well represented. It is divided into two clearly-defined portions, by a massive bed of limestone or yellow chalk, which, when fully exposed, where it has not suffered from abrasion, is 60 feet in thickness. It is seen in the valley of the Smoky, southwest of Fort Hays, as well as seven miles west of that place, and at various points to the northeast, crossing the Solomon just above the Forks, near Osborne City, and entering Nebraska in Republican Valley, near where that river crosses the State line. It is composed of layers of yellow chalky limestone, from 1 to 3 feet in thickness. It makes an excellent building-material, working easily, yet sufficiently compact to be used for stores or dwellings. At Hays, the school-house and court-house are built from it; and 10 miles west of that place the Kansas Pacific Railway has opened a quarry for supplying stone for use along its line. It also burns to a good quicklime. The massiveness and persistence of this stratum make it a well-defined geological horizon. Below this line, as well as in it, vertebrate fossils are few, while above it they are numerous and of varied type. Its fossils are *Inocerami*, fragments of *Haploscapha*, *Ostrea*, with occasional remains of fish and Saurians. The vertebrates are always so rare that we never wasted our time in hunting them in this stratum; still our largest Saurian, *Brimosaurus* of Leidy, was found in it, in Jewell County.

a.—Niobrara proper.

The Niobrara in Kansas differs from the same deposit in Southern Nebraska and on Niobrara River. This difference is seen in the physical features, but more particularly in the fossils. In Kansas it has more of the composition of clear chalky deposit. In its fossils, it gives us a richer and more varied type of vertebrates. Thus far no Pterodactyls have been found north of the Kansas line. In Saurian genera, the Nebraska deposits have given less in quantity and also less in generic and specific varieties than Kansas. This difference begins before we reach the State line, as we did not find a single Pterodactyl bone, and very few of Saurian, within 20 miles of the Nebraska boundary.

The upper portion, which we shall call Niobrara proper, or simply Niobrara, is very unlike the lower, which shades imperceptibly into deposits like the Benton. The two divisions differ in a very marked degree both in the character of the fossils and in physical appearance. This Niobrara occupies a belt of the country next adjoining the Pliocene, about 30 miles in width in the northern part of the State, but gradually widening to more than twice that extent in the Smoky Hill Valley. It is well defined in the tributaries of this river nearly to the high divide between it and the Arkansas Valley. It is but poorly represented on Walnut and Pawnee Creeks, in Ness and Hodgeman Counties; and on the slopes toward the Arkansas River it is seldom seen, and then almost devoid of its characteristic fossils. It also loses most of its physical and fossiliferous features before it enters Colorado, west and south of Fort Wallace, and soon after entering that State it entirely disappears. It is composed of chalk and chalky shales. The former is of various shades of color from buff to pure white, and is seldom sufficiently hard to be used as a building-material. Some of the buildings at Fort Wallace were constructed of it, but did not prove substantial. The whiter portions are almost pure carbonate of lime, and cannot be distinguished from the best specimens of foreign chalk. Professor Dana, in the last edition of his Manual of Geology, p. 455, says there is no chalk in North America except in Western Kansas.

G. E. Patrick, professor of chemistry in the Kansas University, has published, in the Transactions of the Kansas Academy of Science, an article on this chalk, from which we extract the following remarks, with his analyses:

Examined under the microscope, it appears perfectly amorphous—a simple aggregation of shapeless particles. The Rhizopod shells, which almost universally occur in the chalk of the Old World, sometimes comprising nearly its entire substance, seem to be quite wanting in our Kansas chalk. With a good microscope, and a high power, I have been unable to detect a trace of them.

The amount of impurity varies, of course, in different samples of the chalk, but in no specimens that I have seen does this amount exceed 15 or 16 per cent. Two samples yielded, upon analysis, the figures given below. No. 1 was a fine specimen of snowy whiteness; No. 2 had a little yellowish tinge, and was as poor a sample as I could select.

	No. 1.	No. 2.
Moisture	.34	.58
Insoluble in acids (silica, lime, and alumina)	.69	11.40
Alumina (little oxide of iron)	.43	.97
Ferrous carbonate	.14	2.83
Calcium carbonate	98.47	84.19
	100.07	99.97

This chalk is found at various strata, in thickness varying from 1 to 8 feet. It differs in purity and other features, in the same stratum, in different localities. Unlike the European chalk, it never contains flint nodules.

The higher strata were the most impure, being intermingled with sand and other coarse ingredients. Sometimes we found thin layers of flint, from half an inch to two inches in thickness. Occasionally these layers were, in part, covered with a thin coating of chalcedony.

The later strata have been deposited not far from a shore-line, sub ject to currents. Sometimes may be seen marked oblique deposits, but very limited in extent either vertically or horizontally. These were always varied in color and material. Layers of white chalk, with impure ones of various shades of buff, extended to a thickness of 6 to 10 feet, and gave a neat, ribboned appearance. These layers were usually from one-fourth to one-half an inch in thickness, but frequently much thinner. In one instance I counted thirty-five in a thickness of little less than two inches, the white lines being nearly pure chalk, and the buff containing some fine sand. The fineness of material and the distinctness of each line indicate a slow deposit at a distance from the shores of the old Cretaceous lands.

The shales of this division contain lime mingled with clay and sand in varying proportions. They are harder than the chalk, requiring the pick in extricating the fossils. They are of all shades of slate-color, sometimes bleaching on exposure to the weather. Near Fort Wallace, some strata are so much like the Benton in Nebraska, that Professor Hayden, on a hasty inspection, mistook them for a portion of that group. (Final Report on Nebraska, p. 68.)

These shales, in some localities, are traversed by seams, from 1 to 6 inches in thickness, of firm, pure calc-spar, usually in flat crystals. These seams are found in all parts of the Niobrara, though more common in the shales than in the chalk strata. When not crystallized the spar is harder than usual—apparently not quite as pure. In all cases, however, it will furnish good quicklime, and for that purpose is more convenient than the chalk, as it does not crumble and yield to atmospheric influences after burning. The seams were formed by fissures or rents in the original strata, made probably during their upheaval from the ocean-level, and the lime was deposited on both sides of the cavity, and usually united in the center, but sometimes the middle is lined by most beautiful crystals of calc-spar. The seams being firmer than the chalk, stand, like dikes, 2 or 3 feet above the surface, not vertically, but inclined 10° or 20° from a perpendicular. Inclosed in these seams are small crystals of barite. At Sheridan, Wallace County, we find the latter spar in the dark shales. One beautiful crystal, of a rich amber-color, weighed eight and one-fourth pounds.

The darker shales also sometimes contain numerous small lenticular nodules of pyrites, frequently in fine crystals of various shades of brown.

This Niobrara is from 75 feet in Trego and Ellis counties to 200 feet in Rooks County. The fossils are scattered very similarly in all this thickness; some localities will furnish more from the chalk, while others will give more from the shales. We hunt for fossils in all alike, and on the whole with equal success.

A few marine plants are found, but no land vegetation, except an occasional fragment of fossil wood. The absence of terrestrial plants is the more remarkable, as extinct birds and numerous amphibians indicate that dry land must have existed. This wood was, in a few instances bored before fossilization by some small animal. This might have been done by the larva of an insect (a "borer,") when the tree was living, or later by a teredo* when the trunk floated in water. In either case it shows that the Cretaceous vegetation was subject to the same enemies as that of the present period. Some of this wood was in a charred condition, and would burn freely. Other specimens were changed to almost pure silica, the cavities studded with crystals of quartz. In one case a log, weighing about 500 pounds, had all condi-

* A teredo, *T. tibialis*, has been found in the Cretaceous of Alabama.

tions of the transformation; a portion had the appearance of soft decayed wood, which crumbled in handling, and other parts ringing like flint under the hammer. Occasionally specimens were converted into chalcedony, but the annual growth of the wood distinctly remained. In a single instance we detected the fibrous structure of the palm.

It is rather singular that we have never found the leaves so common in our Dakota, and which are equally numerous in the Tertiary of Colorado.

A new and rare form of crinoid, first found by Professor Marsh in the Uinta Mountains, was, in a few instances, procured by our party. It is the only crinoid known in the American Cretaceous. It is described by G. B. Grinnell in the American Journal of Science and Art, July, 1876, page 81, as *Uinta-crinus socialis*.

Of mollusks, the most common are *Ostrea congesta* and *Inoceramus problematicus*. Less common, but still seen in many strata, are fragments of the large *Haploscapha*, with occasionally a perfect specimen. Another large bivalve we have never seen described measures from 30 to 33 inches in length. It is thin, with a transverse fiber like the *Inocerami*, and always lies crushed flat in numerous fragments, but lying in their normal position. A few *Gryphea;* also fragments, frequently weighing ten pounds, of a large *Hippurites* near *H. Toncasianus*. Near Sheridan, we recently discovered a bed of *Baculites*, and on referring them to Prof. F. B. Meek for identification, he decides they are *B. anceps*, not before found nearer than New Mexico. In his kind response to my inquiries, dated November 21, 1876, he writes: "One fact in regard to your specimens, however, is curious to me. All the other forms like this I have ever seen from any part of the far West come from our Nos. 4 and 5*; while all of the other species of anything yet known from those upper rocks is distinct from anything found in Nos. 2 or 3.† Can it be possible that you might have found this in an outlier of Nos. 4 or 5? It has the shell-substance well preserved, like the fossils of those upper beds, while those in the lower beds are usually casts." * *

The situation of the *Baculites* were, however, clearly in the Niobrara, as the characteristic fish and Saurians were found 15 or 25 feet above, in the bluffs not 200 yards distant. It is also a common incident to find the shell-substance of *Inoceramus problematicus*, &c., in excellent preservation in Wallace County. Almost all the shells and fragments are covered in part by the *Ostrea congesta*, which abound everywhere.

But the great feature of this division of the Cretaceous consists in its varied and rare forms of the vertebrate fossils. Three seasons of six or seven months each (1874, '75, '76) have been spent by myself, with two to five assistants, in collecting these vertebrates for Yale College.

The least interesting are the fish, which have, however, given us many new species and some new genera. The small ones are nearly entire, but the larger are represented only by well-preserved portions of the skeletons. Teeth of Salachians are quite common. At one locality over 400 were collected in an area of 30 inches, and apparently from the jaws of one individual—*Ptycodus mortoni*—and all in excellent preservation.

Quite recently I had the good fortune to find the teeth, cartilaginous jaw, and vertebræ of a shark—*Galeocerdo falcatus*—three portions, which, I think, have never hitherto been found together. The flat, porous vertebræ had occasionally been collected, but we had been unable to give them their generic name. The teeth were frequently procured.

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* Fort Pierre and Fox Hill groups. † Fort Benton and Niobrara.

Professor Cope, in his "Cretaceous Vertebrata," has described thirty-six species of fish, and some twenty others have quite recently been found. In 1872, only twenty-four species had been collected from Kansas. The most novel is a new genus (three species), which had a snout appended to the skull like the sword of the sword-fish, but conical in shape, composed of a compact bundle of fibers. In the largest species, this snout is about 15 inches long and 1½ in diameter at the base. Professor Cope has a representation of a portion of the jaws in Plate XLVIII, Figs. 3–8, under the name of *Erisicthe nitida*. But, unfortunately, his specimen did not embrace the snout or much of the skull, so that a correct idea of the fish is not obtained from his description. Professor Marsh has a dozen specimens, recently obtained by us, from which a more detailed description may be made.

In individuals, the fish were quite numerously represented. In the season of 1875, our party saw, according to my note-book, 1,207 specimens, without counting the teeth of sharks. Many of these, however, were so fragmentary that we did not collect them. The genera *Portheus* and *Empo* were most abundant.

Several species of marine turtle have been obtained. One described by Cope, *Protostega gigas*, was 15 feet in the expanded flipper. The type is embryonic. This is seen in the structure of the ribs, which are more free and detached from the dermal plates of the carapace than those now living. Other species, however, from the same horizon, did not show any embryonic features. One, apparently a *Protostega* one-fourth as long, has its ribs closely united with the plates, and in other characteristics had the semblance of a mature type.

A small species was somewhat common, whose size was about that of a fresh-water turtle now found in Kansas. Some species, which Professor Marsh has not yet had time to examine, will undoubtedly be new to science.

Less in number than the fish, but of more importance, are the reptiles of the crocodile and Saurian type. My note-book shows 476 specimens seen by our party in 1875, of which one-half might be called good, and some of them equal, if not superior, to anything before found in Europe or America. Professor Cope, in the work above quoted, has made a list of all the genera and species now known in the Cretaceous, which shows fifty-one hitherto described, of which Europe furnishes but four, and Kansas twenty-six. To this number must be added six or eight which have been discovered by our party within two years, which are now in possession of Professor Marsh, who will soon publish a technical description of them.

New Jersey comes next, furnishing fifteen species. Although this formation extends quite widely into Nebraska, but few vertebrates have been found within that State. They have been collected most abundantly in the Saline and Smoky Hill Valleys, and nearly all from the Niobrara proper, above the massive limestone of the Fort Hays division. It must be recollected that this deposit is never over 200 feet in thickness.

Our labors during three years past have added much to the knowledge previously obtained in regard to the structure of this class of reptiles, particularly of the smaller bones and hind limbs. The collections in the possession of Professor Marsh from Kansas will leave little to be needed in the study of the anatomy of Saurians, as they are more full and complete than any in Europe.

The Saurians are of all sizes. One from Jewell County was about 70 feet long, while two species were only 6 feet. Most frequently they were from 25 to 40.

The specimens are frequently represented by a few bones washed out and lying exposed. But the best are obtained by finding a projecting fragment, and then following the skeleton into the compact shale or chalk. This sometimes requires much hard labor, but is the most satisfactory, as the fossils are, in such cases, in a better state of preservation. A single specimen has cost us as much as six days' labor. As the bones were sometimes friable, sketches of the best specimens were made before removal. The fossilizing material is lime combined with a little silica, and the minute stria and muscle markings were in most excellent preservation. But in some cases they were impregnated with gypsum or iron (sulphide and oxide), when the fine texture and characteristic markings were destroyed, and the fossils were almost worthless.

Our researches were confined to the slides and ravines which had exposed the chalk and shales. These constituted but a small portion of the country, but are slowly being enlarged by the action of the elements. Miles of these exposures yielded us nothing, and again a small area furnished good specimens. The animals appeared to have frequented favorite haunts to the exclusion of larger areas. Three long seasons spent on this territory, besides the labors of other collectors, has nearly exhausted the supply of rare fossils. As future washings occur a few specimens may be obtained.

Coprolites of fish and Saurians are frequently found, containing the remains of the food of the animal. Small fish appeared to be the most common food; but in one instance a rare crustacean was found preserved in this way. The coprolites are not so hard as those of Europe, being little firmer than chalk and finer-grained.

The following analysis of a Saurian coprolite from Wallace County is by George E. Patrick, professor of chemistry in the University of Kansas:

Moisture	1.22
Organic matter	.42
Oxide of iron and alumina	29.99
Lime	24.31
Alkalies, small amount, undetermined.	
Silica (combined)	.19
Phosphoric acid	34.88
Carbonic acid	7.05
Sulphuric acid	1.92
	99.98

In some cases, the undigested organic matter (bones) was one-fourth of the whole weight.

In some cases we find remains of the indigestible portions of food between the ribs, where the stomach was situated. In the *Plesiosauri* we found another interesting feature, showing an aid to digestion similar to many living reptiles and some birds. This consisted of well-worn siliceous pebbles, from one-fourth to one-half of an inch in diameter. They were the more curious, as we never found such pebbles in the chalk or shales of the Niobrara. How far the Saurians wandered to collect them is a perplexing problem. Their structure does not indicate much ability to crawl on land, and yet it is probable that they must have frequented some of the islands of the old Cretaceous ocean for that and other purposes. As such substances remain in stomachs of low organization for a long time, the visits to dry land would not necessarily have been very frequent.

Sharks' teeth were sometimes found in the remains of food, showing the taste of the Saurians and their high carnivorous natures. On the other hand, we frequently found evidence that the sharks returned the compliment, for bones of Saurians were found with the marks of the sharp, serrate teeth of *Galeocerdo*, which could not have been made unless the bones were still fresh and unhardened. That such huge reptiles must have had fierce contests with each other is also apparent. The type of the head and teeth would indicate this. But in addition it was no uncommon thing to find Saurian ribs which had been broken and again united while the animal lived. In one case a more serious injury occurred. In a fine specimen, one of the most perfect collected by us, we discovered that the animal had received a very serious injury to his back, which he had outlived. Five of the vertebræ had been fractured so seriously as to lose many of the spinous processes, after which it had healed, but the whole had grown together (anchylosed) so as to lose the natural form of the separate bones and become a confused, firm mass. The enemy that could have thus injured a monster 35 or 40 feet in length, and whose jaws of defense were 33 inches long, must have made a fierce contest. When we know that the largest (*Brimosaurus*, Leidy) was 70 feet long, with a head 6 feet, those of half that size should avoid an encounter, and those only 6 feet in length might have been swallowed whole.

The Niobrara of Kansas also affords the only Pterodactyls yet known in the United States, and, we believe, in America. They differ widely from those of the Old World in the *absence of teeth* and general structure of the head; the latter is much more elongated and beak-like. On the great divergence from the European type, Professor Marsh* has based a new sub-order *Pterodontia* of two genera, and described six species, viz: *Pteranodon ingens*, *P. occidentalis*, *P. velox*, *P. longiceps*, *P. comptus*, and *Nyctosaurus gracilis*. Cope† has also described two species, *Ornithochirus umbrosus* and *O. harpia*. But it is possible that one or two species of the two authorities may be identical. They average much larger than those of Europe, several species being from 20 to 25 feet in extent of wing. Fragments of the bones are frequent, but usually in poor preservation, in strong contrast in this respect with the other vertebrate remains. The long bones, being very hollow, were compressed to the thickness of one-tenth of an inch, and exceedingly friable. The articulations, being thicker, are firm and better preserved. The bones of the head were more rare. In one instance (of *P. ingens*), I uncovered a hand, with the four long bones of the wing-finger, as they lay in place, and found them measuring respectively 24½ inches, 20¾ inches, 14½ inches, and 9 inches; or 5 feet 8¾ inches in total length. The width of the first, as it lay compressed to one-tenth of an inch, was about 2 inches. My note-book shows seventy-two individual specimens seen in 1875; but little more than half could be saved, much as we valued this rare fossil. In some instances, on opening a piece of chalk, the outline could be distinctly seen, but the bone crumbled to dust. In 1876 we were more successful, and the museum of Yale College has a collection exceedingly rich, particularly in the smaller and frail bones, not well represented in the European species.

In Dr. Coues's Key to North American Birds, published in 1873, Professor Marsh has given a list of the fossil birds from the Cretaceous of North America, at which time thirteen species were known, all first de-

*American Journal of Science, iii, p. 360, June, 1871; xi, p. 507, June, 1876; and xii p. 479, December, 1876.

†Trans. Amer. Philosophical Society, March 1, 1872.

scribed by himself. Of these, five are from the Niobrara beds of Kansas. To this we have added two species, making (as some others are not yet fully identified) at least seven from Kansas. Five of these are so anomalous as to be provided with jaws and teeth. These Professor Marsh described as a sub-class, *Odontornithes*.* In the *Odontolcæ*, we have birds of the largest class of aquatics, measuring 5 to 6 feet in height. The teeth are set in grooves in the jaws. The wings are very rudimentary, too weak for flight. The *Odontotormæ*, on the other hand, are small, with strong wings, giving great power of flight, and the teeth are set in sockets. And what is more singular, the vertebræ are biconcave, like a fish, but still retaining the internal bone-structure of the bird. Bones of the legs and wings were of the usual bird structure. This was found by the writer and first described by Professor Marsh in the American Journal of Science, vol. iv, p. 314, and illustrated in vol. x, p. 402. Professor Marsh has now in press a monograph on the Cretaceous birds, where all will be fully described and illustrated.

The ravines of the Niobrara exhibit many features in common with the cañons of the bad lands of Dakota and Nebraska, but on a diminutive scale. When a firm layer of chalky limestone overlies others of a softer texture, a narrow groove will be cut through the top, and then the wear goes on rapidly down to the level of the lower grounds. Frequently such cañons will be 100 feet long, 15 or 20 feet deep, and but 2 feet across the top, being wider below than above. These occur near each other, and then the ravines become quite labyrinthine; an intricate place for hunters or their enemies to hide. When these partitions between the cañons become detached from the hillsides and divided into sections, they stand as isolated columns. Such are the well-known Monument Rocks of the Smoky Hill Valley, in Wallace County, and Castle Rocks, of Ellis County. The former stand as detached pillars, 20 to 40 feet high, in the valley, at quite a distance from the nearest parent bluffs. In the latter example, at the extreme western angle, a pillar like a detached bastion stands 200 yards from the Castle, 60 or 70 feet high, and only 20 feet through the base. The top is limestone, then chalk, while the base is firm blue shale. The valley around is perfectly level. At the eastern end of the Castle several smaller pillars seem to stand as sentinels in that direction. The top of the Castle, overlooking all, is covered by 10 feet of Pliocene sandstone. The writer regrets that these fanciful rocks have not been photographed, so that twenty years later other photographs might show the rate of abrasion. Rain, frost, and the hands of ruthless men are destroying many of these unique pinnacles.

The soil overlying the Niobrara group being formed primarily by good proportions of chalk, clay, and sand, and subsequently intermingled with organic matter, is rich and fertile. On the high prairie the loam is from 1 to 3 feet deep, while on the bottoms it is deeper but inclined to be too sandy. The want of rain in July, August, and September, west of Fort Hays, renders agriculture unprofitable. The wild grasses, consisting of several varieties of buffalo grasses and bluejoint, are admirably adapted to withstand drought, and make excellent food for cattle and sheep. As a home for stock-raisers it has few equals.

An opinion is prevalent that the region covered by the Niobrara Tertiary is largely supplied by alkali plains and alkali springs. This is a mistake. After more than ten years' acquaintance with it, I have not seen two acres together where the vegetation has been killed by it, or

*Amer. Journal of Science, November, 1875, p. 403.

half a dozen springs so impregnated as to make the water unpalatable. The analyses of chalk, shales, and soils, do not show more than the average of the alkaline bases.

The soil of this division consists of the fine, black loam, so common to the West. Were rain more abundant, it would be a rich farming-region. It is a good grazing-country. The following analyses of soils, collected by S. W. Williston from the Smoky Hill Valley, were made by George E. Patrick, professor of chemistry in the University of Kansas. No. 1 is high-prairie loam; No. 2 is from "bottom" lands. Neither soil had ever been cultivated.

	No. 2.	No. 1.
Water	1.895	3.449
Organic matter	3.039	5.224
Soluble in cold hydrochloric acid:		
Oxide of iron	1.503	1.778
Alumina	.557	.721
Lime	4.268	1.618
Magnesia	.422	2.084
Potassa	.214	.202
Soda	.038	.002
Silicic acid	.050	.023
Sulphuric acid	.041	.078
Carbonic acid	3.510	.567
Phosphoric acid	.173	.118
Sodium chloride	.003	.007
Insoluble in cold hydrochloric acid	84.287	82.129
	100.000	100.000

b.—Fort Hays division.

The massive stratum of limestone above described, together with all the deposits above the sandstones of the Dakota, I shall call the Fort Hays division.

Professor Hayden, in his Final Report of the United States Geological Survey of Nebraska and Adjacent Territories, p. 67, says:

At Wilson's station I saw the chalky limestone of the Niobrara group filled with *Inoceramus problematicus*. A part of the bed is in slabs or thinnish layers, as it usually appears wherever it occurs south of the Missouri River; but a part also is more arenaceous and rust-colored. Between the two hundred and forty-fifth and two hundred and fiftieth mile-stone west, the road cuts through No. 3 (Niobrara) very distinctly, the whole country appearing to be underlaid by this rock.

As this deposit thus seen and described by Professor Hayden rests directly on the Dakota, and all those which he supposed might possibly be Benton are clearly above the strata seen at Wilson's station, the Benton is not seen in Kansas. The lower portion of our Fort Hays may be an equivalent of the upper portion of the Benton, though there does not appear to be any line of demarkation, either by fossils or physical structure. Yet if Professor Hayden and myself could spend a few days on these beds it is probable that we should conclude that it is the Fort Benton group. We therefore only provisionally call it Fort Hays. The great difference between the Kansas Niobrara and this is readily understood when we say that no turtle, pterodactyl, or bird has been found in the latter, and that saurian bones are comparatively rare, and limited in species and genera.

At Wilson's station and at other places in the same geological horizon, to the thickness of 140 feet, it is composed of shales and thin layers of limestone. The latter are filled quite largely with *Inoceramus* and a few other marine shells, and occasionally with fish-remains. The shales are variable in color, hardness, and composition, lime and clay predominating. This deposit is variable at the same horizon at different points, containing no thick bed of limestone. To make a section at any particular locality would be of little value unless half a dozen others were made for comparison.

The only persistent feature is a thin stratum of buff sandy limestone, in the upper portion, never over 10 inches in thickness. It extends from Smoky Hill Valley northeasterly into Nebraska. It contains *Inoceramus problematicus*, *Gryphea*, *Belemnite*, and an *Ammonite*, all poorly preserved, and, excepting the first, too indistinct for specific identification. It is much used as a building-stone on the whole line named. It is soft, fine-grained, and easily wrought, and its color is pleasing to the eye.

The line of division between the Dakota and Fort Hays is very obscure, and the shales appear to shade into each other, in such a manner as to indicate that no interval of time intervened between the last deposition of the one or the first of the other. Near the apparent division there are scarcely any fossils, and those in poor preservation, which renders the tracing of the dividing line more difficult. In the Arkansas Valley, both bend toward Colorado. During two weeks spent in this valley west of Fort Dodge, I collected only a few obscure fragments of an *Inoceramus* and fish-teeth, and no leaves. Yet in 1876, Prof. M. V. B. Knox collected a few leaves (*Phylites*, *&c.*), apparently of the Dakota, near Fort Lyon, Colo., very near the geological horizon of the sandstone, which extends from Fort Dodge to the Colorado line. All our Cretaceous groups lose most of their characteristic fossils as they approach the western line of the State. Near the Nebraska line, in Republic County, the transition from one group to the other is more rapid and clearly defined.

Under the heavy bed of limestone, forming the highest portion of the Fort Hays group, is seen a friable, bluish-black, or slate-colored shale. It abounds in concretions, or septaria, of all sizes from 1 inch to 6 feet in diameter. The body of the concretions is of hard clay-marl with cracks lined with beautiful crystals of calc-spar. These cracks frequently extend to the outside, and are then filled with a light lime, which gives them fanciful markings, inducing several persons to send small ones to me as "fossil turtles". This stratum is well exposed near the railroad, a few miles west of Fort Hays, and in most places where the massive limestone lies on the high bluffs. It is about 60 feet in thickness, and frequently contains fine clusters of compound crystals of selenite. It affords a few fish and saurian remains. It is more noted, especially in the Saline and Solomon Valleys, for the number and variety of its *Ammonites*, embracing several species, from 1 to 30 inches in diameter. The most common is *Prionocyclus woolgari*. The larger specimens are almost invariably in fragments, although a portion of the original shell-substance of a bright pearly luster is still to be seen. Forms allied to the *Ammonites* are also found, as *Scaphites*, *Mortoniceras*, &c., and also several *Inocerami*, one near *I. nebrascencis* of Owen.

Some of the lower strata give thin impure beds of lignite, but no plants could be identified from them.

The total thickness of the Fort Hays group is 260 feet.

2.—Dakota.

The Dakota group includes all the Cretaceous east of the Niobrara. As no fossils of the Triassic or Jurassic have yet been discovered, after ten years' search, we conclude that the Dakota rests directly on the Permian. While the dividing-line has not usually been very well defined, yet in a few instances the fossils of the Permo-Carboniferous and Dakota groups have been collected within 35 feet vertically and one-half mile horizontally.

The material of this deposit is formed very largely of brown and variegated sandstone, of all degrees of compactness, from that which crumbles in the handling to that which requires a sledge-hammer to break it. This extreme hardness is, in most cases, owing to the presence of iron, in the condition of oxide and silicates. Sometimes poor limonite is seen. In some places, in every county where it abounds, it affords a good building-material. It is frequently interstratified or overlaid by clay-shales, of almost all colors. Many ledges give concretions of fanciful forms, sometimes hollow, or with the center filled with loose sand. Some of the hollow concretions are sufficiently large to be used by the farmers as feeding-troughs for hogs and cattle. In a few localities they assume the form of tubes of various sizes, some being 3 inches in diameter and 3 to 8 feet in length. These concretionary deposits are sometimes glazed and distorted, as if they had been subject to the action of fire; but the cause is the oxidation of iron, and not any application of heat. Such specimens of sandstone frequently inclose well-preserved dicotyledonous leaves.

The fossils of the Dakota consist of a few marine mollusks, some few remains of fish and saurians, but it is more particularly noted for its dicotyledonous plants. The *Molluscæ* are rare, having been found in three localities only. Two of these are in the western part of Saline County, in the vicinity of Bavaria, and the other is in the western portion of Clay County. On one of these spots, covering not over two acres, we procured twelve species, new to science, and described by Prof. F. B. Meek, in United States Geological Survey, Hayden, 1870, pp. 297–313.

A few fish and one saurian (*Hyposaurus vebbii**) have been found in this group.

Of the fish, the most interesting is the *Pelocorapis varius* Cope, an ally of the flying-fish, found near the dividing line between the Dakota and Fort Hays.

But it is in its fossil flora, represented largely by dicotyledonous leaves, that the Dakota claims the attention of the student of nature. Professor Lesquereux, our greatest American fossil botanist, has devoted to this flora most careful and valuable study. In his Cretaceous Flora, and other publications connected with Professor Hayden's Geological Survey, he has given us the results of many years' study, to which we refer the reader. Professor L. says: "The plants of the Dakota group, as known mostly by detached leaves, are striking by the beauty, the elegance, the variety of their forms, and of their size. In all this they are fully comparable to those of any geological epoch as well as those of our time." †

The fossil flora is almost entirely represented by leaves, though a few specimens of fruit, imperfectly preserved, have been collected; also some poor fragments of wood and bark. The leaves, however, are usually in excellent preservation, the veins and veinlets as they lie imprinted on the stone being frequently as clearly visible in all their outlines as those just taken from the living tree.

In collecting fossil leaves we have frequently examined every visible outcrop for 15 or 20 miles without finding a specimen; then perhaps a single square mile would present several good localities. In this irreg-

* See Cope's Cretaceous Vertebrata, p. 17, where this specimen is incorrectly stated to be from the Niobrara. Brookville, the locality there named, is clearly on the Dakota.

† Hayden's Report, 1874, p. 318.

ular manner we have collected specimens from Washington County to Fort Larned, a distance of 150 miles. The fossil plants are usually obtained from thin layers, or strata, extending in a horizontal position along a ravine or around a hill. They may occur at several places in the same vicinity, but usually without any connection. They are found at all depths in the Dakota, from within 35 feet of the Permian to within 40 feet of the Fort Hays limestone. The numerous indications show that the trees must have grown on islands near the shore-line, and that the leaves were imbedded in the marine sediment immediately after dropping. Worm-borings are also found in the same strata with the leaves. The contrast between this fossil flora and the plants of the older formations is very strong, while its resemblance to those now living is equally remarkable. The interest attached to this numerous variety of modern plants is enhanced by the fact that in the earlier formations no Dicotyledons are found, the Conifers which come down from the Devonian age being the highest type. But in our Dakota and the corresponding age in Europe, we have a sudden influx of new types covering nearly all the forms now living. These are "the first known of the great modern group of Angiosperms," "and the ordinary fruit-trees of the temperate zones," "distributable not in a single one, but in all of the essential groups of vegetables living at our time."* This sudden appearance of the full type of modern vegetation will be more apparent on examination in detail. Professor Lesquereux, in his Cretaceous Flora, describes one hundred and thirty-two species, distributed among seventy-two genera and twenty-three orders, of which one hundred and seven species of nineteen orders and fifty-two genera are dicotyledonous plants. Of these, more than one-half have been collected in Kansas, and about twenty of the new species were described by Professor Lesquereux from specimens discovered by the writer. To these are to be added twenty-six new species described by the same author in a recent bulletin (VII of No. 5, second series) of Hayden's reports. Additions to these are constantly being made. There are nine species of Conifers, five of poplar, six of willow, eight of oak, six of platanus or buttonwood, seven of sassafras, five of magnolia, two of fig, one of palm, and two of cinnamon. The last four were probably hardy species of their kinds. Still they indicate a warmer climate than now exists. When we recollect that at the period of their growth, this part of the country was nearly on a level with the ocean, and the dry land was composed principally of a few islands, the variance of the climate is easily explained.

Taking Professor Lesquereux's list of Dicotyledons we find 56 per cent. of his genera are identical with those now living east of the Rocky Mountains, in the temperate zone of the United States. To this must be added 24 per cent. which are apparently identical, represented by *Populites*, *Betulites*, *Acerites*, *Negundoides*, *Laurophillum*, &c. Of the remaining 20 per cent. some, like the fig and cinnamon, are now living in the tropics, while a few are probably extinct genera.

This feature of resemblance to living vegetation is increased by the examination of specific forms. At first Lesquereux was disposed (like all paleontologists who find familiar forms in an unexpected geological age) to say that all the species were extinct, but in his later writings, after exchanging opinions with the best floral paleontologists of Europe, he has been led to change his opinion on, at least, one species. In naming a new sassafras he honored me by calling it *S. mudgei*. By a com-

* Lesquereux.

parison of numerous specimens from Greenland and Europe, with our Dakota and the living *Sassafras officinale*, we obtain the following conclusion by the highest authorities. Prof. W. P. Schimper says, "That these leaves, very variable in size, present such a remarkable likeness to those of *S. officinale*, now living in North America, that one would be disposed to consider them as belonging to an homologous species." And Lesquereux adds, "Comparing leaves of *S. officinale* with those represented by Count Saporta, in the Flora of Sezane, and the specimens of *S. mudgei* from Kansas, it is impossible for me to recognize any character, even any specific difference by which these leaves could be separated."* This extreme persistence (by which I lose my namesake) it must be recollected covers a period of one-eighth of the earth's geological history. On more careful study of these fossil leaves it is most probable that others may be found specifically like those now living. The fig, in its nervation and especially its areolation, is of the same character as many species now living in Cuba and Florida.† Had these leaves been found in Post-Pliocéne very many of them would have been assigned to living species. The persistence of vegetable forms has been more strong, through all geological ages, than any other organic life.

In the Dakota Group there are a few veins of brown lignite, which is always an inferior variety of coal. The most important seam extends irregularly, and with frequent omissions, from the State line in Washington and Republic Counties, southwesterly to the Arkansas Valley. It varies in thickness from 10 inches to 40; but usually a portion of this thickness includes seams or layers of clay-shale. This lignite contains a large percentage of ashes; but a more objectionable feature is its tendency to crumble on exposure to frost. This alone renders it almost worthless as a marketable coal. At some localities it has much pyrites, with sulphur so free as to cover the deposit with a yellow coating. This coal sometimes takes fire by spontaneous combustion. Notwithstanding these defects, it becomes of value in sparsely-timbered counties, by furnishing to the settlers a cheap fuel, costing only the time and labor necessary to dig and convey it to their farms. It is usually mined at the surface in the open air, by "stripping", *i. e.* removing the few feet of soil or shale that overlies it. An average outcrop will yield at least a ton for a day's labor. It is found in Washington, Republic, Cloud, Mitchell, Lincoln, Ottawa, Saline, Ellsworth, McPherson, Rice, Barton, and perhaps some adjoining counties. These lignite-beds give us no vegetable remains that can be identified. It appears to be of a low swamp type unlike the leaves so highly characteristic of the Dakota group.

As this group is composed, to a very large extent, of siliceous sandstone, the first impression would be that the soil would naturally be poor and sandy. This is not the case. The best materials of the soil must have come from another source, and must have been from the later divisions of the Cretaceous which were above it. We find the Fort Hays limestones and limeshales overlying the western portion of Dakota, and other indications show that they formerly overspread the whole of it. As these lime-deposits are now disintegrating by rain, frost, and other agencies, such action prevailing for a long period would have commingled lime with the sand and produced a fertile soil.

The farms on the Dakota show as much natural fertility as any portions of the State. The moderately sandy subsoil furnishes a natural

* See Hayden's Geological Report for 1874, p. 328.
† Ibid, p. 327.

drainage, even better than usual, and in the spring frequently gives the grasses and winter grains twelve to fifteen days earlier start than the farms of the adjoining Permian. No soil in the State is so easy to work and so free from baking or the ill effects of drought. The eastern half embraces the best wheat land in the State. It is also an excellent fruit district. The iron in the sandstone, uniting with other good materials, makes it particularly favorable to pear culture.

The average width of the Dakota is less than 50 miles, being somewhat less than that in the north part of the State, and more on the Smoky and Arkansas Rivers. The dip is to northwest and very slight. It is difficult to decide the amount, but it does not appear to be on the average more than 5 feet to the mile. It is conformable to the Fort Hays lime formation above it. It corresponds very nearly to the Cretaceous of Swallow's Report, p. 9, and also to Nos. 2 and 3 of his Triassic.* The maximum thickness of this group may be 500 feet. It is difficult to estimate the thickness, as the larger portion of the material consists of sandstone, much of which was originally thrown down in oblique deposits.

The total thickness of the Cretaceous in Kansas we estimate to be 960 feet.

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* The other numbers of his Triassic belong to the Permio-Carboniferous.

PART II.

GEOGRAPHY AND TOPOGRAPHY.

REPORT OF A. D. WILSON, TOPOGRAPHER OF THE SOUTHEASTERN DIVISION, 1875.

LETTER TO DR. F. V. HAYDEN.

WASHINGTON, D. C., *April* 23, 1877.

SIR: I herewith transmit my report on the principal topographical features of the district surveyed by the southern division during the summer, 1875. Also, a topographical report by Franklin Rhoda, who was my assistant in the field. Dr. F. M. Endlich will report on the geology and the mineralogy of the district examined.

The party outfitting at Denver took the field June 6. Our supplies, instruments, and baggage were transported on eight pack-mules, carrying only such things as were absolutely necessary. Thus, having no incumbrances, we were enabled to travel very rapidly and to pass through the rough mountains, where otherwise we might have been compelled to make long detours to avoid rough passes.

The party returned to Denver on October 12, having obtained the data with which to map (both topographically and geologically) the district assigned this division, which comprised an area of 12,000 square miles. Within this area we have established one hundred and forty-three topographical stations on the more prominent peaks of this district.

I wish here to acknowledge the many obligations I am under to Dr. F. M. Endlich and Franklin Rhoda, for their hearty co-operation and uniform kindness which they displayed during the three seasons they accompanied me in the prosecution of this work.

Owing to the pressure of other matters, I have not been able to work up the material on hand in time for this report.

Hoping that this may meet your approval,

I am, very respectfully, your obedient servant,

A. D. WILSON,
Chief Topographer.

DR. F. V. HAYDEN.
United States Geologist-in-charge.

TOPOGRAPHICAL REPORT ON THE SOUTHEASTERN DISTRICT.

The territory set apart for the southern, or San Juan, division, for the summer of 1875, was embraced between 36° 45′ and 37° 45′ north latitude, and from 104° 30′ to 108° west longitude, with some irregularities where joining the work of previous years, especially toward the west, where the unsurveyed district tapered down to quite a narrow belt.

This area is divided naturally into five parts, viz, the eastern slope, Sangre de Cristo Range, San Louis Valley, San Juan Mountains, and the mesa country to the west.

The first, lying east of the Sangre de Cristo range, embraces a portion of the great plains, the Spanish Peaks, and the Raton Hills. This portion of the district is drained mostly by the Huerfano, Apishpa, and Purgatoire Rivers. All of these streams flow eastward, and join the Arkansas River in the plains below. Along the banks of the streams there are bottoms of more or less extent, which are easily irrigated, and are composed of a rich loamy soil, susceptible of a high degree of cultivation, producing good crops when properly cultivated. The table-lands appear to be covered with a very good soil, and would probably produce good crops if the necessary water is once brought upon them. The foot-hills and valleys along this portion of the district furnish pasturage for a great many sheep and cattle. The Denver and Rio Grande Railway is now running as far south as Elmoro, and, skirting along the foot-hills, gives an excellent outlet to the products of these valleys.

Next in order is the Sangre de Cristo Range, trending nearly north and south, with a slight curve eastward along the middle of this section. This range is one of the finest and best defined in Colorado, and it contains many very prominent peaks. The following are some of the more noted, commencing at the north end:

Names.	Elevation, in feet.
Hunt's Peak	12,446
Mount Rito Alto	12,989
Kit Carson's Peak	14,100
Crestone	14,230
Blanca Peak	14,464
Baldy Peak	14,176
Trinchera Peak	13,540
Culebra Peak	14,079
Purgatory Peak	13,719
Boundary Peak	12,840
Costilla Peak	12,634
Venado Peak	12,800

There are many more unnamed points along this crest, which are as high, and even higher, than some of the above; but these will serve to convey some idea of its general height.

The San Luis Valley is really a great plain surrounded by high ranges and lofty peaks, bounded on the west and northwest by the San Juan and Sawatch Ranges, on the east and northeast by the Sangre de Cristo Range, and on the south by a succession of volcanic buttes. It extends from Puncho Pass on the north to the above-mentioned hills on the south, which separate it from Taos Valley, along the line of 36° 45′ north latitude, giving it a total length from north to south of 114 miles, with a breadth at the south end of 28 miles, while along the central portion it is from 40 to 45 miles in width, tapering to a point at Puncho Pass, with a total area of 3,470 square miles.

The Rio Grande del Norte enters the valley from the west about midway between the north and south ends. As it passes through the valley it makes a long sweeping curve, and by the time it reaches the center of the valley it has changed its course and flows nearly due south through a small group of volcanic table-like hills, which occupy this portion of the valley, and enters a narrow basaltic cañon, through which it flows, until reaching Taos Valley below. The valley has a general elevation ranging from 7,400 to 8,000 feet. All the central or bottom portion is covered with a thin growth of sage-brush, intermingled with scattering bunch-grass. Along the borders and on the foot-hills there is a very good growth of grass, while along the main streams the bottom-land produces fair crops of hay. The soil along the streams is very good and easily irrigated, but owing to the shortness of the summer season it is only the more hardy vegetables and grains that are successfully grown.

The settlers have turned their attention mostly to the raising of sheep and cattle; the valley being of such an immense size, is capable of supporting large herds of stock.

The Denver and Rio Grande Railway is now being built by way of Veta Pass, striking the valley at Fort Garland, and will probably be carried across the valley to Del Norte, thence up the Rio Grande to the San Juan mines, thus giving an outlet to the products of the valley as well as those of the mines in the mountains beyond.

The San Juan Mountains is a peculiarly massive range, composed almost entirely of volcanic rocks, and presenting probably a greater area above 12,000 feet than any other mountain mass of similar size on this continent.

The greater mass of this range is that portion lying in the vicinity of Baker's Park, and is drained by the San Miguel, Uncompahgre, Rio Grande, and Animas Rivers. From this center of upheaval the range trends a little south of east, gradually curving to the south until it reaches latitude 37° 10′, where its general trend is nearly due south, whence it soon spreads out and loses its identity in the low hills to the south. The heights of all the main peaks along the western portion of this range were given in the report of 1874; therefore I will only give a few of the more important points along the southeastern extension:

Names.	Elevation in feet.
South River Peak	13,160
Pagosa Peak	12,674
Summit Peak	13,323
Pintada Peak	13,176
Conejos Peak	13,183
Banded Peak	12,860
Brazos Peak	11,214
Black Head Peak	12,514

There are but three passes over this range to the east and south of the one at the head of the Rio Grande, over which most of the travelers to the San Juan mines pass. The first is called Weeminuche Pass, and is crossed by a very fair Indian trail, which leaves the Rio Grande some twelve miles above Antelope Park, descends to the headwaters of the Piedra, a branch of the San Juan, thence leading to Pagosa Springs, and branching off to the southwest. The elevation of this pass is only

10,570 feet above sea-level. The next trail crossing the range follows up the South Fork of the Rio Grande, wends its way through the mountains, and, striking the head of the main San Juan, follows it down to Pagosa Springs. This trail has been used but little of late years by the Indians, and is, therefore, quite dim in some places. The pass has an elevation of about 11,200 feet.

The most southerly pass in our district is crossed by a very well used trail which follows up Rio San Antonio from Conejos, crosses the head-waters of the Brazos, thence down one of the spurs to Tierra Amarilla. The highest point on this trail is about 10,000 feet above sea-level. It is used by the settlers to considerable extent in driving their sheep to the San Luis Valley and thence eastward; but their supplies and utensils are transported by wagon over a pass to the south.

The region of country to the west of the high mountains examined by this party is made up of broken hills, flat table-like mesas, and small valleys. The hills are generally covered with a thin growth of piñons and cedars, while along the foot of the mountains there is a very good growth of yellow pine. The valleys along the streams are generally very rich, and as the heights of these valleys are not very great, they will be found very productive. All of this region west of the San Juan Mountains is drained by the San Juan River and its tributaries.

I will not attempt here to give any detailed description of the district, but will refer the reader to the appended report of Franklin Rhoda, in which will be found a more detailed description of the country we explored.

I will refer the reader to the report of Dr. F. M. Endlich, geologist of the party, for any information that may be desired in reference to geological or mineralogical features.

The accompanying drainage-map of Colorado was compiled from the final sheets, and reduced to a small scale in order that it might not be cumbersome in size. Much of the minor details have been omitted to avoid confusion, giving only the water-courses, principal mountain-peaks, roads, trails, towns, &c. The heights of all the more important points are indicated by figures placed thereby.

TOPOGRAPHICAL REPORT ON THE SOUTHEASTERN DISTRICT.

By Franklin Rhoda,
Assistant Topographer.

On June 6, 1875, we left Denver on our summer's journey. The spring had just begun on the plains, and the grass had been up some time, but the wintry chilliness had only just disappeared from the air, and the mountain-ranges to the westward were still covered deep in snow. Notwithstanding all these facts, the grasshoppers were before us, and along our whole march, from Denver to Huerfano Park, the grass had been almost completely devoured. Before reaching the nearest point of our work we had to march about 170 miles along the plains in a southerly direction. The nights were quite cool, but the days were very hot, and, to add to our discomfort, a blustering wind blew from the south in our faces, raising clouds of dust from the road. At the best season of the year these plains are arid and desolate, but this year the grasshoppers made their appearance especially gloomy.

Passing through Pueblo, on the Arkansas, we continued southward along the plains to the east of Greenhorn Mountain, till we reached the Huerfano. Thence, we took the Fort Garland road over Sangre de Cristo Pass, and soon again found ourselves among the mountains, with timber, and grass, and cold water in abundance. After our long and dreary ride, we found ourselves in a fit condition to appreciate these great luxuries of nature. Our first regular station was made on a prominent point north of the pass; the first three had been made along the course of our march. The region in the vicinity of this pass is one of peculiar interest, as well for its botany as for its geology and topography. It is a region in which special volcanic action has left its traces in every direction. There are several peaks in the near neighborhood which appear more like giant dikes than true mountains. Stations 4 and 5 are good examples, but there are many more exactly similar but less imposing masses included within a space 10 to 15 miles square. Each is entirely separated from the others, yet their common direction show them to be closely related in their origin. They all consist of a sharp ridge-crest extending in station 5 to a length of two miles, and less in others, with the side-slopes very steep and composed of loose rock. The slides commence at the crest and extend down into the timber. The solid rock seldom makes its appearance, but bluffs may be seen in a few places. The apparent elevation of these peaks is very deceiving. The fact that the side-slopes are in nearly all cases destitute of timber, make these mountains appear very high, although the summits of all of them are much below the snow-line. As Veta Mountain is the most remarkable of this group of peaks, and yet is a good sample of the class, a more detailed description of it may be of interest. Leaving our camp on the north slope of the pass, we rode southeastward along the summit. During the morning a very strong wind blew from the west. From the lay of the country, I should judge that this pass was seldom free from wind. The mass of the Sierra Blanca north of Fort Garland and the high narrow Sangre de Cristo Range to the south form a great funnel facing the southwest. All the westerly winds that cross San

Luis Valley south of the latitude of Sierra Blanca are caught by this funnel and a great part of them forced through the pass. In the beginning of our climb of station 5 we found evidence of this in a peculiar gap cut through the crest of the mountain-ridge. It is a narrow gateway probably not over 100 feet in width, while the walls on either hand rise an equal distance vertically. The west slope was very steep, but the east was the same as the general slope of the mountain, and was covered with low pines. The trees that reached to the crest were dwarfed down and planed off as smoothly as if it had been done with shears. The west side presented a bare face of fine loose rock without vegetation. There is no doubt but that this whole gap has been gradually worn through the mountain by the west winds. Being near the center of the depression in the range which forms the pass, it gets the most concentrated part of the mass of air passing through the great funnel above described. Of course it is probable that most of the work has been performed by drifting snow and beating rains; but that the wind, unaided by other elements, has at times done great execution here cannot be doubted. Climbing up through the gateway we ascended the ridge south of it, and this, after a long walk, brought us to the summit of the mountain. On the east side a deep cañon is formed between this and a somewhat similar mass about three miles distant. This drains to the southeast into the Cucharas River. The mountain has a general trend from northwest to southeast, being nearly straight. The crest is very sharp, while on either side steep slides of loose rock extend 2,000 feet down to the timber. The only trees on the side-slopes of the mountain are a few pines near the gap through the ridge. This peculiar barrenness of vegetation gives to the peak the appearance of great height, but in truth the summit is only 11,512 feet above the sea, or 500 feet below the true timber-line. Almost all the related knobs to the east and north have bare crests also, although the highest is still lower than station 5. The ridge of this station is nearly 2 miles long, and has its highest point a little southeast of the middle. From here an extensive and interesting view of the surrounding country is obtained. The fact that it occupies a position opposite the center of the pass and high above it, makes it a key-point for the topography around it. To the south the headwaters of the Cucharas are spread out before you, with the junction-points and important bends so sharply defined as to be accurately sighted with the instrument. In the same direction, but distant about 16 miles, the two Spanish Peaks—notable landmarks in this region—stand out boldly with their curious system of radiating dikes extending many miles into the valley of the Cucharas.

Between the West Spanish Peak and the main range there are some hogbacks, so sharp and so continuous that from a distance they would certainly be taken for dikes also, but a closer inspection reveals their true nature. To the south of station 5 we see Trinchara Peak, distant about 20 miles in a straight line, but as we are looking in the direction of the range, most of the high mountains near it are hidden. To the southwest we can look over the depression in the range, and get a view of the southern part of San Luis Valley. To the right of this we see the great mass of the Sierra Blanca, with the bare smooth crest of "Old Baldy" in the front. North of us, and about 30 miles distant, we could see the depression of Wet Mountain Valley, with the Wet Mountains east of it, culminating in the bald summit of the Greenhorn Mountain. To the east these mountains fall very abruptly to the level of the great plains. About one hundred degrees of the horizon east of us, extending from Greenhorn Mountain around to East Spanish Peak, is taken up by the plains.

The general course of the Huerfano is traceable by its low bluffs almost to its junction with the Arkansas River. The curious little volcanic cone east of Saint Mary's forms quite a prominent landmark in the course of the river. Several other cones, much resembling it in appearance, are to be seen east of station 5 and north of the Spanish Peaks.

Leaving the peak, we traveled down the west slope of the pass and found camp on the Sangre de Cristo Creek. The vicinity of this pass is one of special interest, and a description of it may be necessary. The pass proper is a double one; the road over the northern branch leads to the northeast down a small stream to Badito, while that over the other leads down the Cucharas to La Veta. The north pass is called the Sangre de Cristo, the south Veta. The height of the former is 9,454 feet, while the latter is 9,300 feet. It is by way of this latter pass that the Denver and Rio Grande Railroad is to be extended to San Luis Valley. All heavily-loaded teams going west must take the Cucharas route, as it offers a very even and gentle grade, but the distance is several miles greater. On the west side of the summit the two roads unite and follow down Sangre de Cristo Creek with a gentle grade to San Luis Valley.

Turning up a branch of the Sangre de Cristo on the north side, we made station 6, on a peak just above the timber-line. We found some miners at work along the stream, on placer-claims, but they seemed to be doing poorly, as the gold was very scarce. Returning again to the main stream, we marched to Fort Garland, making station 7 on a low point near the creek. The next station to be made was on the highest point of the Sierra Blanca. We had seen this mountain mass from all sides, and nowhere did we see any easy way to the summit. The center peak was buttressed on all sides by secondary peaks, over which we would have to climb to reach it. After camping high up on Ute Creek, north of the fort, we started on the morning of June 19 to make the ascent. Knowing what was before us, we took an early start, leaving camp at half past five in the morning. Following up a ridge on the south slope of the mountain, we were compelled to tear our way through thick, quaking aspen over very rocky ground. But, taken altogether, this part of the climb was no more difficult than usual. We succeeded in riding as high as the timber-line, where we left our mules. From this point, taking our books and instruments, we traveled the remainder of the distance on foot. Climbing upward about 2,000 feet over the loose rocks, and crossing over a low peak by the way, we reached the summit of the high secondary peak which appears so prominent when viewed from Fort Garland. From here the fort was distinctly visible, although it was nine miles and a half distant in a straight line, and 5,670 feet below us. From this point we had for the first time a clear and distinct view of the difficulties before us. Extending across from us to the main peak was a narrow, sharp ridge, one and a half miles in length, cut across in many places by deep notches. Even in these mountains, so characteristic for their ruggedness, this ridge was a wonder of narrowness and sharpness. On either side of it was a great amphitheater, 1,500 to 2,000 feet in depth, the one on our left draining out to the southwest through a narrow gorge, while that on the right drained into Ute Creek through a much larger gap. Each was about one mile in diameter, each contained many great banks of snow. The one on the west was most perfect in form, and was more nearly surrounded by great precipices, but that on the east side contained by far the greater quantity of snow.

Passing from the secondary peak toward the main summit, there was a fall of a few hundred feet to the sharp ridge, which continued for some distance very irregular but approximately level, after which it began to rise gradually. But in the details it was so uneven that we were continually going up and going down without any level parts or regular slopes. On the east side the ridge was bordered by great precipices many hundreds of feet in height, ending below in rock slides, secondary precipices, or banks of snow. In some places the bluff must have been nearly a thousand feet down and nearly vertical. On the west the slope was gentler, but still so steep that, excepting in a few places, a slip of the foot would send a chill through you, and a fall meant utter destruction.

These facts gave us little opportunity to choose our way, but we were forced for the greater part of the distance to walk erect along the narrow crest, which generally consisted of blocks of stone set edgewise and cracked through and through. Almost all mountain-ridges are very narrow in some places, but in others widen out considerably, but this was all narrow. As we neared the peak the grade visibly increased, and when we got within a horizontal distance of a few hundred yards of the summit we were confronted by a very steep slope of cubical blocks of a very black kind of rock. Up this rise of a few hundred feet we climbed with great difficulty, and at last reached the summit at just five minutes before 12 o'clock, having been six hours and a half from camp. In that time we had traveled more than ten miles horizontally and 6,400 feet vertically. From the summit the view was very extensive. A long range of high peaks appeared, extending southward from Sangre de Cristo Pass far into New Mexico, till they were lost below the horizon. The whole southern portion of San Luis Valley was laid out beneath us, with its many little plateau-peaks massed together near the Rio Grande, while not far from its lower end two great volcanic domes of very oval profile stood nearly opposite on each side of the valley. In the far west the main range was clearly visible, with its high plateaus covered with masses of snow. From one point near the head of the Alamosa, great volumes of smoke issued forth and extended in a low streak eastward across the valley, and at certain times in the day reached beyond Fort Garland, a distance of 70 miles. We afterward found it to be the result of a fire in the Alamosa Cañon, near the Summit mining-district. The Rio Grande had overflowed its banks during the spring thaw, and the water still covered many miles of the level valley. The valley itself spread out, an area of nearly 4,000 square miles, apparently as level as the ocean, but the whole of it appeared quite as much like a desert as any to be found elsewhere.

For a time we may survey the horizon and wonder what further mysteries dame Nature has hidden beneath the veil, but we cannot do so long, for of all the grand and rugged scenery which in these mountains has been presented to our eyes, nothing can surpass, either in ruggedness or in grandeur, the little piece of country immediately about us. If we seek for grandeur, where can we find a greater or more precipitous descent than the north face of the peak, where a stone thrown out into space will fall half a mile without striking? The great precipice of Uncompahgre Mountain is more imposing, because it stands above all its surroundings, but its height is only a thousand feet. If we look for grandeur in mountain form, what is more grand than the great mountain under our feet? Nor are snow and frozen lakes at all wanting to give luster or add sublimity to the scene which the God of nature has laid before us.

Not less than six great peaks are arranged about us as a center, yet there is no confusion. At least three are connected with the main one by ridges similar to the one by which we came up. On the east side Old Baldy, with its bare conical summit, the most distinct of all the subordinate peaks, connects across to our present position through a much lower gap than any of the others, but for a short distance between the gap and the main peak the grade is almost precipitous. From some of the subpeaks secondary ridges lead to other peaks beyond. One mile to the southwest of us is the highest of the secondary peaks. It is connected with the main summit by a ridge as high or higher than that we have already described, but so rough as to be perfectly impassable to man. The east face of the peak is one immense wall of rock, more than a thousand feet high, so steep and rugged that snow can nowhere find a resting-place till it reaches the bottom of the amphitheater. To the southwest a ridge leads down from the peak to the timber, but this is apparently inaccessible also.

Northwest of us are several peaks quite as high and rugged as their neighbors, having a scraggy ridge connecting with the main peak as in the other cases. Among the quartzite mountains of the San Juan Range we had seen peaks, quite as rugged as these and nearly as high, massed together in great numbers, but the one thing lacking was unity. They were indeed giants, but lacking the subordination of the parts to a distinct head; we saw nothing but confusion. The Sierra Blanca, on the contrary, is a family of giants, and when you stand on the center peak you can look over all the others. All the secondary peaks are distinctly subordinate to this primary one. The highest of the others is several hundred feet below it. When we first set foot on the summit we were struck by this fact, for such a beautiful subordination of parts we had not before seen anywhere among the mountains of Colorado. Southeast of us lay one of the great amphitheaters, which was almost covered with snow and ice, while many little frozen lakes extended to a level more than 2,000 feet below us, notwithstanding this was a clear and beautiful day on the 19th of June, and high up above where we stood the sun seemed to give out a fair modicum of heat. The steep, rocky wall on the south side of the great cavity was marked with many long and curious streaks of snow, which, accommodating themselves to rough ledges and crevasses of the rock, formed a great variety of figures, yet all reaching like fingers down toward the frozen lakes and fields of snow in the bottom of the basin. So high above them rose the walls of rock that the lakes were nearly all day in the shadow.

The summit of the mountain was a model one, about 10 feet in width, and covered with finely-broken rock of a very hard, dark variety. The only relics of former visitants consisted of a curious circular excavation 6 to 8 feet across, surrounded by a wall of loose rock 1 to 2 feet high, which must have been the work of an Indian; but how an Indian could have climbed up there I cannot imagine. But why he did it is still less explicable. It would be useless as a lookout, since it is 7,000 feet above the base and nearly 10 miles distant from the nearest point of the valley. It could not have been used in hunting game, since, with the exception of a rock-dog, we saw no evidence to show that either sheep or bear had ever visited the place. The latter animal often scratches a bed in the rocks on the high peaks, but the excavation here was too large and regular to have been his work. In the center of the circle was a well-built monument of loose stones about 5 feet high, in which we found a printed form, on the back of which a short note was written in pencil and signed J. T. (J. Thompson). In this, Mr. Thompson says that, excepting the Indian relic, he had found no evidence of the peak having been previously visited. I understand that he staid all night alone on the summit, which must have been a strange experience.

Having occupied three hours in work on the peak, we started for camp. On the way we made station 9, on the southern knob. We reached camp at 9 p. m. The ascent occupied six hours and twenty-five minutes, and the descent six hours and five minutes. The difference of level between the summit of the mountain and the foot of the flagstaff in Fort Garland was very carefully determined by direct fore-and-back sights between the two points, checked by sights from each point to secondary points in the vicinity. The difference of level as calculated is 6,467 feet, and our determination of Fort Garland is 7,997 feet above sea-level, which gives the absolute height of the peak at 14,464 feet above the sea. Our height of Garland is from a number of barometric observations.

From Fort Garland we took our course westward across San Luis Valley toward Del Norte. From the fort there is about 30 miles of desert entirely devoid of water, except at two points, one about seven miles out, where there is a cattle-ranch, but the water here is poor. About an equal distance from the Rio Grande on the same road is a house and a fine spring of pure water.

Marching up the Rio Grande we reached Del Norte on June 22. After making a number of stations on the volcanic buttes and high plateaus north of the town to fill in an unfinished piece of the work of 1873 and 1874, we came back and traveled southward toward the Summit mining-district. Taking the new wagon-road, we soon attained a considerable elevation above the plain, which gave us relief from the heat that had been so oppressive on the lowlands. The road takes no roundabout course up cañons and byways to avoid grades, but takes its course for the highest point in sight, and passes directly over the summit of a dome-shaped peak 13,176 feet above sea-level. From the road almost the whole of San Luis Valley is visible, with the great ranges east of it spread along the horizon. The mountains north of the Rio Grande and many peaks west and south of this are to be seen, making the view quite an extensive one. Many points 80 to 90 miles away are visible. The road passes along near the brink of a precipice on the east side of the peak, where a large bank of perpetual snow is to be seen, several hundred feet below. The bank has eaten a large cavity out of the side of the mountain. The road is very steep in many places, and for over 10 miles it remains above timber-line. It was expected to have it soon ready to bring castings over it for the mining-machinery in the district. The great height will make the road impassable for the greater part of the year, while even in summer the boggy nature of the soil will be very troublesome. From the road we got a good view of the Alamosa Cañon to the south, and a rugged place it appeared. In a very rough part of the deep cañon near the mines a great fire was raging among the spruce trees; from this the smoke rolled up in enormous masses so dense it almost seemed it could be cut. Occasional glimpses of the fire beneath, revealed to us through gaps in the column of smoke, gave us some idea of the intensity of the heat generated by the combustion of the forest. The depth and ruggedness of the cañon, with the dense rolls of smoke boiling forth, and occasionally illuminated by the blaze of the fire whenever a gap opened to view the burning element below, all taken together made the scene a suggestive one. But this smoke had been troublesome to us, as it obscured the view of all distant points, and at times even the near objects were lost to sight. We were daily expecting the summer rains to commence, which would soon extinguish all the fires. On June 28 we camped at the mines, and although it was considerably below timber line, we found some snow still lying about, but it was fast melting away. All the high plateaus west and south of us were covered thick with snow-banks, so that the nights were very cold; still we found the mosquitoes so numerous that we could scarcely work for them; they were everywhere in great numbers, except on the high sharp peaks, where there was wind enough to blow them away.

In this region we made stations 17, 18, and 19, all above the timber-line. The latter has been named Summit Peak. On some of these points we were troubled by electricity, but not seriously.

From this place we moved northward and westward, to the head-waters of the South Fork of the Rio Grande. From some of the peaks near the continental divide we obtained distant views of the San Juan River. After following the divide in a westerly direction, accompanied by the pack-train, we turned to the right and descended into the cañon of a small branch of the South Fork and made camp. During our high ride we were enabled to see the courses of many neighboring streams. To the south and southwest there is the most abrupt descent, being in many places made up of a succession of bluffs. From Summit Peak northward and westward these bluffs attain great dimensions, and are weathered into a wonderful variety of forms.

The eastern branches of the South Fork run through rough cañons, composed of steep timbered slopes, extending many hundred feet above the stream-bed, terminating above in bluffs, which are the edges of plateaus contained between the water-courses. These have once formed a continuous flow of lava several hundred feet thick and many miles in area. The following day (July 1) we left the train to move a few miles down stream while we climbed again up to the divide, this time a little farther west than we had been before. On our way we found a great deal of snow still remaining in the forest far below the timber-line. This made the soil very miry and difficult to pass over.

Making stations 21 and 22, near the divide, we started for camp, and found a very good Indian-trail leading nearly in the direction we wanted to go. We were thus enabled to avoid much thick timber and many swampy places. This trail is the most direct route from Del Norte to the Rio San Juan. As far as we traveled over it it was good, but it is probably very steep on the south side of the pass, as the mountains fall very abruptly to the valley of the San Juan. We found camp located near the junction of two creeks, one of which we had camped on the night previous, and the other came in from the southwest. Near their junction both streams cut deep, narrow channels through the rocks. The bed is in most cases very narrow and the current very swift. The main stream retains this characteristic for many miles of its course. The next day we traveled down-stream. Here and there we found the remains of an extinct Indian-trail, but it was too dim to be followed. It is even doubtful whether there ever was any Indian travel up and down the cañon. It is probable that Indians reached the headwaters of the stream from the San Juan and Del Norte sides, in which case the old trail might have been used for hunting only. Except in a few small breaks, the box cañon was very continuous, and we had to travel along the side of the ridge near the brink of the precipice.

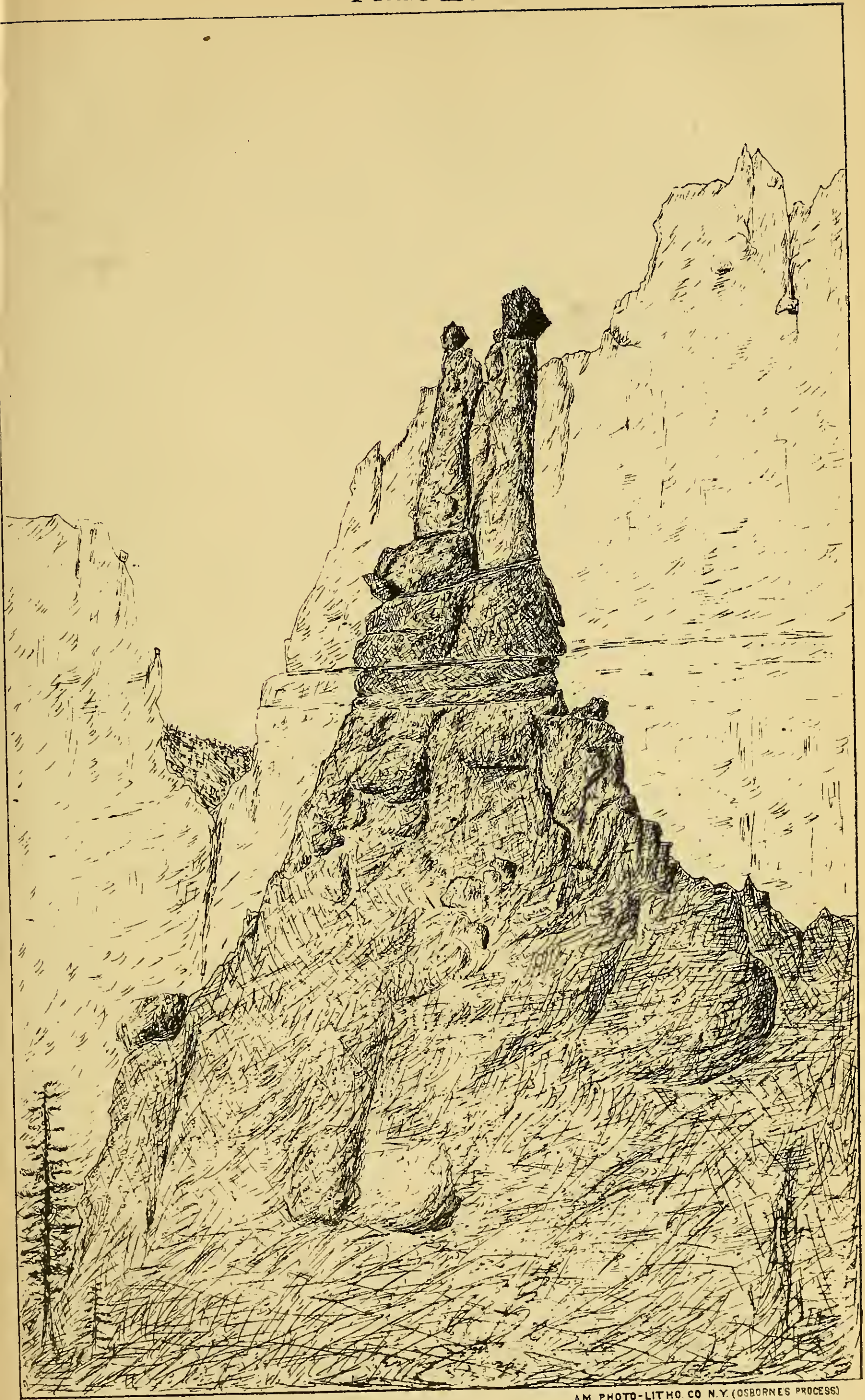
Wishing to make a station on a high bare plateau west of the stream, we had great difficulty in finding a break in the bluffs through which we might descend to the stream. After a time we succeeded in finding a narrow gap filled with loose rock, in which was growing a few pines and shrubs. The slope was very steep, but as far as the fine loose rock continued we could slide our mules well enough, but near the lower end the rocks were very large and sharp, but with some difficulty we reached the bottom without sustaining any injury to our animals. The depth of the cañon here is about 700 feet. The stream-bed was filled with large bowlders, among which the waters rushed with impetuous velocity. The space between the stream and the walls on either side was very narrow, scarcely affording room for us and our three mules to stand while looking for a place to cross. The creek probably did not exceed thirty feet in breadth and only a few feet deep, but the crossing was still a dangerous undertaking, on account of the swiftness of the current and the fact that it was bordered by a thick growth of willows and other trees, making both the ingress and egress difficult. Passing over in safety, we came to a little level space beside the water, then another steep slide leading up to the top of the bluffs. This was higher than the preceding, and quite as difficult. Above we came into thick timber, whence we ascended steep slopes, with fallen trees across our path, other but lower bluffs, then went down into a depression, in the bottom of which was a lake, surrounded on all sides by dense timber. It looked as if this little body of water had been studiously hid from the eye of man, and whether a white man will ever again see it I do not know. But I do know that it cannot be seen from any peak or pinnacle, rock or crag, in the vicinity. It cannot be seen till the traveler comes within a few hundred yards of it. It is guarded by such barriers of horrible bluffs and cañons, fallen timber and swamps, that I hope never again to break into this most secret sanctuary of nature. From this lake we followed up a ridge for a few miles, when we emerged from the timber upon a high plateau above the snow-line, covered with a short growth of grass whenever it was not too rocky, and in some places with low willows two to four feet high. Several high peaks appeared to the south, but the highest peak near was situated about seven miles to the west of us. On this plateau, of station 23, we saw a small band of elk; and from what we have seen at one time and another, I should judge that almost all the elk in the region south of the Rio Grande have resorted to these plateaus for safety, and from the ruggedness of the country it is probable that they are seldom disturbed in their retirement. There is no doubt, however, of the fact that all kinds of game, and especially elk, have always been very scarce in this part of the country. Returning to the South Fork by the way we came up in the morning, we again crossed the cañon and came upon the tracks of the pack-mules, which soon lead us to camp, which we found on the top of the bluffs near a stream which enters from the east. Near camp a sandstone point extended out over the main cañon. From here the stream could be seen far below, with the walls of rock rising 700 to 800 feet on either side. All this has been cut out by the creek, thus giving one some idea of the power of erosion of even a small stream when it is permitted to work ceaselessly through the ages. Standing upon this rocky promontory, the noise of the stream came up to us as it boiled and surged through its rocky bed.

From this camp we continued on our course toward the Rio Grande. At first we found the trail quite difficult, but before long the bluffs began to decrease in height and a narrow valley to appear between the walls. Along the latter we rode without trouble, and soon found ourselves in an old wagon-road. Soon the bluffs disappeared and were exchanged for timbered slopes and ridges, the air felt warmer as we reached a lower level, and the valley was covered with scattering yellow pine. This species never grows above a certain line, which may be given roughly at 9,000 feet above the sea, and never grows in thick forests, but in groves of scattering trees. The individual trees attain a height of from 70 to 100 feet, and a diameter at the ground of 2 to 4 feet. In our ride down the stream we passed a saw-mill in a grove of these same pines, near the head of the little valley. We made camp on the Rio Grande a few miles above the mouth of the South Fork. Following up the narrow barren valley of the Rio Grande, on the fourth of July we made station 25 near Wagon-Wheel Gap, just above the toll-house. The region of this gap is very curious on account of its great bare bluffs. The gap itself is composed of a portion of the river-bottom, probably 300 feet wide and a few hundred yards long, with a detached wall on the west and the bluff edge of a high but small plateau on the east. The wall on the west is about 300 feet high, while the height of that on the east is 600 or 700. The plateau has probably at some time been continuous where the gap now is, and the river must have passed through a low place a few hundred yards southwest from the gap. The detached table on the west or south side of the stream has been used by the Indians to guard the passage up the river. Many little walls of loose rock, to shoot over, line the whole length of the bluff. The wonderful adaptation of the gap for defense against intruders must have been noticed by every observant person who has passed through it. It is almost, if not altogether, impossible to get up the river except through this narrow defile, which affords a roadway not more than 50 to 100 feet in width. It is supposed that the fortifications have been built by the Utes, who held the mountains in their wars with the Arapahoes and Cheyennes of the plains.

The plateau on the east side is far from level, but dips toward the northwest. The bluffs continue eastward from the gap, following the course of the stream till opposite the toll-house, where they attain their greatest elevation. The walls here have a height of about 1,900 feet, nearly perpendicular. On the highest point we made station 25, riding up to it from the north side. These high bluffs, being of a dull gray color and presenting little variety of form, may be imposing, but are very far from picturesque. In making the station we were treated to a cold drenching rain, accompanied by hail and sleet. Opposite to the station to the south a stream, called Hot Spring Creek, joined the main river. Near the mouth of this creek we camped. A little up-stream from camp were some large hot sulphur-springs, with a temperature ranging from 120° to 130° Fahrenheit, but the great quantities of sulphur and soda contained in them made the water appear to be boiling. A number of invalids were in attendance. The morning of July 5 we moved up the Rio Grande, and on the way crossed over to the north side of the river and made station 26 on a high peak, in the group south of Los Pinos, on which station 33 of 1873 and station 2 of 1874 were located. From this point we had quite an extensive view of the plateau-system which extends southward from this mass. While at work on the summit, clouds began to gather, and we had the novel experience of a snow-storm on the 5th of July, which is a rarity even in this region of storms and cold. When we left, the snow covered the peak, but not deep enough to be much in the way. After camping on the river about five miles above the gap, we again moved up stream, making station 27 on a hill south of Bristol Head. Crossing the river we struck into the range south. In this vicinity the Rio Grande bends five or six miles to the south to avoid the great promontory of Bristol Head. In all the flat places along the river the marks of old river-beds, far from the present position of the stream, show that the river has often shifted its course, and is even now changing continually. Later in the season we found large bowlders of quartzite which had been brought from the head of the Rio Grande and deposited on the eastern edge of Antelope Park 900 feet above the river. These are now over 40 miles distant in a straight line from their point of starting. This, however, can scarcely be accounted for by supposing the stones to have been transported by water. These transfers must have been brought about by glacial or other agencies.

At the bend in the river south of Bristol Head two large creeks enter from the mountains south. These streams are nearly equal in size, and the eastern one is made up of four distinct branches. One enters near the mouth from the low mountains to the east. This runs the least amount of water of any of the branches, as it does not drain any high country. The next one is a little larger, and comes in from the west, and drains the super-timber-line plateau, on which station 30 is situated. The next tributary, a still larger one, enters from the east and drains much of the high region east of station 28. The main stream heads west of station 28. It was on this, about four or five miles above the mouth of the largest tributary, that we camped. Rain had commenced falling quite early in the day, and now it was coming down steadily. The next day the storm continued, and the next, till the little stream of pure mountain water, near our camp, was changed into a raging muddy torrent, perfectly impassable except at great intervals. Having passed a mile or two below camp some wonderful natural monuments, we took advantage of the storm to climb through among them and examine them. The number, variety, and size of these natural carvings were well worth the study, and we only regretted that Mr. Jackson could not be there to photograph them. The monuments were of all heights, sizes, and shapes. Many were 300 to 400 feet high, with a thickness at the base of 40 to 50 feet, while others were mere pigmies. All were either capped with large stones of a different kind from the mass of the column or bore marks of having been once so capped. In fact great numbers of these hard, dark-colored bowlders lay scattered about below, many of which had fallen from the tops of columns. In some cases we noticed rocks of a dark color, and, apparently, very hard, weighing many tons, which rested on a pillar several hundred feet in height, when the top of the column sustaining the great weight had no greater diameter than one foot. Some stones resting on low pedestals which we could reach were balanced so delicately that a touch of the hand would move them and a push would throw them down, although their weight was very considerable. In some cases a second short pedestal rested on the capping-stone, while this again was capped off with a bowlder. The mass of the column were composed of conglomerate of a reddish color, made up of gravel cemented together very firmly. The capping stones were of an entirely different kind of rock. If you consider that these cap-stones varied in size from a few pounds weight to 20 tons or more, and that the columns ranged in height from a few feet to 300 or 400 feet, and that they were massed together so thickly that we could scarcely find our way among them, you will be able to form some conception of the strange scene presented. The general plan of the arrangement was this: The area covered was probably half a mile long up the stream and several hundred yards wide. The ridge of which these formed a part commences at station 28, and taking a general northerly course, lies for the first four miles far above the snow-line, when it culminates in a high red peak and then plunges suddenly down to the timber, whence it falls quite gradually till it loses itself in the level of the valley near the junction of the first stream from the east. Now, it is on the west side of this ridge, at a point about six miles south of the Rio Grande, that we find this curious group of monuments. The mountain-rock is a kind of conglomerate of coarse gravel, with dark, hard bowlders interspersed. Running out from the ridge and at right angles to it is a series of parallel walls, from 40 to 60 feet thick at the base and 300 to 500 feet high at the highest points. These walls are from 100 to 200 feet apart, and their summit lines join the ridge at the crest. The spaces between the walls have a very steep slope, so that the heights in each wall range from zero at or near the top of the ridge to the maximum height near the middle of the length of the wall. These walls are wonderfully regular as to thickness and direction. In one place two of them, each over 400 feet high, inclose a space completely, except at the lower side, both being perfectly unbroken. Many monuments with their capping-stones rise from the top of these walls. In some of the spaces between walls are high lone monuments. In the northern part of the group the regularity of the walls seems to disappear, and an immense number of lone monuments take their place. I believe this part to have more wonderful curiosities than the southern end, but we only had time to examine a very small part of the whole group near the edge, and did not get into the center of the mass at all. Several of the walls had large and very regular arches worn through them. From some views these arches appear as perfect in form and proportion as if built by the hand of a mason. I succeeded by climbing along the wall on a very narrow ledge to get into one of these, and found it remarkably perfect on a near view also. It was about 50 feet span, with an altitude of 20 to 30 feet, the base being somewhat uneven, and the wall about 40 feet thick. This would seem to be a pretty large arch, but looking at it from the outside it is dwarfed into insignificance by the size of the massive walls through which it forms a gate-way. This arch was situated about 100 feet above the foot of the wall, and about 200 below the summit. Looking out of it on either side you could see an inclosure formed by the walls on the sides. The illustration is from a drawing made under the arch of a column between it and the next wall to the north. (See Plate L.) This is nearly 300 feet in height. The wall in the background was nearly 500 feet high at the highest point. It was surmounted by a number of monuments of many different sizes, which, with their cap-stones, might well be likened to sentinels keeping guard on the walls of a great city. These are sentinels in more senses than one—sentinels guarding from profane eyes the holy secrets of nature—for the stones which they bear upon their shoulders, far over the traveler's head, carry a menace not to remain unheeded. They resemble human sentinels in another sense also, for they possess that characteristic so rarely found in inorganic nature, a very definite term of existence. The hard bowlder incrusted in the walls has all the softer material around it worn away by the storms, and it, in turn, protects from the weather the column of conglomerate vertically under it. Thus it slowly grows out of the destruction of things about it. In fact almost all the wonderful forms in nature grow in this way. This is a remarkable case of nature's sculpture, slow sculpture, too; for nature when she comes to work up the details of her monuments is very deliberate. This work, unlike the great and noble carvings of mountain forms, does not require thousands of ages,

Plate L.



AM. PHOTO-LITHO. CO N.Y. (OSBORNES PROCESS)

but is accomplished in a few. Here nature does not work through the slow lapse of geological time, but the chiseling of a hundred years is appreciable. This, too, is slow, but not in the same degree as the great geological changes.

Finally, after a long but still a definite period of time, the monument is finished. A great column, beautifully tapering to its summit, is formed, and is surmounted above by its capping-stone, giving to it a dignity and a character. But scarcely is the work finished before the very elements that brought the statue out of the solid wall commence its destruction. The powers of erosion that carved it out slowly wear away the column itself, so that it becomes more and yet more slender, yet even in its decay its grace and beauty increase also. Finally the part of the column near the summit becomes too attenuated to bear up its colossal burden, and the great stone topples and falls, plunges down hundreds of feet, and then rolling down the mountain-side soon finds its resting-place in the thick timber that skirts this natural museum on all sides. Thus we can see monuments of all ages from inception to decay, and some newly decapitated look like corpses among their fellows. These are not yet exempt from the terrible power of their uncompromising foes, but must year by year be worn away, till another stone now embedded in the body of the column succeeds to the place of the first. This process may continue through many generations of statues, but the ultimate end is plain. This group of monuments is far superior to the Garden of the Gods, near Pike's Peak, in the number, size, and beauty of curious forms contained in it. The general appearance of the two is very different also. Whether this strange group has ever been visited before I cannot say, but anyway it is well worthy of a much more extended notice than the above. Its situation, only about seven miles from the main road from Del Norte to the San Juan mines, makes it very accessible for such as take an interest in the things that are grand and picturesque in nature.

On the morning of July 9 the rain still continued to fall, but we determined to attempt the ascent of South River Peak, at the head of the creek. Climbing up the ridge above the group of monuments, we crossed over it, and followed diagonally across the east slopes of the peaks which form the highest part of the ridge. We rode along near the timber-line, and crossed the head of the stream draining the east side of the ridge. This cañon was quite deep, and just above the timber line contained a number of little lakes in basins hollowed out of the solid rock. Reaching the summit of the peak, we found it well suited for a station, as it commanded all the surrounding drainage. To the south and west there were a great many peaks nearly as high as this, and a considerable area of plateau-country above the snow-line. Just to the west of us, and almost under the peak, was a deep and broad basin with bluffs nearly surrounding it. This forms the head of the creek on which we were camped. A considerable cañon led down toward the northeast also. We were much favored by a partial breaking up of the storm, which gave us clear but detached views of the near country. We found on the summit a monument of loose stones which had been built by Mr. Gardner the year previous, but since the time of his visit the lightning had struck the peak and thrown down the upper half of the monument. We noticed also where the same element had entered the solid rock of the mountain and ripped it up in several directions, showing the power of the stroke. These slight monuments on the peaks are struck hundreds of times without leaving a mark, but now and then you will find where the hardest rock is cracked and torn up in blocks of great size. These facts tend to show the enormous and almost unlimited power that may be contained in a stroke of lightning in these high regions. While on the summit we noticed again one of our old-time friends, a lone grizzly, traveling along the east slope of the peak, some hundred feet below us. In his travels he came to a steep slide, part of which was occupied by a snow-bank about 40 yards in length. The bear walked out upon the snow, and sitting on his haunches, slid down to the bottom as deliberately as if he had never traveled in any other way; then proceeded on his journey across the rock-slides. From where we stood we could see distinctly the long streak left on the snow-bank after he had passed. Returning to camp, we were still harassed by rain to some extent, but during the night it set in heavily again. The morning of the fourth day found it still coming down. We moved camp a few miles down-stream, and then rode up the east branch of the creek, passing through fallen timber and marshes, till we at last came out upon a high, bare plateau. In the forenoon the storm abated, and we traveled along quite comfortably till nearing the summit of the peak, where we had to leave our mules. The foot-climb was short, but before we reached the top rain began to fall, and before we had commenced work a cloud settled over the peak like a great extinguisher, and we could nowhere see a hundred yards before us. Rain and sleet fell steadily, and we were compelled to abandon the station. On our return the heavy west wind and the sleet made the riding very uncomfortable, both for us and for our animals. At a point of the plateau, probably 12,500 feet above the sea, we noticed a number of little walls of loose rock, which had been used as rifle-pits by Indians in shooting mountain-sheep in the days of arrows. The plateau was very bleak and cold, but as soon as we reached the timber we found the temperature quite comfortable. The next day we made station 30, on a plateau west of South River Peak, and the next we started from our camp on the Rio Grande to ascend another larger table-land southward from Antelope Park. This plateau is very uneven. In some places the portion above the timber-line is several miles across, while in others it narrows to a mere ridge, but it continues essentially unbroken from station 31 to Weeminuche Pass, a distance of over 10 miles in a straight line. In some places side branches lead off to a considerable distance. On our return, while yet far above the timber-line, Mr. Wilson shot a grizzly; and as we were riding along with some of the meat behind our saddles we saw a young elk trotting toward us from the north side of the plateau and closely followed by three grizzlies in single file. The latter seemed to be perfectly mad with the excitement of the chase, while none of them, either pursued or pursuers, seemed to notice our two mules, although we were in open sight, with no obstructions in the way. I shot and wounded the elk as it came within range, but the bears were so wild with excitement that they did not hear the shot, though they were only a few hundred yards away. They followed, one behind the other, and each would rear up on his hind legs at every 20 or 30 feet distance and gaze around in a fierce, excited manner over the low willows, then would drop on all fours and snuff along the trail. As they rose up and presented their black fronts, their fierceness and power was much more manifest than when they trotted. Had they run straight on without snuffing the trail, they could have caught the elk in a minute, as it was tired out and lost. By this time our mules were getting restless; and as they were already carrying some bear-meat on their backs under protest, we feared a stampede, so for want of anything to tie them to we tied them together, and tore the meat off the saddles.

We now took a long-range shot at the bears; whether we hit them or not, they appeared for the first time to see us, and, taking the back track, quickly disappeared over the ridge whence they came. In the strife the wounded elk limped away, and getting down off the plateau disappeared in the timber. The bears had probably made a dash upon the band of elk while in the forest, and, separating them, had followed the calf, and doubtless would have caught it had we not come along when we did. Returning to camp, we crossed the Rio Grande the following day, July 13, and making station 33 on a bluff near the river and station 34 on a point on the eastern edge of Antelope Park. At this latter place we found quartzite bowlders that must have been brought from the group of peaks near the head of the Rio Grande. The next day we marched up the river along the trail leading to the San Juan mines, and striking the Ute trail from Los Pinos we turned southward and followed it up to the summit of Weeminuche Pass, where we camped. This is the best pass through the range between the Rio Grande and the San Juan. It is broad and even through nearly its whole extent, but the ascent from the Rio Grande and the descent to the head of the Piedra are very abrupt. It is scarcely possible to ride an animal up either; but, for a pass in these mountains, it is remarkably free from dangerous places and from bogs. On July 15 we ascended the range east of the pass. On the high plateau, about 12,500 feet above sea-level, we found a ptarmigan's nest, with four eggs, built on the level ground. I believe this is the first specimen of the kind found, and it was carefully preserved for the Smithsonian Institution. These birds are met with in considerable numbers in all places above the timber-line. They are a little larger than quails, and in winter are as white as the snow about them; but in summer, as the snow melts away, they take on a grayish color, with only a few white feathers on the wings. From this region we had a fine view of Rio Grande Pyramid and many other peaks in the work of 1874. Leaving this region, we traveled southward along the trail. For some distance it follows down the Rio de Los Pinos, and then turns to the left through a curious narrow gateway in the granite that here makes its appearance. The bed of this gap is so low that it seems probable that at one time the drainage of the pass flowed into the Piedra instead of the Pinos. From here the trail follows the Piedra, being very steep for the first few miles. As we rode down this south slope of the range, we noticed that the trees and small plants all increased in luxuriance. For a great part of the way the weeds bordered the trail very thickly, and in many places were 4 to 5 feet high. Flowering-plants of many kinds grew in the greatest abundance, while the quaking-asp trees and pines, by their increased size and richness of foliage, testified to the effect of the climate and soil. As we reached the valley below, we found great meadows covered with a rich growth of grass and flowers, and very unlike any of the country through which we had been traveling.

The range from this point eastward is remarkable for its abruptness, and the result is that the many little valleys along the water-courses reach up close to the mountains without attaining an elevation too great for rich vegetation. The head of the valley through which the trail passes has an elevation of about 8,000 feet. Station 36 was made on a low peak south of the main range. From here a good view of the peaks north was obtained, with their precipitous fronts facing the south. These walls presented a degree of beauty rarely to be found in bluff faces bare of timber. The horizontal lining and the peculiar weathering conspired to make these quite picturesque. In height they ranged from 2,000 to 3,000 feet, but the variety produced by the projecting crags and ledges, the spires and pinnacles, took away any appearance of heaviness that otherwise would have been oppressive.

We next marched eastward, crossing the several branches of the Piedra, all of which are beautiful little streams of the purest water. There are no valleys proper, but the whole country may very well be considered as a single valley, since the spaces between the streams are low and quite level. This region is remarkable for its vegetation, as compared with any other part of Colorado. Several important facts conspire to bring about this result. First, the abruptness of the south face of the range permits the valleys to approach close up to the bluffs without attaining an elevation of over 8,000 feet. By reaching the vicinity of the range the rain-fall is much increased. By being low, and having the walls of the range to the northward, a greater degree of heat is attained. These, taken together, give to plant-life its peculiar richness. In summer the weather is quite pleasant, but the rain-storms that continually pass over it keep it much cooler than it would otherwise be. The rainy belt extends to a distance of 20 to 30 miles from the base of the range. This region is subject to continual storms during the summer-time. These commence late in June, before the snow is gone from the mountains, and continue till fall, in September or October, when there may be a few weeks of clear, cold weather; but in some cases there is scarcely a break between the rain-storms of summer and the snow-storms of winter. The whole region is covered with fine yellow pine, and rich grass growing between. Here and there extensive meadows are to be seen. The area covered by this rich growth of grass may be roughly estimated at 600 or 700 square miles, the mass of it lying between the Piedra and the San Juan, while little areas similar to it in their characteristic features are to be found along the Animas, Florida, Pinos, Navajo, and Chama. This would be sufficient to furnish summer pasture at least to numerous herds of stock, but I cannot certify as to the winters, which in this country form an element in the stock-problem; yet it would not be very difficult to drive the herds down the Piedra to the San Juan River, where an elevation of 6,000 feet would prevent the possibility of bad winters. But here again the limited area of grass would give support to only a small number of animals through the long winter of six months. The whole south slope of the range from the Animas to San Luis Valley is covered with a splendid growth of pine timber, while on the Animas and Florida extensive veins of coal outcrop in many places. The whole as far down as the New Mexico line, which passes near the mouth of the Piedra, is included in the Ute reservation or held by that tribe, thus preventing settlers or miners from entering it. Good placers are worked on the La Plata by miners who have rented the land from the Utes, but on the other streams no mines are worked.

Passing from the Piedra southward across large open meadows, we followed down the Rio Nutria, a stream which runs very little water in the summer-time. Here we came to the sandstone tables, which extend southward many miles from this point. At a point just above the junction of the Piedra and the Nutria, and between the two streams, are two notable monuments of red sandstone, which we had first seen from a high station at the head of the San Juan, nearly 40 miles distant in a straight line. They consist of two immense pillars of sandstone, 150 to 200 feet high, and about a hundred yards apart, set on the crest of a hill over a thousand feet in height. The summits of both are flat and probably 50 feet in diameter, and are perfectly inaccessible. Several branches of low brush and a tall growth of grass ornament the top.

The monuments rest on loose slaty rock, which wears away very fast, while the rock above is firm and breaks off in large cubic blocks. With the constant wearing away of the foundation and the cracking of the columns themselves, these curious pillars are fast going to ruin.

West of this region, across the Piedra, there commences a series of hog-backs, very sharp and continuous, which give a peculiar form to the topography. Between two of these the Ute trail from Pagosa passes over to the Animas. Above the crossing of the Piedra that stream is inclosed in a deep cañon for some 10 miles, but below it is open all the way to its mouth. When we crossed it on July 23, it was 30 to 40 yards in width and from 1 to 3 feet in depth, with a rocky bed and swift current. A short distance below the ford we saw a new-made grave, the occupant of which (A. R. Stewart) had been drowned while trying to cross the stream a few months before. This vicinity is a favorite camping-ground for the Weeminuche or Southern Utes. We found a few of these, with their horses and goats, when we passed through. To the west, the trail takes its course up a little stream between two of the hog-backs, thus having a smooth, even grade, with a wall on either hand. These spaces are trough shaped, with very abrupt sides. The ridges are very sharp, with their steepest slope toward the mountains. The Indians, appreciating the peculiar adaptability of the region for defense, have taken pains to fortify a narrow gap near the Piedra with piles of loose stones, to be used as rifle-pits. Under a good leader, a small band of Indians could hold this place against an army, especially since toward the mountains it is backed by dense timber.

Passing by these we came to the Rio de Los Pinos, a stream quite as large as the Piedra. Here we found the ruins of an old bridge, which we supposed to have been built by Major Macomb in 1859. Near this, on the east side of the stream, we found a few pieces of pottery and a dim circular mound in the sage-brush, indicating that we were approaching the region of the ancient ruins. On the west side of the river and several miles below we found a number of these marks of ruins that had long since crumbled to dust. Whether the houses were made of adobe, or whether of stone as the rest farther south, I cannot tell. If the latter theory be true, we may properly assign to them great antiquity, but if the former, the weather of the region might accomplish the same result in a short time. These last relics were situated on a table adjoining the river and about 50 feet above it, which is now sandy and covered with sage-brush. When we were there late in July all vegetation was parched by the great heat, except along a strip a few hundred yards wide near the stream. Considerable quantities of pottery were found on the surface, but all was very much discolored by the weather. The only remains of the buildings consist of a circular mound of earth seldom if ever one foot high, with a basin inside of it distinguished from the rest of the plain by being covered with flint-grass, from the water standing in it in the spring. About some a great deal of burned rock was to be seen. Except one or two little scraps of pottery, we saw nothing to indicate that these early inhabitants occupied the region along the Nutria. They seem to have kept at a considerable distance from the mountains, probably to avoid the cold winters. As they must have used the water of the streams for irrigating their corn, it is not improbable that a close examination among the sage-brush west of the Pinos might reveal some traces of the ditches, since these would likely be preserved long after many other artificial works had disappeared. Between the Pinos and the Florida, and extending southward to the mouth of the latter, is a desert plain, in which the vegetation is mostly sage-brush and cactus, with a few piñons here and there. This dry area extends from the timbered foot-hills and hog-backs on the north to a mass of hills whose northern border forms an east and west line between the two streams a few miles above the mouth of the Florida. This little desert covers about 100 square miles. The edges of it along both streams are occupied by ruins of the extinct people. Traveling down to the Animas and noticing occasional bits of pottery and other relics by the way, we followed the course of the latter stream. Below the mouth of the Florida the highlands are all composed of a dull red sandstone, in layers one above another indefinitely. The side-slopes are formed of numerous successive bluffs, with great blocks of stone in the spaces. After having climbed and wandered among the noble forms of the mountain peaks, the making of stations on these miserable dreary tables is very tiresome and monotonous. Here we miss the cool atmosphere of the higher levels, and a burning sun seems to have dried the very marrow out of the bones of the land. The highest points are all covered with brush, so that we cannot see much of the country about us, but after climbing through the masses of stone blocks we are finally compelled to make the station half way up the side of the hill on some projecting ledge.

On July 27 we came upon a large ruined castle about 25 miles below the mouth of the Florida, on the west side of the Animas. The building was a very large one, but as we approached it we saw nothing to indicate great antiquity. In fact, at first we half thought that after all this might only be the remains of a modern Mexican pueblo, but the pottery that lay strewn about soon dissipated all such ideas. The building was about 250 by 300 feet, with the rectangular corners. The remains of three stories were still standing, while the great quantity of *débris* seemed to indicate that a fourth story might once have existed, but this was only a matter of conjecture. By crawling down under the decayed walls, through a low door, we came into a cell on the second floor. This was the only room which we could enter that was still in a fair state of preservation. It had evidently been a prison-cell. The door was 3 or 4 feet high, and about 2 feet wide. The dimensions of the cell itself, as near as I can remember, were about these: say 7 feet long by 5 wide, and 4½ to 5 feet high. It was situated in the midst of the building, with no opening of any kind to let in light or air except the little door. The wood-work of the ceiling was quite well preserved. On the walls was a plaster resembling sandstone, on which were a great many scratches that looked very fresh, and some rough outlines of men and horses that so much resembled the Ute carvings on the trees along their trails that we did not hesitate to ascribe the work to Ute artists.

The walls were of cut stone about twice the size of a common brick, but the weather had worn away the corners and edges, and the rains had leached out all the mortar if there ever had been any there. In the spaces between the stones were pieces of pottery. The floors were of round poles of juniper with the bark on. The ends of the logs were in no case found smooth-cut, but were ragged, as if worn off by some dull instrument. In one part of the building was a circular tower about twelve feet in diameter, built of scraps of stone of very irregular shapes. The bottom was partially filled with *débris*. In the near vicinity there were circular mounds, marking the position of smaller houses, but they were few in number, scarcely more, in fact, than might be needed for workshops by the inhabitants of the large building. Here we found great quantities of pottery, all more or less elaborately painted. All of it seemed to be of a finer quality than any we had seen near the mountains. I have said that these ruins did not look very ancient, but it must be remembered that as yet we know almost nothing about the climate of this region, but the vegetation and other things point to a very small annual fall of rain, in which case the rate of decay of a stone building might be very slow indeed. The elevation of this place is about 5,500 feet, and the distance from the high mountains thirty to forty miles, which facts would be likely, in this region, to reduce the rain-fall to a very small figure. What is most needed to throw light on the age of these relics is a good set of meteorological observations somewhere in this vicinity.

Crossing over from the Animas to the San Juan, we found another large ruin, but smaller than the preceding. Here, again, was the usual assortment of pottery, out-houses, &c., as in the former. In the banks of a wash that had been cut through on the east side of the house we found a stratum of burned corn, about an inch thick, a little below the surface, with here and there pieces of the cobs. In this ruin, as in the previous, the whole lower story is covered over with sand and trash, and may be in a good state of preservation. A couple of men in a few days could open a way into any of the lower rooms, in which case important relics might be unearthed.

Near this point we noticed a fine kind of cottonwood, having a large, spreading top, entirely unlike the common variety. As we moved upstream we found scraps of pottery everywhere, and the marks of towers on some of the prominent points. It is one of the peculiar features of the subject that the pieces of pottery are so widely distributed. There is no place where you can feel sure that you will not come across them. In some places, on dry sandstone tables, many miles from the river, we found them.

Near here the river is very small, the greater part of it running through the sand underneath. The surrounding country is very uninteresting in appearance. To the south as far as the eye could reach there extended plains very similar in appearance to those along the Union Pacific in Wyoming, only they appeared more desolate, and, being further south, were not so well watered. These rose considerably above the level of the river, and were not terminated by mountains but extended to the horizon. Farther to the east, a mass of sandstone tables, ten times more desolate than the country near it, formed a prominent object in the landscape. The tables were separated by washes from a few hundred yards to half a mile wide. Some points far south of the San Juan seemed to rise several thousand feet above the general level. The river cuts off the northwest corner of the mass, and runs through it for some 30 miles of its course. Almost all of the tables were covered with pines, mostly piñons. We passed through the northern edge of the formation, but this is not nearly so desolate as the northern part.

On our way up the San Juan we followed a trail that turned eastward into this curious country. The first day we traveled 30 miles up a dry wash without finding the end of it, then turned to the left to another wash, and after traveling five miles more we camped near a small spring of very strong alkali water. These dry washes are very peculiar. First as to their length. One that we came across was more than 50 miles in length, without water, except alkali reefs at intervals of many miles. Second, they have such a slight fall that you may travel up one for a long distance and be firmly persuaded you are going down-stream. This fact adds much to the danger of getting lost, especially as there are no bare points above the rest from which to get a lookout, but all the tables are formed of a single horizontal stratum, and the tops are evenly covered with scrubby trees. To find which way the wash leads, the best plan is to examine the reeds and plants in the bed of the water-course, and see which way they are bent. Another peculiar question connected with the subject is this: how have these wide washes been formed? The side walls are vertical, with little or no rock scattered between, but generally the bottom is covered with sand. There can be no doubt but that in the winter or spring great floods of water flow down these almost interminable water-courses, but with the slight fall which they have, no great amount of erosion seems possible.

In our march through this region, soon after we crossed over to the second wash, we saw a number of ancient towers perched on the projecting points of sandstone, far above the valley. One, which was about 20 feet square and two stories high, was built on a little promontory over 100 feet above the bed of the wash. This was well preserved, the walls intact, and the rooms quite perfect. The lower floor was the natural soil tramped solid by use. In one corner the stone was much blackened by fire, marking the fire-place, but a number of pegs driven over it to hang kettles on looked decidedly modern. The whole air of the place was Mexican, all except the building itself, since it must have taken much labor to collect the great number of stones and cut them for the walls. All who are acquainted with the settlers of New Mexico will appreciate the force of the argument that the great labor necessary to erect these buildings points to an origin other than Mexican. In this house no relics were found, but the general appearance made it seem very probable that the place had been recently occupied by Mexicans, probably shepherds, while herding their sheep in the valley during the early spring, when water is abundant. The location of this building makes it admirably adapted for a lookout, and it is not improbable that the original builders may have used it for some purpose similar to that of the present Mexicans. In this vicinity we also noticed towers on the edges of high tables, hundreds of feet above the wash. In one place just beside the trail, a circular tower six or seven feet across was built on a rock that had rolled from the bluffs above. The walls were standing four or five feet high, but whether they were ever higher I cannot tell. This again had a decidedly modern appearance; the stones did not show much weathering. In the vicinity the grass is abundant, but water is wanting. Fifteen or twenty miles east of this we came to some Mexicans with flocks of sheep and goats. The alkali water seemed to ruin the mutton, as it was very dry and stringy, although the country was covered with good grass. After having traveled about 60 miles, counting from the San Juan River, we camped at a spring of good water draining eastward into a basin running north and south, in which were a number of lakes. Along the road we passed several high dikes running in a northerly direction. Making another march of 30 miles, we reached Tierra Amarilla, on the Chama, having traveled about 90 miles through the desert region. On our last day's ride we found a change in the formation from sandstone to quartzite, indicating the approach to the volcanic rocks. As soon as we reached the latter we found the water free from alkali. We found the New Mexican town located in a deep depression, on a table of considerable extent, on the east side of the Chama. A few miles north of it the end of the mountain-range appears faced with high precipices. To the east the mountains fall far below the timber-line, but are still quite rough. To the south, the Chama runs through a rough-looking country, much cut up by cañons, while above it in the distance a number of pretty high mountains may be seen. On the west the country already described, with its bluffs and ridges of sandstone, fills many degrees of the horizon. The settlement is composed of three distinct villages, each several miles from the others, two situated on the banks of the stream and one to the east at the end of the open table at the edge of the timber.

When we arrived, on the last day of July, there were many hundred acres of wheat under cultivation, and the grain looked well, but it was only beginning to head out. Water for irrigation was brought by ditches from the mountain-streams. The houses were nearly all of adobe. The eastern village was built on the pueblo plan, having the houses placed close together, all facing inwardly on an open space, which was neutral ground, on which dogs, cats, chickens, horses, sheep, goats, and Mexicans, of all sizes and ages, might be seen in great numbers. Utes and Apaches were associated with their neighbors. The dress of the Mexican children usually consisted of a dirty shirt, but many were entirely naked. The post-office was situated in the southern village, which went by the name of Nutrites. Leaving this point we took our course northward and westward up a long meadow-valley, then past large bands of sheep down to Navajo. Thus far a plain trail leads on its way to Pagosa Springs. Camping on the Navajo, which was a large creek at that season of the year, we ascended a high plateau west of the stream. On the east it is bordered by great bluffs. Being of volcanic rock and quite elevated, we found fine water, grass, and timber on the top. This table is about four miles in length from north to south, but toward the west it falls considerably and is cut up by many deep gorges.

Following down the Navajo a few miles through a narrow cañon, we left the stream and ascended the slope to the south of it, and soon struck the direct trail from Tierra Amarilla to the San Juan. Below this point the Navajo runs through shallow but very rugged cañons, so that it is quite impossible to follow down it. The Indian trail passes down a wash several miles south of the Navajo. Taking this course, we crossed the San Juan River and traveled down to the mouth of the Piedra, making stations along the route. We found a great many scraps of pottery, both in the narrow valley of the stream and on the sandstone points above it. In some places dim basins on the high points marked the place of extinct ruins. In one place we found a child's skull protruding above the surface of the soil, but it was much decayed.

From our camp on the Piedra we rode down to the point where the river enters a close cañon, in the sandstone. Here we made station 70, on a low sandstone table near the river. On this point we found great quantities of painted and unpainted pottery, all very bright. The pottery above the mouth of the Piedra was much tarnished. This is due to the fact that the rainy belt is very sharply defined on its southern border. This line passes about midway between the mouth of the Piedra and that of the Nutria. Above this the rain-fall is very heavy, but below it would seem to be scarcely appreciable. Above and below the Piedra, on the San Juan, there is a narrow valley, probably 15 miles in length and in breadth ranging from one-quarter to two miles. At present it is covered with sage-brush and cactus, but with irrigation it would undoubtedly produce good crops. The junction of the Piedra and San Juan is about 6,000 feet above the sea.

Having finished this region, we returned up the San Juan, passing along the narrow valley, and finding relics of the ancient settlers even above the Navajo. The sandstone bluffs continued, but the cañon was so wide as to offer no obstruction to our march. At a distance of nearly 10 miles above the Navajo we came to the Rio Blanco, a stream nearly as large as the preceding. This joins the main river from the east and drains the mountain-country between the Navajo and San Juan, while its head branches lead almost up to Summit Peak. Between this stream and the main river is a sandstone plateau covering several square miles, and bordered on the west by high bluffs. Following up the river several miles we noticed some burned cabins, and about 12 miles from the mouth of the Blanco we came to the Pagosa Sulphur Springs. They are situated in a bend of the river and are very large. For a particular description, I refer the reader to Dr. Endlich's geological report, as he made a detailed examination of the springs. They are held and jealously guarded by the Utes on account of the medicinal qualities of the waters. These Indians often resort to the springs in small parties to bathe. In our travels we met the chief of the Weeminuche or Southern Utes on the Piedra, and he related in the eloquent sign language, of which he was master, how his men had driven out various parties from his country. To persons that do not desire to settle in the country they are often quite obliging. Whenever we asked for information about the trails or roads or grass, they would always tell us and take great pains to make us understand. In this latter respect I cannot but contrast them with their New Mexican neighbors. The latter seemed too lazy to talk, no matter how well you paid them for it, and the most information to be got out of them was generally the words "*a qui*" (there), with a nod of the head to indicate direction. The Southern Utes, unlike Indians generally, are very talkative.

Following the course of the river for a few miles above Pagosa, we turned to the southeast and traveled along the foot of the range. All this country is covered with timber, except in small patches. On the lower hills we found much oak brush, but yellow pine abounds, and above them come the spruces, which extend to the timber-line. Grass and water are abundant.

Making station 77 on Blackhead Peak between the two branches of the Blanco, we again found ourselves surrounded by deep cañons, precipices, and rock-slides. Far below us we could hear the bleating of mountain sheep, but we could not see the animals themselves. After this we continued along the range to the Navajo, on the east side of which we found a considerable level area of good pasture-land. From here we passed over to the Chama, the whole distance being one great meadow, with several herds of cattle grazing on it. On our left the mountains rose up very abruptly, many peaks reaching far above the timber-line. This region is well adapted for pasturage in the summer, as the grass is very rich and good water is abundant. Being near to the mountains, there would be a great fall of snow in winter, so that stock would have to be driven down the stream to be saved. Turning northward, we followed up the Chama, and found that the valley soon ended and the ridges on the east and west coming down to the stream, a narrow cañon was formed. After a few miles the trail from Tierra Amarilla leaves the main stream and follows up the eastern branch; our course lay up the western. A short distance above the junction the basin widens out, and to the west long timbered slopes lead up to station 81; but after a few miles, as we approach the head of the Chama, the peaks on either side increase in height and present great bluffs toward the stream. On the west side Banded Peak is the highest summit in the vicinity. On station 81 we saw a number of deer, a band of mountain-sheep, and a bear. In the creek, Harry Yount found trout in great abundance. In some places the fallen timber seriously impeded our progress. Our object in ascending the

Chama was to reach the divide, and by following it make a number of stations in the heart of the range, but at the head of the stream we found ourselves surrounded by walls, while the only way leading to the plateau above was a narrow crevasse filled with loose rock and soil. Here the slope was very great, and a small stream running through the middle of the gap left only a few feet on the side to walk on. As the height was many hundred feet, it was a difficult matter to get the pack-train up. On reaching the summit, we found ourselves in a pass through the ridge which was grown over with spruce, but the ground was very marshy, and great numbers of ponds were to be seen everywhere. After camping here, at an elevation of over 11,000 feet, we traveled northward with the train. We soon came out upon a high plateau considerably above the timber-line. Many snow-banks were to be seen, but in the day-time the weather was very pleasant. The land above the timber-line varied in width from one to two miles in this vicinity. In making station 84, near the middle of the plateau, we saw a large grizzly pass from the Atlantic to the Pacific slope, but he was out of gunshot. We found the plan of ascending the peaks from the plateau much easier than from the plains, for here we could camp nearly up to 12,000 feet elevation, which gave us a good start. From station 85, a point on the west edge of the plateau, we had a fine view of the head branches of the Navajo. The main cañon and its branches are deeper and more rugged than any others in this part of the range. In going to this peak we passed a little piece of timbered land at the head of the Chama, in which was a small lake. On the south side this little park was bordered by a precipice hundreds of feet in height, over which the little streams fell in cascades to the valley of the Chama below. On the north and west and a part of the east side, low but impassable bluffs hemmed it round. The only entrance was a narrow gap at the northeast corner, and that was only just passable. A well-beaten trail led from the high plateau down through this gap into the park. This was probably made by wild game, elk, bear, and may be sheep. The area of the park may have been more than a square mile, and was well supplied with grass and water. Having their only possible entrance from the side of the high plateau above the snow-line, the game could resort to this covert in summer with comparative safety, especially as we have seen how difficult it is to make the ascent up to the plateau.

Continuing our march to the north, and following the general course of the continental divide, we camped at the head of the middle branch of the Conejos. Here we noticed many fresh tracks of elks, but saw none of the animals themselves. The next day, August 22, we ascended Conejos Peak to the northeast to make station 86. This proved to be a good station, and, the ascent being easy, we had plenty of time for work. From this peak we had a fine view of the cañons of the three streams which form the head of the Conejos. Many facts tend to prove that these have been cut by glacial agency. The general course of the streams is made up of peculiarly regular and sweeping curves, very unlike those produced by erosion of water alone. From the peak this feature appears very prominent. The details of the cañons still further bear out the theory. The cross-section is very regular and not subject to those abrupt changes so common in most cañons. The walls are nearly vertical for hundreds of feet, with a narrow valley along the bed of the stream. The depth of the cañon at the head of the south branch, near the pass by which we came upon the plateau, is 700 feet, but down on the main stream it is more than 1,000 feet. At the head of this fork, on the plateau, we found a great many polished surfaces of rock, with occasional scratches, showing that a glacier once passed over the precipice into the amphitheater at the head of the cañon.

Eastward from station 86 the slope was quite steep for some distance down to a super-timber-line plateau, which extended out to the bend of the Conejos. Between the southern and middle forks of the stream there lay a table of about 20 square miles in extent, mostly covered with timber, that seemed to be almost completely isolated from the main-land. Along a circumference of about 20 miles it was bordered by an impassable precipice, extending down to the stream-beds. On the west, a narrow isthmus, a mile in width, connected it with the high plateau. After we had nearly finished work on the peak, there came up a snow and hail storm, accompanied by electricity. The storm was of short duration, but left the rocks white with snow.

During our stay on the summit, in the intervals of work, we killed two grizzlies, took long-range shots at a third, and just missed getting a shot at a fourth. These bears live on grass and roots, and come up regularly to wander over the plateaus in search of food. What may be their object in climbing up to these high regions I cannot say. It is possible the cold, clear air has some attraction for them, although the beds of the cañons are already so elevated that the weather is always cool.

Returning by the trail we came over the plateau, we again camped in the pass, where we were visited during the night by a heavy rain-storm. The next day we ascended the plateau south of the pass, and found a level area of many square miles, all above 12,000 feet elevation. The storm continued, and the clouds reached far below the summit of the plateau, but by dint of patient watching and waiting we were able to make a partial station (88) on the southern brink of the table. Descending to the head of the Rio de los Pinos, we camped near the timber-line. The storm continued all night, and the camp, being high, was surrounded by bogs and marshes, making it doubly disagreeable. One who has only experienced the storms of the lower levels cannot appreciate the feelings of a person caught in a storm of several days' duration at the timber-line. There is a certain dreary sensation connected with it that cannot be described. The next day we started out in the storm, and descending rapidly down the creek, soon came to beautiful meadows and scattering clumps of spruce and quaking asp, and an increased degree of heat seemed to suffuse all things with life, very different from the region of perpetual cold and dampness 2,000 feet above. Taking this course, and crossing a low ridge to the southward, we again struck the trail from Tierra Amarilla. Following this eastward, we made stations 90 and 91, on a table near the lower extremity of the Conejos Cañon, and a short distance from the edge of San Luis Valley. Returning, we followed up a small stream to the south, then crossing a divide, came to the head of the Brazos, along which we found a wide space of land devoid of timber and covered with grass. On the evening of August 27 the weather turned off clear and cold, with heavy frost during the night. This marks the fall change. Some years, at this season, there are several weeks of clear fall weather, but in others there seems to be no definite interim between the summer rains and the winter snows. Continuing down the stream, we came to another trail from Tierra Amarilla, which we followed westward, making station 93 north of the trail, and 94 on the brink of the precipice overhanging the Brazos. At this latter point quartzite makes its appearance. This mass fills the space in the bend of the Brazos, and presents a great bluff face to the south and east. Toward the west the country is cut up into many gorges, and hills continue down to the Chama. It is said that these mountains are subject to an extraordinary fall of snow in winter. In returning from this peak we passed through a large and fine-looking meadow, with a cabin built on its northern border, near the trail. A blacksmith-shop had been built near it, but all was now deserted. It is probable that some one selected the site in summer, but did not take into account the great elevation and the consequent fierce winters.

Following the trail eastward, we passed several large herds of sheep on their way to Denver. Some bands of cattle were also to be seen. Crossing the divide, we followed down the San Antonio, and camped a few miles above the main bend. The next day we made station 97, on San Antonio Mountain, a great dome-like peak directly east of the bend in the creek. This mountain is so completely isolated from the range that in coming toward it down the San Antonio it is quite impossible to tell whether that stream flows around the north or south side of it. It is about two miles in diameter at the base, and rises nearly 2,000 feet above the plain. This peak commands very distant views to the north and south. From its summit we could see Mount Princeton, near Chalk Creek, distant 130 miles in an air-line, while to the south another peak appeared to be still more distant.

Following northward down the San Antonio, we found the formation to be of basalt, through which the stream had cut a peculiar little cañon, about 100 feet deep and from 100 to 200 feet wide, with the walls so precipitous that a footman could descend to the stream only at long intervals. The water here was bad, being polluted by the bands of cattle and sheep on the head of the stream. After riding many miles, and passing the junction of the San Antonio and Pinos, we finally found a narrow gorge leading from the basalt table down to the bed of the creek. The wash terminated in a bed of sand. In front of us there rose a detached piece of the basalt table, a few hundred yards in length, and bearing a striking resemblance to an island. A regular channel about a hundred yards wide separated it from the mainland. It is probable that at some time long since the San Antonio ran through this channel.

At the junction the Pinos is much the larger creek, but the name of the other has been given to the main stream. The valley proper commences on the former, a short distance above the junction, and continues out into the desert. The upper portion is thickly settled by Mexicans, engaged in raising grain on the bottom-land and herding sheep on the basalt tables. A great many clusters of adobe houses, each bearing a separate name, are scattered along the stream, far out into the valley; but the only productive land along any of these streams is comprised in a very narrow strip near the water, and extending only a few miles from the base of the range. In this little area fair crops of grain are raised with irrigation, but the elevation is too great and the summer too short for grain to ripen with any certainty. The warm weather does not commence till the last of May, and this year a foot of snow fell on September 20, while the frosts of the fall commenced several weeks earlier. Thus we see that the whole growing-season is scarcely over three months. During this time the weather is very hot during the day, but the nights are cold. All these things are important drawbacks to farming operations. As we passed this place (August 31) the wheat was only heading out, but as the fall had commenced, and the winter followed close on its heels, none of the grain could have come to maturity. The heavy storm three weeks later must have found the crops still unripe, and the foot of snow that then fell must have destroyed them utterly. It may be objected that this season was an exceptional one; but I remember seeing different persons cutting their fine-looking wheat for hay, which they would not have done if they had had any hopes of harvesting the grain. Much has been said of the indolence of the Mexicans and the rudeness of their farming-implements, but I doubt very much whether the most enterprising white farmers, with all the modern appliances, could make grain-raising a success on the west side of San Luis Valley.

Traveling northward along the main road to Del Norte, we reached Conejos, a Mexican village on a stream of the same name. Its elevation above the sea is 7,880 feet. Here is the post-office for the many villages in the vicinity. The stream is fringed with a rich growth of cottonwood far out into the plain, but, as with the San Antonio, the Alamosa, and others, the timber ceases long before the stream reaches the Rio Grande. This seems to be due neither to the great heat nor to the want of water, but to the leanness of the soil. As far as the sediment from the mountains extends, just so far the timber grows, but no farther. The Conejos runs in a shallow shifting bed, and every spring the water overflows its banks. Passing this point, we camped a few miles to the north, near a low bluff, where a ditch supplied us with water. From here we had an extensive view of the plain. Standing on the general level, and looking toward the northeast, we could see the plain 50 miles away, and nearly the whole height of the sand-hills at Mosca Pass. As the curvature of the earth for the given distance would be nearly 1,700 feet, the sand-hills would be entirely invisible if the valley were truly level; but it slopes from the ends of the line to the Rio Grande near the middle, thus nearly neutralizing the effect of curvature. At this season so clear was the atmosphere that in the morning and evening we could see distinctly all the main ridges of the Sierra Blanca and many of the small ravines, although they were 40 miles distant in a straight line. We made stations 99 and 100 on a grassy plateau between the Conejos and the Rio de la Jara. On the sides facing the streams are bluffs of considerable height, but on the east the plateau is raised above the level of San Luis Valley by a low bluff 20 to 50 feet in height. West from station 100 across the Jara a number of small streams came down, cutting deep gorges. Between them appeared narrow plateau peninsulas surrounded by bluffs, except on the west, where a narrow isthmus connected them with the main plateau.

Crossing the Jara and the Agua Caliente, we made station 101 on the north side of the Alamosa where that stream emerges from its cañon into the valley. At the time of our visit the grasshoppers covered the ground in great numbers, and consumed all the grass left by the sheep. These pests, continually jumping into the stream, furnish food for the trout. Harry Yount, our packer, succeeded in catching a number of these fish, and found them gorged with the insects. Thirty-five full-grown grasshoppers and a water-worm were taken from one fish of about a pound weight.

Having finished the main range, we took our course eastward, down the Alamosa, then across the intervening plain to the Conejos. Here, at a point a few miles above the mouth of the stream, we found some white settlers, and succeeded in getting some potatoes, which we esteemed a rare luxury after our long abstinence from vegetables. The valley of the Conejos in this region is very narrow, while beyond on either side the plain extends for miles, being covered with sage-brush and cactus, the latter quite scarce, however. The plain is not composed of loose, shifting sand, like many deserts elsewhere, but the sand and gravel form a bed, which is usually very firm. Herds of cattle were feeding on the meadows near the lower ends of the Alamosa and Conejos, while some found good picking among the sage-brush. The entire lack of timber or even brush on the plain detracts much from its usefulness as a pasture. Moving again toward the southeast through the volcanic hills, we camped on the Rio Grande. During the day we made station 102, on the most northerly table of the group, a point about 500 feet above the valley. This group of hills, in the center of San Luis Valley, is bounded on the west and north by the Conejos, the stream running northward over 12 miles, in an opposite direction to the Rio Grande, to pass around them. A part of the group is east of the Rio Grande, but does not reach as far north as the mouth of the Conejos, and eastward from the river only about 8 miles. The western group extends southward nearly 20 miles to the Lower San Luis Plain, but as the hills stand isolated one from the other, much plain-land is included between them. This mass covers somewhere about a hundred square miles, while in the eastern there may be 30 or 40. Between the eastern group and the Sangre de Cristo Range is a low gap apparently the same height as the valley north and south, which is supposed to have once been the strait connecting the upper with the lower lake that once covered San Luis Valley. Between the western hills and the main range is a smooth plain, but one considerably above the general level of the valley. The hills are of various shapes and heights; many are nearly level tables with bluff edges, but others are very regular cones. In height they range from 200 to 1,600 feet above the plain. One, on which we made stations 103 and 104, rose 1,500 feet above the valley, and its summit covered an area of two or three square miles, being surrounded by bluffs, which were impassable except at few points. On the summit we noticed the holes of prairie-dogs in several places. On the south side was a little timber, while grass was quite abundant. Cattle had roamed over the plateau, having climbed up from the plain in search of grass. South of this was another similar table of about equal height, but even greater area. The hills east of the Rio Grande are more irregular in form and usually much smaller and lower. Soon after passing the mouth of the Conejos the river changes quite abruptly. Above for many miles it winds about over a great area, and sloughs lead in all directions, but at this point it becomes very straight and enters a rocky bed, and for a short distance cuts a narrow gorge. Passing through this and emerging from the hills near the mouth of the Culebra, it runs through a shallow but definite bed in the rock. This continues for five or six miles to a point below the ford, where the stream enters a narrow cañon cut in the basalt, very similar to that of the San Antonio.

On our march down the river we made station 105, on a sharp rocky cone on the west bank of the river, near the mouth of the Culebra. In following down the river we expected to have camped on the Costilla, but we found it dry near its entrance to the Rio Grande, the water having been consumed in irrigation near the mountains. Its course was marked by a gorge about a mile in length, cut through the basalt from the plain to the bed of the river. The walls were so nearly impassable that the Mexican shepherds had used it for a corral, and had built little coverts near the upper end to sleep in. Into this curious inclosure they drove their sheep and goats at night, and herded them on the plains during the day. This is the only path to the river within many miles. No water can be had except by following down this narrow defile. The cañon of the main stream is similar—only more impassable. The walls are from 100 to 200 feet apart, and about 100 feet in vertical height. These are essentially perpendicular, being produced by the rock breaking off in cubic blocks with a vertical fracture. The hardness of the basalt prevents any appreciable weathering, thus preserving the abruptness of the walls. Through this narrow gorge the Rio Grande rushes with great velocity, very unlike the same stream 30 miles above. From our southern stations we could distinctly trace the narrow cañon down to the parallel of 36° 45′, at which point the stream passes between two great hills, which, with others to the west, form the sudden southern terminus of the great San Luis Valley. The length of the cañon brought under our observation was about 30 miles. After camping on the bluff near the river, the next day we made stations 106 and 107, on the Ute Peak, a great dome about four miles south of the Colorado line. Its diameter at the base is about four miles, and it rises 2,500 feet above the plain. West of this peak, across the river, there is a large area of very level plain quite isolated from the rest of the valley.

From a camp in the southeast corner of San Luis, we ascended a peak of the Sangre de Cristo Range, and made station 108. This commanded a very distant view to the south. The range seemed to preserve the definite character as far as we could see. A little southward of this peak San Luis Valley ended, and the depression of the Rio Grande seemed to be very rough, being covered with hills and cut through with gulches. On the southern edge of the valley, north of the range of hills that follows the parallel of 36° 45′, and east of the Rio Grande, we saw a Mexican village, with a large area of grain to the north of it. The fields belonging to the different individuals were separated only by single furrows, and fences were nowhere to be seen. Several similar settlements were also seen on the Costilla and Culebra. North of station 108, and nearly under it, was a deep cañon, with a small grassy valley at the bottom, in which we noticed numbers of wild cattle. These had evidently strayed from the settlements in the valley, and finding this hidden park, did not return. At the lower end the stream passes through a narrow rocky gorge to the plain, thus cutting off all direct communication with the little park. Besides cattle, other game was numerous. Harry Yount killed a splendid buck deer, with enormous antlers, bearing on one side eleven prongs, and on the other, thirteen.

Following northward along the foot of the range, and coming to Costilla Creek, we followed up the latter stream to its head. There are many peaks in the vicinity reaching above the timber-line, but none to a very great height. For about 12 miles the Costilla runs along the range from north to south, dividing it into two distinct parts; then, cutting through the west ridge in a rugged cañon, turns toward the northwest, and crosses the plain to the Rio Grande.

In making station 110, on a high plateau peak north of the bend, we were caught in a storm, and for many days after this we were harassed by occasional showers.

From station 111, on Costilla Peak, we obtained a good view of the country about the head of the Purgatory and Cimarron. The whole region south from the Spanish Peaks and west from Trinidad is covered with low black hills, of a sandstone formation. The entire lack of any definite order among the parts of the mass gives to it a monotonous aspect. The courses of the main streams cannot be traced from a distance, from the fact that there are no valleys along their banks. These hills extend a considerable distance into New Mexico, and cover an area of about 1,000 square miles.

On September 12 we made station 112, on Boundary Peak, west of the Costilla, and were caught in a storm of hail, rain, and electricity. On this peak we found a stone monument marking the line between Colorado and New Mexico. The next morning being clear, we rode northward along the summit of the range to make station 113, on a high point south of Culebra Peak. For four or five miles our course lay entirely above the line of perpetual snow, while the ridge was very uneven, so that we were compelled to cross several high peaks before reaching the one we wanted to use as a station. Here we left our mules and climbed to the summit on foot, a vertical height of 1,200 feet. The weather was quite clear till we neared the summit, when, a cloud coming over us, enveloped the whole mountain, and rain and hail began to fall. Setting up the instrument, we obtained disjointed views through the breaks in the clouds. The storm increased, but we waited patiently, amusing ourselves by laying the foundation of a fine monument that was destined never to be finished. One thing that made our position the more aggravating was the fact that through the gaps in the cloud we could see the bright sunshine on either side of us, only a few miles away; but the clouds seemed to hug so closely to the summits of the range that the wind could not remove them. The clouds, as they come from the west, are caught against these high peaks, and become massed together, thus producing continual storms. The direction of the range, at right angles to the prevailing winds, makes it an almost impassable barrier in the way of the east-bound storms. During our work to the west of San Luis, we noticed that all the clouds in passing over the Sangre de Cristo Mountains were retarded in their journey. Once in particular, while there was a steady breeze from the west, we saw a small cloud, probably not more than a few hundred yards across, which had caught against the very crest of the Sierra Blanca. The part of the peak touched by the little cloud was not more than one or two hundred feet in vertical height, yet that much served to hold the cloud in face of a strong breeze for several hours. The storm encountered on station 113 was apparently not over 10 miles in breadth. Returning the way we came, we found camp located in the pass from the head of the Costilla to the Culebra. The next morning we started again to make 113. Again the weather was clear for the most of the journey; but, alas! when we reached the summit the cloud again surrounded us, and again the hail and rain came down. After remaining a few hours, we returned, the cold rain and wind persecuting us along the whole dreary line to camp. The third morning again was clear, and for the third time we attempted to do our duty, but after going a short distance, we saw the storm gathering, and we turned southward and finished station 112. By reaching it early we succeeded in doing a little work; but soon the clouds fell, while hail, rain, and electricity forced us to return to camp. The morning of the fourth day saw us crossing the pass, and going down the west slope toward the valley of the Culebra. At an elevation between 9,000 and 10,000 feet we found the sun shining brightly and the air warm and pleasant and full of life.

Between the mountains proper and San Luis on the west, there intervenes a small valley or plain 8 to 10 miles long from north to south, and several miles across. This is separated from the San Luis Valley by a low range of hills. This causes the southern branch of the Culebra to run parallel to the range for so long a distance. Traveling northward, close to high mountains and crossing several streams on the way, we camped high up on one of the branches of the Culebra. The next day we made station 116, on the Culebra Peak, the highest summit between Sangre de Cristo Pass and the Colorado line. The weather was quite clear, but the clouds continually passing over us and shading the peak made it much colder than was comfortable. The wind was now from the north, and it was very interesting to see how the clouds were gradually consumed before it. Some, as they passed over Fort Garland, would appear to be a mile in diameter, but before they reached us they would be nearly destroyed. The manner in which they melted away before the dry air from the north was curious in the extreme.

On September 19 we marched to Fort Garland. In the evening a blustering wind arose from the west, which soon brought up a storm, and snow fell thick and fast all night. Soon a fierce wind came down from the north, caused by the sudden cooling of the high Sierra Blanca by the fall of snow. The next day the wind continued, with occasional showers of rain and some snow, but on all the high summits the snow fell without cessation, and they were entirely hidden from view, being enveloped in the clouds. During the night four or five inches of snow fell on the valley, and the mercury reached a minimum of 22°. The second day there was a slight break in the storm during the forenoon, but it soon set in steadily raining and snowing. During the third day, September 22, the storm lightened considerably and cleared away during the night. In this three days' storm there fell about one foot of snow on San Luis Valley and about two feet on the Sangre de Cristo Range. During the storm we were furnished quarters at the fort, and I take this occasion to thank the officers at the post, on behalf of our party, for the very kind treatment we received at their hands.

On the morning of September 23 we started up the East Fork of the Sangre de Cristo, known as Indian Creek, and camped at the summit. The ground was covered deep with snow. After making station 119, near this pass, we traveled southward and climbed upon the mountain ridge south of the station. We rode along the divide for four or five miles, at an elevation ranging from 12,000 to 13,000 feet above the sea. A stiff breeze was blowing from the east, and the snow on the ridge was nearly two feet deep. On attaining the summit of a high peak, where we expected to make a station, we found the wind blowing so hard that we could scarcely stand against it. What was still worse, however, thick fog began to cover the range, and we were forced to return in haste. The wind now blew a perfect hurricane directly across the ridge, and we were compelled to follow along the crest for nearly five miles before we could leave it. Our clothes were soon saturated by the driving fog, and the deep snow gave a terrible sharpness to the wind passing over it. At times the gusts came so strong that the mules were moved bodily several inches, although they leaned far over toward the wind. The valley of the Cucharas seemed to act as a funnel, so that the wind, spread over many miles of the plain, was forced through this narrow place, thus increasing its velocity to such an alarming extent. The storm was so blinding that our mules made little headway. Their hair hung with icicles, produced from fog by the wind. After a long and fearful tramp we finally turned down the east slope and soon found ourselves in the timber, where the weather seemed wonderfully warm in contrast to that above, although great masses of snow covered the ground even there. After camping on a head branch of the Cucharas, and having a slight fall of snow during night, we crossed the head of the cañon of the Cucharas. Here we found a road leading over a pass southward to some settlements near the head of the Purgatory. Between the west Spanish Peak and the range there is a sharp hog-back, jammed in between the two volcanic formations. From a distance it would generally be mistaken for a dike. It extends northward from the pass several miles, and is notable for its sharpness and its continuity. Its position may be easily found on the map, as it lies between the Cucharas and a branch on the east running parallel with it. In fact, it has produced that peculiar parallelism of the two streams.

On September 26 we ascended the West Spanish, and found the ascent quite easy. We had about 1,500 feet to climb after leaving our mules. The summit was covered with deep snow, but the weather was clear, and the station a perfect success. On account of its great height and isolated position, it was a commanding point for topography. The system of dikes radiating from the mountains give it a peculiar character. Some of these, after reaching the base of the mountains, extend for several miles out into the valley in unbroken walls, often more than a hundred feet in height. A few dikes crossed the main system at acute angles. Some were to be seen on the south side of the peak also. The whole mountain has a very regular form, and with its lesser companion, a few miles to the east, forms one of the great land-marks in this part of Colorado.

The next day we climbed Trinchera Peak, a high mountain at the head of the Cucharas and west of the pass. Above the timber-line we found the snow about two feet deep, with banks much deeper. Earlier in the season the climb from this side would have been quite easy, but the deep snow made it very difficult. On reaching the divide, at an elevation of 13,000 feet, we were much surprised to see the fresh tracks of a large grizzly, leading down from the summit of the peak and following the ridge northward. We made good use of his tracks, however, for by stepping carefully in them we avoided breaking through the deep snow-banks, which would have been very tiresome. Thus, too, we were enabled to put to good use the unerring instinct of the bear in selecting the best route to travel by. In one place the tracks led down a very dangerous descent. At this point the ridge was very sharp, so that it was impossible to travel anywhere except along the crest. On the west side was a very steep snow-bank, glazed hard with ice, which after 20 or 30 feet terminated in a precipice several hundred feet down. Above it was a rocky ledge about 20 feet in height, with the projecting stones very loose and covered with snow and ice. Now the steep snow-bank, with the most of its surface frozen, occupied a gap between the ledge of rocks and its continuation down the ridge, yet the bear had come head foremost down the ledge and passed the snow-bank without faltering or taking time to consider. We followed his footsteps up the same place, but were compelled to hand the instruments up one at a time. The climb required great care, as the rocks were loose and covered with snow, and we made the ascent at the risk of our lives. On reaching the summit of the peak, we found the bear-tracks winding about all over it. The animal had come up from the south side, and must have been on his travels very early, as we first came upon his track early in the morning. This peak is very high, but the summit is broad, and many peaks in the vicinity obstruct the view, so that it was not very well suited for a station. Returning, we traveled southward along the wagon-road. After a few miles we came to several curious hog-backs, having a general course from north to south. Between the two principal ones is a fine transverse valley, called by the settlers in the vicinity Stone Wall Valley, and the name is not inappropriate. The grass is fine and some farming is carried on near this place, but again the elevation and the proximity to the high mountains interferes seriously with the grain-crops. Between the hog-backs and the range game is quite abundant. We saw many deer between Mount Trinchera and the Spanish Peaks. In our travels we continued southward to the South Fork of the Purgatory, where we found some Mexican settlements. Along the upper portion of the stream there is quite a valley, and some corn is raised, but a short distance below where we struck the stream it enters a cañon, through which the wagon-road leads to Trinidad. At the lower end of the valley in the cañon is a curious little butte, near the summit of which a wooden cross has been inserted by the Mexicans.

After making stations on the hills south of the river we started for Trinidad, passing several Mexican villages on the way, and making stations wherever necessary along the route. In many places we saw veins of coal cropping out along the bluffs. Some have told of the great and extensive valley of the Purgatory, but all the valley we saw consisted of small patches here and there, seldom a hundred acres in extent, and generally less. Where we passed through, the river had overflowed its banks and destroyed a great deal of the corn planted on the bottom-land. The elevation of the valley proper nowhere reaches 6,000 feet above the sea, so that wherever water for irrigation can be conveniently obtained any kind of crops may be raised. I may mention here that among the settlers the river does not go by the name of "Purgatory," but the original French name of "Purgatoire" has gone through a curious transformation, and has been corrupted into Picket-Wire, which has a ludicrous resemblance in sound to the former name. A few miles above Trinidad we passed the mouth of Long's Creek, which was almost dry, although it has a length of 30 miles. This is accounted for by the fact that it runs its whole length through the low, dry hills. Leaving the Purgatory near this point, we crossed over to Raton Creek, a very small stream, draining the west side of the Fisher's Peak plateau. From there we ascended the plateau and made stations 131 and 132, on the west edge. This table is surrounded on all sides by bluffs, in many places several hundred feet vertical. It extends southward several miles and eastward as far as we could see. In form it is very irregular, being in some places several miles across, and in others a few hundred yards. Fisher's Peak is the highest point, at the northwest corner, and detached from the main mass by a deep space. It is 9,460 feet above sea-level. On the plateau we found plenty of grass and water and a few quaking asp-trees, while in the valley, 3,400 feet below, everything was parched by the burning sun.

Resuming our march, we rode into Trinidad, and found it to be a town of considerable size, with a heterogeneous population of whites and Mexicans, seemingly contending for the mastery, with the odds in favor of the former. A number of neat business buildings occupied the center, while the suburbs were made up of Mexican huts. A number of coal and iron mines are being worked in the vicinity.

Leaving Trinidad, we followed up the Purgatory to the mouth of Higbee Creek, a dry water-course coming in from the north. Thence we crossed over the divide to the north and came to the Apishpa. With this stream, as with the Purgatory, the natural euphonious name had been transformed by some western pioneer into Fish-Paw, and the creek goes by that name among the settlers. This stream drains the region south of the Spanish Peaks, but contains only a small quantity of water. Along its banks we found a number of Mexican huts, made of adobe, but the general air of filth and indolence seemed to indicate a low order of civilization. Every house had a number of dogs, sometimes as many as six or seven. The clothing of the adults approached the minimum, but the children were often entirely naked. The valley of the stream is small and unimportant, but most of the available soil is planted in corn by the Mexicans. Following down the stream to the plain, we turned northward. From Trinidad to the northern extremity of the hills, a few miles above the Apishpa, they present an abrupt front toward the east, and their junction with the plain is very sharply defined.

Following along the plain toward the north, we came to the Cucharas, where we found a considerable area under cultivation. Coal-mines are being worked near the stream. After this we crossed the Huerfano, followed up Williams Creek into the Wet Mountain Valley, past Rosita, and thence to Canyon City. Here we made our hundredth camp, having been one hundred and twenty-seven days on our journey. The next day, October 12, we took the narrow-gauge train and arrived in Denver, our point of beginning.

REPORT OF HENRY GANNETT, M. E., TOPOGRAPHER OF THE GRAND RIVER DIVISION, 1875.

LETTER TO DR. F. V. HAYDEN.

WASHINGTON, D. C., *April* 30, 1877.

SIR: I have the honor to submit to you herewith my report on the geographical work of the Grand River division during the field-seasons of 1875 and 1876.

It was found to be almost impossible to write a separate report on the work of each year, as the areas covered during the two seasons were so closely connected that they cannot be treated separately.

In 1875, my party consisted of ten persons: Dr. A. C. Peale, geologist; William R. Atkinson, assistant topographer; William S. Holman, barometrical observer; L. Dallas, general assistant; four packers, and a cook.

Leaving Denver on June 4, we traveled, via Turkey Creek road, South Park, Arkansas Valley, San Luis Valley, and Cochetopa Pass, to the Los Pinos agency. My work began at this point. We followed the route of the present mail-road to the Uncompahgre Valley. At the ford of the Uncompahgre River, I detached Messrs. Holman and Dallas and two packers with orders to proceed to the Gunnison River at the mouth of Roubideau's Creek and establish there a temporary supply-camp. With the balance, which formed the working party, I followed the Uncompahgre River to the foot of the San Juan Mountains. Then turning westward, I reached the summit of the Uncompahgre plateau, and followed its crest northwestward to the Grand River, reaching, from the crest, all the country between the Uncompahgre Valley on the east and the San Miguel and Dolores Rivers on the west. Thence I returned to my supply-camp, fording the Gunnison a few miles above its mouth, and again at the mouth of Roubideau's Creek.

Finding it advisable, I decided to remove my supply-camp to the Dolores River, at the western mouth of Unaweep Cañon. The route taken was via the Unaweep Cañon, which forms a natural highway between the Gunnison and Dolores Rivers. On the way we met Mr. Gardner's party, and decided to remain together, under the orders of Mr. Gardner, while working in the vicinity of the Sierra la Sal, which was known to be infested by a band of troublesome Indians.

Leaving the supply-camp and the packers, who were engaged in freighting provisions thence from the settlements, we followed up the Dolores to the mouth of Salt Creek, or Rito Salado, up this small stream, and thence across high plateaus to the foot of the La Sal Mountains. About a week was spent in and about these mountains, which afforded magnificent opportunities for work. Thence our course of travel was southward toward the Sierra Abajo or Blue Mountains. On our way we were attacked by Indians, and our season's work summarily ended. As the public has been treated to numberless accounts of this affair, all more or less highly colored, it is unnecessary to do more than mention it here. After reaching Parrott City, Dr. Peale, Mr. Atkinson, and myself accompanied Mr. Holmes's party on a short trip to the country about the head of the Dolores, after which I came to Pueblo with my party via Baker's Park, the Rio Grande Valley, and Mosca Pass, reaching Pueblo in September.

In 1876 my party was composed of Dr. A. C. Peale, geologist, Mr. J. E. Mushbach, topographical assistant, two packers, and a cook. Mr. James Stevenson, general executive officer of the survey, accompanied my party during a portion of the trip, as executive officer.

We took the field at Cañon City, Colo., on August 23. We went up the Arkansas, over Marshall's Pass, down the Tomichi and Gunnison to the Uncompahgre agency, at the head of the Uncompahgre Valley. Here we engaged the services of four Ute Indians, as guides and as a sort of escort, to prevent trouble with the band of Indians with whom we had a brush the preceding summer, as we were first to finish the survey of the country in which they range. This work was completed without trouble, after which we returned to the Uncompahgre agency, reprovisioned, and started down the Uncompahgre and Gunnison Rivers, to survey the part of our district lying north of Grand River. We followed the Salt Lake wagon-trail down the Grand River to the mouth of the Dolores, then, leaving the river, we struck north, toward the crest of the Roan or Book Cliffs. Reaching their crest, we traveled generally eastward along it, on the divide of land between the Grand and White Rivers, a route affording magnificent facilities for rapid and accurate work. Reaching the head of Roan Creek, we descended into its cañon, and followed it down to the Grand. Thence we went up the Grand to the eastern edge of the Roan plateau, where our work ended. From there we went to Rawlins, Wyo., via White River Indian agency, reaching the former point on October 23.

Besides the regular topographical work, particular attention has been paid to the agricultural capabilities of the country, with a view to obtaining some idea of the extent of arable land. Every considerable stream which was crossed was roughly gauged. It is my intention to publish in the report for 1876 a chapter on the physical features of the State, its agricultural resources, timber and pasture land, &c.

In closing, I wish to thank Mr. H. F. Bond, late agent at the Los Pinos and Uncompahgre agencies, for the great assistance which he has afforded me in the prosecution of my work; also Dr. David Mack, late surgeon at these agencies.

Very respectfully, your obedient servant,

HENRY GANNETT,
Topographer.

Dr. F. V. HAYDEN,
United States Geologist-in-charge.

TOPOGRAPHICAL REPORT ON THE GRAND RIVER DISTRICT.

The area assigned to the division under my charge for the field-seasons of 1875 and 1876 comprised about 10,000 square miles. Its limits were as follows: Commencing at the intersection of the parallel of latitude of 39° 30′ with the meridian 109° 30′, the north line runs east along the parallel 39° 30′ to its intersection with the Grand River in longitude 108° 08′. Thence it follows down the Grand to the mouth of the Gunnison, up the Gunnison to the mouth of Lake Fork, up this latter stream to the northern edge of the San Juan Mountains, and follows this edge westward to the end of the range; thence it follows the parallel of 37° 52′ westward to the meridian 109° 30′, which meridian forms the western limit of the work.

In the prosecution of the work 130 topographical stations were made, an average of one in every 77 square miles. This area is mainly made up of plateaus considerably disturbed by the same forces which have elevated the great ranges farther east. It is drained by the Grand, Gunnison, Uncompahgre, Dolores, and San Miguel Rivers.

The remarkable parallelism of the separate ranges which make up the mountain system of Colorado has been previously noticed in the reports of this survey. Their trends are all between southeast and south, while the ruling trend is about south-southeast. This I call, for convenience, the *normal* trend. The Front, Park, Sangre de Cristo, Sawatch, San Juan, and Elk ranges, with their inclosed valleys, all trend in this direction. Almost every one of the secondary streams of the State conform to this normal course.

West of the Elk ranges lies the district under consideration, and here the same conditions prevail; but instead of mountain ranges there are long inclined plateaus, low, hogback-like ridges and cañons. There is, first, the valley of the Uncompahgre, which extends down that river 35 miles, then down the Gunnison about the same distance to its mouth, and thence down the Grand 40 or 50 miles, with a general course to the northwest, but bending around more to the west on Grand River. West of the valley and parallel to it is an inclined plateau, the Uncompahgre Plateau, sloping toward the northeast very gently, and breaking off abruptly to the southwest. Its crest extends from the foot of the San Juan Mountains to the head of the bend of the Grand. Its mean height above the valley at the mouth of the Uncompahgre is 4,000 feet, or about 9,000 feet above the sea. West of this is the Rio San Miguel, in a close cañon, with a northwest course from its head to its mouth. Then a succession of ridges and valleys is met with, all having the same northwest trend. North of them rises the group known as the Sierra la Sal, of igneous origin, and of later date than these ridges, as the latter are carried up on their slopes.

The Rio Dolores enters this district from the south, with a course about north-northwest, in heavy cañon in the "Great Sage-plain" of

Professor Newberry, west of the succession of parallel ridges just mentioned. After a few miles of this course it leaves the plateau, soon turns to the east, and flows across these ridges to its junction with the San Miguel, whence it pursues a north-northwest course to its junction with the Grand.

The southwestern part of the district is occupied by the Great Sage-plain, which is drained toward the southwestward by the Montezuma, a dry affluent of the Rio San Juan.

The heights which are distributed through the following pages were determined by the usual methods followed by the survey, by mercurial barometer, aneroid, and vertical angles. The barometric observations were referred as follows: My temporary bases in 1875, on the Gunnison and Dolores, we computed from the base observations at White River agency. To these were referred all observations at camps. The latter being established, all observations on stations and other points were referred to them; or, in cases where the observations would be too far from coincident in time, directly to my temporary bases.

Barometric observations on the Sierra la Sal were connected by a system of vertical angles and reduced to a common point, for the attainment of greater accuracy.

In 1876, my observations at camps were referred directly to White River agency. My stations and other points were referred either to camps or directly to White River agency.

The Uncompahgre River, after leaving the San Juan Mountains, in which it heads, flows northward through Uncompahgre Park. This is a small but fine valley, about ten miles long by two wide. It is the favorite summer camping-place of the Ute Indians, but owing to the elevation, 7,000 to 7,500 feet, it is not a desirable winter resort.

At the foot of the park, a large branch, known as Dallas Fork, enters the Uncompahgre from the west. Fine meadows extend up this fork for four or five miles. Below the junction, the river enters a cañon in a plateau, where the walls are about 500 feet in height. This cañon extends down the river about seven miles. Just below its base, on the west side of the river, is the Uncompahgre agency, at an elevation of 6,400 feet. From this point to its mouth, the river flows in a broad valley, of an average width of 15 miles and a length of 35, containing about 500 square miles. This area is nearly all bench land, elevated 50 to 200 feet above the river. The river bottom-lands have a width of one-fourth of a mile to a mile. The soil of the latter is good, and can easily be made productive by irrigation. The soil of the bench is adobe clay, varied by occasional patches of gravel. Alkali, everywhere present, becomes more abundant farther down the valley. Its present vegetable product is in the main part sage. White sage is abundant in the upper part of the valley, with a little bunch and grama grass. In the lower end, even sage does not grow with much animation, and the field is almost abandoned to cacti and sterility.

With exception of the Uncompahgre and three small branches near the head of the valley, no water is brought in. During early spring most of the water-courses are full, but this lasts a few days only. Two small branches carry water all the year, but these are unimportant for irrigating purposes. About eight miles below the agency, a small stream enters the valley and immediately spreads over the surface, naturally irrigating an area of about a square mile. Here a family of Utes are engaged in cultivating corn, potatoes, and other common garden-vegetables, in which they have good success, although occasionally interfered with by early frosts.

The Uncompahgre was gauged at the agency early in September, and the amount of water carried per second found to be 356 cubic feet. This, however, is a very slight indication of the amount carried during the irrigating season. Owing to the character of its drainage area, which, though not large, consists entirely of high mountains, the spring floods must raise the river immensely and continue for some time.

With the amount of water carried early in September the river will, by using it all, irrigate about 120 square miles, using Captain Smith's rule, which is applicable to the sub-Himalayan districts, that one cubic foot per second will irrigate about a third of a square mile. This is equivalent in amount to a monthly rain-fall of about 2.3 inches, not too much, certainly, for any crop, and not enough for some crops.

There is every probability that in May, June, and July the river carries water enough to irrigate a large part of the valley, and where the soil is not too alkaline it will make good farming-land. The rate of fall of the river through the valley is given below:

	Miles.	Elevation. Feet.	Fall per mile. Feet.
Mouth of the Dallas Fork	0	7,400	
Uncompahgre agency	14.5	6,400	69.0
Crossing of the wagon-road	25.5	5,800	54.5
Mouth	54.5	5,100	24.1

The slope of the bench-land follows approximately that of the river, and in consequence of this and the rapid fall it will be easy to bring the water to the top of the bench. The latter is nearly horizontal for a long distance back from the river, rendering irrigation of large areas comparatively inexpensive. Its low elevation compared with most of the valleys of Colorado gives it a climate sufficiently warm for the production of all kinds of grain, garden-vegetables, &c.

THE UNCOMPAHGRE PLATEAU.

Westward from the valley of the Uncompahgre the country rises gradually. It is impossible to say along what line the valley ends and the slope of the plateau begins. At a mean distance from the Uncompahgre River of 20 miles, and at a mean elevation of 10,000 feet, this long slope suddenly ends, in most places breaking off abruptly in a succession of two or three steps to the cañon of the San Miguel. In a few places, instead of breaking off, the beds are bent over and slope down to the cañon of San Miguel or Dolores at a steep angle. The crest of this inclined plateau extends from the foot of the San Juan Mountains in a direction nearly northwest to the head of the northern bend of the Grand River. It decreases gradually as it recedes from the mountains from a height of 10,200 feet at its head to 8,600 near its northwestern end.

Following down toward the northwest the depression of the valley of the Uncompahgre, we find that it crosses the Gunnison and continues down the latter stream on the eastern side. The gentle rise of land on the western side of the valley also continues down across the Gunnison, and this river flows in a cañon in this slope at a level but slightly below that of the bottom of the valley, but two or three miles to the eastward, a marked instance of the conservatism of streams.

Near the mouth of the Gunnison, and for several miles down the Grand below its mouth, this plateau slope is broken off abruptly in a precipice, leaving the river in a valley at its foot.

At the south end, where the protrusion of the mass of the San Juan range is first felt, there is a decided rise, followed by breaking off of the upper beds, leaving a saddle. Station 15 is on the south end of the crest. Its elevation is 10,200 feet. Just south of it, and three miles away, the height of the saddle is but 8,700 feet. The saddle continues south with about this height for half a dozen miles, and then the mountains rise abruptly to an altitude of 13,000 to 14,000 feet, presenting a magnificent array of cliffs and peaks. They rise in single slopes to the highest summits without any foot-hills and secondary summits which elsewhere so dwarf the loftiest peaks.

Nowhere is the influence of elevation on the character of the vegetation more plainly marked than on this plateau. In the interior, near the crest, the land is, to the Utes, one flowing with milk and honey. Here are fine streams of clear, cold water, beautiful aspen groves, the best of grass in the greatest abundance, and a profusion of wild fruit and berries, while the country is a perfect flower-garden. This extends as low as 7,000 feet, below which the scene changes to one in all respects the reverse. Aspen gives place to piñon and cedar. The grasses, fruit, and flowers, to sage, cacti, and bare rock. The streams become confined in rocky cañons, turn muddy and warm, and gradually disappear. The game changes. Black-tailed deer give place to the white-tailed species. Grouse disappear, while rattlesnakes and centipedes assert their proprietorship. In the place of an open, rolling country, we enter a district traversed by deep, narrow gorges, of abrupt precipices, a country difficult in the extreme to traverse, without a knowledge of its few highways.

Geologically, this inclined plateau has been produced by a gradual rise of the underlying granite, about an axis in the Uncompahgre Valley, carrying with it the sedimentary beds. The thickness of the latter differ in different places, but nowhere on the plateau does it exceed 1,000 feet.

Cutting this plateau transversely into two parts, is a remarkable topographical and geological feature in the form of a cañon, which connects the Gunnison on the northeast with the Dolores on the southwest. It enters the Gunnison six miles above its mouth, at an elevation of 4,600 feet. Following it southwestward, its bed is seen to rise slowly, with a stream flowing into the Gunnison, while the walls on each hand rise more rapidly. The bottom rises to a divide, with an elevation of 7,000 feet, several miles east of the crest of the plateau. The walls at the divide have an elevation of 1,200 feet. West of this divide, there is a stream flowing into the Dolores. At the crest of the plateau, which here breaks off abruptly, the depth of the cañon is fully 3,000 feet. Beyond the crest the walls fall off abruptly and become broken up, and the most rapid fall in the bed of the cañon is here. At its junction with the Dolores, about 12 miles above the mouth of the latter, the elevation is 4,618 feet, or the same as at the junction with the Gunnison.

Below the point marked "*a*" on the accompanying map, the cañon is narrow, not deep, and is cut in soft sedimentary beds. It is here probably the work of the small stream which now occupies it. At "*a*" granite appears on the bottom, and thence westward the lower part of the cañon is cut in this, evidently by a powerful stream. The granite portion of the walls increases in height as the cañon deepens, and at the crest of the plateau forms two-thirds of the height of the walls, the upper third, or 1,000 feet, being sedimentary beds. At "*b*" the granite suddenly disappears. The cañon is narrow near the Gunnison end; but beyond the sharp elbow-like bend it gradually widens as far as the crest of the plateau, where it contracts suddenly, and is very narrow until it clears the granite.

The granite cliffs are everywhere vertical, or nearly so. In the narrow parts of the cañon the sedimentaries (red beds) are cut very raggedly, while in the wide part their smooth slopes and rounded angles look very much like terraces. This is a brief statement of the physical features of this remarkable cañon, and they would seem to be sufficient to give a clew to its history. That it marks the former course of a large stream, there is no reason to doubt. It is a cañon purely of erosion, as there are no signs of fracture whatever in the formations in the neighborhood. The beds on the two sides are continuous, and have the same slight dip toward the northeast. The streams which now occupy it are very small, and are totally unable to cut into the granite. The course of this cañon is in a direct line with the general course of the Grand, above the mouth of the Gunnison. The courses of these two streams, as far as this point, have been described and shown to have been established previous to the disturbances now existing about them. Suppose that their course below this point, before the elevation of the Uncompahgre Plateau, to have been on the line of this cañon. As the plateau slowly rose, swinging about a horizontal axis, situated in the valleys of the Gunnison and Uncompahgre, the stream would commence to cut a cañon to keep its course. The rate of rise of the crest being greater than the cutting power of the river, a dam would be formed at the crest, and a lake would be the result. As the dam rose, and with it the surface of the lake, the stream flowing over the dam would have its rate of fall and its eroding power increased, until there would be a balance of forces and the dam would be cut away as fast as it rose. Cutting would take place not only below the dam, but the summit of the dam would be moved back. This hypothesis meets all the observed facts. The cañon is broad just east of the crest; the stratified beds there have smooth rounded forms, as if cut by gently-flowing water; the fall of the bottom of the cañon west of the crest is comparatively rapid, and the rocks cut in ragged shapes, as if erosion was rapid, and the divide is not at the crest of the plateau, but several miles farther east. Further, suppose that the elevation of this plateau, in its later stages, or some other geologic change, opened and made more practicable the present course of the Grand, around the northern end of the Uncompahgre Plateau; naturally, the river would take it.

This deserted cañon is known to the Ute Indians as "Unaweep" (Red-rock) cañon. The scenery which it presents is grand beyond description. From the elbow-like bend, where the walls first attain a considerable altitude, westward for several miles, the granite rises vertically from the bottom of the valley, in narrow, bas-relief columns, for some hundreds of feet; above, the red beds cap it in broken precipices. West of station 38, the granite assumes a more massive, characteristic form; great masses jut out into the valley. The scenery reminds one strongly of the Yosemite, but the foliation of the granite and the forms that result from it are wanting here. In the close part of the cañon west of the crest of the plateau, the granite becomes far more rugged and broken.

All the streams which enter the cañon from the sides have cut only through the stratified beds to the top of the granite. Thence they reach the bed of the cañon in fine waterfalls, of hundreds of feet, and in two or three instances, of nearly two thousand feet fall. In spring, when these streams are full, from the melting of the snow, some of these falls must be of surpassing beauty.

The following heights are on or near the crest of the Uncompahgre Plateau:

	Approximate latitude.	Approximate longitude.	Elevation, feet.
Station 14	38.08	107.54	9,561
Station 15	38.12	107.56	10,202
Station 18	38.16	108.07	9,557
Station 23	38.25	108.25	9,223
Station 26	38.30	108.35	9,789
Station 32	38.35	108.38	9,518
Station 36	38.42	108.45	-----
Station 33	38.43	108 48	9,315
Station 41	38.50	108.47	9,525
Station 43	38.49	108.53	9,334
Station 47	38.52	109.00	8,600
Station 48	38.52	108.58	8,766

West of the Uncompahgre Plateau the country assumes the form of broken plateaus and mesas, a character which it maintains to the Wasatch Mountains, varied only by the occurrence of a few groups of eruptive mountains.

The Rio San Miguel heads in the San Juan Mountains, and, emerging from them, takes a general northwest course, which it keeps to its junction with the Dolores, following the southwestern foot of the Uncompahgre Plateau. Its course is entirely in cañon, and in few cases are there any bottom-lands. In one place, where it has a west course for a few miles, there are half a dozen square miles of bottom-lands. The plateau, along its course, which I have named the San Miguel Plateau, is very flat and uniform, gradually falling from a height of 8,000 feet near the foot of the mountain to 6,000 at its mouth. The cañon walls range from 200 to 2,000 feet in height, but the ruling height is 800 to 1,000 feet. They are very rugged, and can be passed in few places. A few heights along its course are appended.

	Miles.	Elevation, feet.	Fall per mile, feet.
In valley below Bear Creek Pass, (head)	0	10,200	
Junction of east branch	12	7,700	208
Exit from the mountains	22	7,200	50
Crossing of the Navajo trail	40	6,300	50
Foot of western bend	64	5,500	33
Mouth	86	5,000	23

This stream was gauged in September at the crossing of the Navajo trail, and found to carry 288 cubic feet of water per second. But a very small part of this water can be used for irrigation.

The San Miguel Plateau is, near the mountains, covered with a scattering growth of heavy pine. Farther north, pine gives way to sage and grass. Here is also found in great abundance the *Yucca augustifolia*, whose pulpy, sweet seed-vessels form a staple article of food among the Indians.

The Rio Dolores heads in the western and southwestern slopes of the San Juan Mountains. Its course after leaving the mountains is at first nearly south, then, suddenly turning back almost upon itself, it flows northerly against the slope of a plateau, in which it buries itself deeper and deeper. In approximate latitude 37° 50′ it reaches the edge of this plateau, and by a succession of zigzags, alternately with the dip and the strike of steeply inclined beds, it reaches the level of the valley of Disappointment Creek. This valley has an elongated saucer shape, being surrounded on all sides by beds dipping toward its center. The Dolores flows around the west and north sides of this valley on the outside of its rim, most of the way being in a cañon between this rim and the wall of the plateau. At the northeast corner of this valley, the river suddenly turns from east to north, flows in this course a few miles between immense walls of sandstone, then turns again to the eastward, and holds this course to the mouth of the San Miguel, crossing on its way two sharp ridges and a transverse valley. After being joined by the San Miguel, this erratic stream seems to lose its desire to perform strange and unexpected things and quietly follows a northwest course to its mouth.

The annexed table of heights along the course of the Dolores will give an idea of the character of its fall. Many of the figures were given me by Mr. Chittenden, topographer of the southwestern division in 1875.

	Miles.	Elevation, feet.	Fall per mile, feet.
Lost Cañon	0	6,950	20
Lost Cañon	23	6,500	32
Mouth of Disappointment Creek	51	5,600	15
In Paradox Valley	85	5 100	17
Mouth of San Miguel	91	5,000	18
Mouth of Unaweep Cañon	113	4,600	17
Mouth	134	4,250	

Within my district there is little agricultural land on the Dolores. In the valley crossed by this stream just above the mouth of the San Miguel (which I have named Paradox Valley) a few square miles may be irrigated from the river, but not a large amount. At the foot of Saucer Valley, also, there are a few square miles of irrigable land.

The Dolores was gauged at the mouth of Disappointment Creek in September and found to carry 292 cubic feet per second.

The country between the San Miguel and Dolores consists of broken plateaus, here and there thrown up into ridges. In the southern part, it has a uniform slope toward the north from the western end of the San Juan Range. Farther north, the disturbances occur in lines running northwest and southeast. Westward from the San Miguel we note first a ridge dipping northeast, with an abrupt descent to the southwest. Then an anticlinal valley—Paradox Valley—with the same trend, crossed at right angles by the Dolores. Next a ridge, dipping southwestward at a low angle and breaking off toward the valley just mentioned. This ridge forms the eastern edge of a large, shallow, saucer-like depression. The northern edge of this breaks off against the Dolores, forming the southern wall of its cañon in a part of its eastern course. The southern rim was elevated by the San Juan Mountains. Its western rim is the next of the system of parallel ridges which diversify this plateau country, a part of an anticlinal, dipping northeast. West of this ridge is a long, narrow valley, with the prevalent trend, and draining northeast to the Dolores. The ridge on the farther side of this valley is the other half of the anticlinal, is low, and forms the eastern rim of the saucer-shaped valley of Disappointment Creek. There are here, then, two anticlinal and two synclinal valleys with their dividing ridges.

West of the Dolores is the plateau in which its cañon is cut. This plateau, called by Dr. Newberry, who accompanied Macomb's expedition to this country in 1859, by the generic name of the "Great Sage-plain," is drained entirely by the Montezuma, a branch of the San Juan. From the east, north, and west the slope is toward a center, forming a third saucer-like basin, but here the influence of the mountains is not felt on the south, and therefore in that direction it is open.

All this country west of the San Miguel, except immediately under the San Juan Mountains, is almost destitute of water other than the Dolores. One or two small streams carry a little water throughout the year, but it is more or less (and generally more) alkaline. There are a few springs and water-holes which can be depended on, not only for water but alkali, and often more of the latter than the former.

Speaking generally, grass is very scarce and sage is abundant. The little timber consists of piñon pine and cedar. It is valueless to the agriculturist and nearly so to the stock-raiser.

The Sierra la Sal is a small group of eruptive mountains standing south of Grand River and surrounded on the east and south by the Dolores. The group is about 12 miles in length from north to south and 6 miles in breadth. It derives its name from a small branch of the Dolores, whose water is a strong brine. This stream heads in a small valley at the eastern foot of the mountains.

These mountains are in three groups, connected with one another by low saddles. Their summits are 12,000 to 13,000 feet high, while the plateau near them is 6,000 to 7,000 and the beds of the principal streams are 4,000 to 5,000 feet above sea-level.

Heights of the principal peaks are given in the annexed table, with their approximate latitude and longitude.

	Approximate latitude.	Approximate longitude.	Elevation feet.
Northern group:	° ′ ″	° ′ ″	
Mount Waas	38 32 00	109 13 00	12,586
Station 66	38 33 00	109 14 00	12,032
Station 67	38 30 00	109 09 00	12,218
22–66	38 32 30	109 14 00	12,237
i	38 32 30	109 14 15	12,421
m	38 32 00	109 14 15	12,468
e	38 31 00	109 14 00	12,522
Mount Tomasaki	38 30 30	109 13 00	12,489
b	38 32 00	109 12 00	12,062
a	38 32 00	109 11 30	11,997
Middle group:			
Mount Peale	38 26 00	109 13 30	12,980
h	38 28 00	109 14 00	12,890
k	38 26 00	109 15 30	12,724
l	38 26 30	109 16 00	12,300
Southern group:			
Mount Tukuhnikavats	38 24 00	109 15 30	12,004

Since there has been talk of utilizing the salt deposits in Sindbad's Valley, as the valley in which Salt Creek heads has been named by the miners in the San Juan region, I will briefly mention here the best route to reach them. I know of no route practicable for wagons, and can conceive of none which can be opened without great labor. The best and most direct trail leads down the southwestern bank of the San Miguel, keeping back some distance from it, leaves it at the foot of the western bend, and keeps a northwest course down a long valley, crosses the Dolores in this valley, climbs its eastern wall a few miles farther on, and enters Sindbad's Valley on the west side. This trail is marked on the drainage map accompanying this report. The only bad place is in getting down the wall of Sindbad's Valley.

These salt deposits, though not extensive, are worthy of examination for economic purposes.

The Grand River, below the mouth of the Gunnison, flows in a valley for about 20 miles, closely hugging the precipices, which here form the border of the Uncompahgre Plateau. Its course is in this part about west-northwest. Twenty miles below the mouth of the Gunnison it runs into a low cañon 50 to 200 feet deep, among hogbacks which are outliers of the northern end of the Uncompahgre Plateau. Its course changes abruptly soon after entering this cañon to southwest and then to south-southwest, which it holds as far as the mouth of the Dolores; turning then to the southwest again, it keeps this course quite straight to its junction with the Green. There are but three or four places between the head of this cañon and the mouth of the Dolores where the river can be reached. At the mouth of the Dolores it buries itself in a deep, narrow, winding, but short cañon, cut into red beds, and emerges therefrom north of the Sierra la Sal into a valley of erosion, surrounded by tremendous cliffs of deep-red sandstone, 1,600 to 2,500 feet high, carved in fantastic forms, here simple, broad, and massive, there cut into spires, pinnacles, and buttresses. Below, it flows alternately in cañons and across narrow, transverse valleys. This river was gauged in September, at the ford, just above the mouth of the Gunnison. Its discharge was 4,850 cubic feet per second.

The work of this season completes the barometric profile of this river. This is given below:

	Miles.	Elevation, feet.	Fall per mile. Feet.
Grand Lake, Middle Park	348	8,153	
Mouth of Blue River, (head of cañon)	302	7,183	21.1
Foot of cañon in Park Range	295	7,000	26.1
Mouth of Eagle River	228	6,125	13.1
Mouth of Roaring Fork	209	5,734	20.6
Mouth of creek	203	5,645	14.8
Mouth of North Main Creek	188	5,445	13.3
Mouth of Roan Creek	152	5,100	9.6
Mouth of Gunnison River	120	4,523	18.0
Head of low cañon	104	4,500	1.4
Horseshoe Bend	70	4,300	5.9
Mouth of Rio Dolores	52	4,250	2.8
Junction of Grand and Green	...	3,900	6.7

The same valley as that known above the Gunnison, as the Uncompahgre Valley, and between the Gunnison and Grand as the Gunnison Valley, extends on down the Grand, on the north and west side of that river, to the western limit of my work, longitude 109° 30′. This part of it I call the Grand River Valley. Its length, following the general course of the river, is about 75 miles, and its average width is 15 miles. Area, about 1,100 square miles. It is almost flat, with a slight slope toward the river, from the foot of the Roan or Book Cliffs, which limit it on the north; and in the western part it rises toward the west, to form the divide between the Grand and Green. A few small hogbacks near the river alone diversify the surface.

With the sole exception of one little trickling stream, strongly alkaline, there is no water in the valley except the Grand River. The Roan Cliffs send down several small streams, but the water sinks very soon after entering the valley. Vegetation is very scanty. In the bottom-lands (which are very limited), there are fine groves of cottonwoods, and greasewood grows rank and dense. On the hogbacks along the river there is considerable grass, but elsewhere in the valley there is only a scanty growth of sage. The soil is everywhere impregnated with alkali. It is a stiff, heavy clay, which, when dry, has a surface as hard as a board, but, when wet, becomes mud of almost incalculable depth. The upper part of the valley, just west of the Little Book Cliffs, can be easily irrigated from the river, and thus several hundreds of square miles may be made available for agriculture. Farther down, however, the level of the valley rises so much that water from the river cannot reach it. Neither can it be irrigated by artesian wells, as the dip of the strata is away from it. It must remain what it is utterly valueless, unless a change of climate takes place.

The Grand River Valley is limited on the north by the Roan or Book Cliffs. The first name has been given them from their prevailing color, the second from the characteristic shape of the cliff, which, with its overhanging crest and slight talus, bears considerable resemblance to the edge of a bound book.

The line of these cliffs extends almost unbroken from longitude 107° 45′ westward across the Green River. The western limit has not yet been determined. The general course is slightly south of west, generally following the line of the Grand, being at a greater or less distance from it as the river trends more to the southward or northward. These cliffs are but the southern escarpment of a gently-inclined plateau, sloping north or northeast toward White River. With the exception of two large branches of the Grand, which, near the eastern end of the cliffs, cut some distance back into the plateau, the edge of the cliffs forms the divide between the waters of the Grand and White.

Above the mouth of Roan Creek the cliffs are simple walls of rock, nearly vertical, with the crest only three or four miles from the river. Their height is about 8,600 feet, or 3,500 feet above the river. North of the western end of Grand Mesa, the cliffs send off southward a heavy spur, dipping at a low angle toward the northeast. This spur joins the slopes of the Grand Mesa, and across it the Grand River has cut its way in a direction the reverse of the dip, making a tremendous cañon, which reaches, in the deepest part, a depth of nearly 3,000 feet.

Farther westward the cliffs consist of very rugged and precipitous foot-hills, rising by a succession of broken steps to the crest.

In this part the crest is 8,000 to 9,000 feet high, very narrow and winding. On one side are sheer precipices, several hundreds of feet in height, at the bases of which head small branches of the Grand. On the other side, on the sloping plateau surface, branches of the White River head. These streams rapidly cut their way down in the soft sandstones, so that their progress northward is little more rapid than that downward. The divide is in many places not more than 30 or 40 feet in width, with a sheer cliff many hundreds of feet high on the south and on the north an earth-slope of at least 30°.

On the crest water is very scarce. A heavy trail winds along it, and at every 12 or 15 miles there is a spring of excellent water.

The crest is mainly covered with grass and sage; quaking-aspen groves are found here and there, and, in a few localities, spruces and pines.

The following heights are on the crest of the cliffs:

	Approximate latitude.	Aproximate longitude.	Elevation. Feet.
Station 16	39.11	109.38	8,787
Station 17	39.15	109.32	8,620
Station 18	39.19	109.32	8,758
Station 19	39.22	109.26	8,207
Station 20	39.25	109.10	8,368
Station 21	39.26	109.17	8,379
Station 22	39.26	109.06	8,051
Station 23	39.31	109.02	7,904
Station 24	39.32	109.00	8,681
Station 25	39.37	108.54	8,669
Station 26	39.36	108.49	8,770
Station 27	39.32	108.37	8,850
Station 28	39.25	108.37	8,431
Station 29	39.27	108.37	8,591
Station 30	39.24	108.35	8,571

WAGON-ROADS, TRAILS, ETC.

The following are the principal wagon-roads in the district under consideration:

Wagon-road from Los Pinos (old agency) to the Uncompahgre agency.—This wagon-trail, though at present in a rough condition, can be put in good order at slight expense. It leaves the toll-road to Lake City at Lake Fork, and almost immediately climbs the high plateau which borders this stream on the west. This ascent is one of the most difficult parts of the route, from its length and steepness, and requires considerable grading, cutting, and embanking to render it practicable for heavy loads. On the plateau it runs nearly northwest, over a gently undulating surface, crossing two streams whose banks are quite steep, for a distance of about 8 miles, where it meets Gunnison's wagon-trail. This is the easiest part of the route. There is no improvement needed, except slight cuttings in the banks of the two streams mentioned above. The road thence follows Gunnison's wagon-trail to the Uncompahgre Valley. It passes along a depression between the spurs of the San Juan Mountains on the south and a high plateau on the north. This depression is cut by a succession of northward flowing streams into a series of saddles. The ascents and descents of these saddles are quite steep, but by a little cutting easy grades can be made. The road strikes the Uncompahgre at the old ford, and follows the river upon the west side to the agency. Wood, water, and grass are abundant everywhere on the route, except between the crossing of Cebolla Creek and the Uncompahgre. Here is a stretch of 25 miles without water, except in two alkaline springs, as Cedar Creek is dry nearly all the year.

From December to April this route is not practicable for wagons, owing to the snow; and for three months at least traveling it with pack-animals is impossible. There is no other route from the east practicable for wagons, and in winter this is the only available mail-route, and at any time of the year it is the shortest and best.

The following table is made out to give a few distances and elevations on this route:

	Miles.	Elevation, feet.
Los Pinos, (old agency)	....	9,290
Broad Plateau, average elevation	....	10,300
White Earth River	16.0	8,300
Leave Earth River	19.4	8,100
Plateau summit	22.2	8,900
Lake Fork	27.8	7,860
Plateau, gradually rising to	37.6	8,900
Mountain Creek	38.0	8,739
Divide	38.5	8,900
Blue Creek	39.3	8,600
Divide	40.0	8,800
Creek	40.4	8,300
Divide	41.6	8,500
Strike Cimmaron Creek	44.6	7,459
Leave Cebolla Creek	45.5	6,874
Divide	51.0	7,900
Ford of Uncompahgre	70.5	5,800
Uncompahgre agency	81.5	6,400

SKETCH OF THE SALT LAKE WAGON-ROAD FROM OURAY, COLO., TO SALINA, UTAH.

As many inquiries concerning this road have been made recently by settlers in the San Juan region of Southwestern Colorado, with a view to using it in freighting provisions, &c., from the settlements of Southern Utah, the following itinerary is presented to answer these inquiries:

In the prosecution of the work of this survey during the past two years, the writer has examined this road from Ouray nearly to the crossing of the Green River; and, through the courtesy of Prof. A. H. Thompson, of the survey under Maj. J. W. Powell, he has been supplied with notes respecting the portion of the route from Green River to Salina, the nearest settlement of any consequence.

Distances have been taken from the maps, and, as they disregard the minor curves of the road, they will in general be found rather under than above the distances traveled.

From Ouray to the Uncompahgre agency is 28 miles. The road follows the eastern bank of the Uncompahgre to a point two or three miles above the junction of the Dallas Fork, where it turns back from the river, and, after winding among the hills for a few miles, returns to the river in the cañon. The rest of the distance it follows the river, crossing it three times. These fords, and especially the second one, are dangerous in times of high water, and to avoid these a branch has been prospected. This, leaving the main road above the mouth of the Dallas Fork, crosses the Uncompahgre and this stream, climbs the high cañon wall by terrific grades, and then keeps along the plateau, descending by easy grades to the agency.

There are good camping-places everywhere on each branch of the road as far as the agency, where grass and wood are scarce. From the agency to the ford of the Uncompahgre, where the road from Los Pinos crosses, is 11 miles. The road follows the river on the western bank.

From this point to the ford of the Gunnison is 28 miles. The road keeps along the western bank, or near it, to a point about half a dozen miles from the mouth of the Uncompahgre, where it leaves it and bears off northwestward to the Gunnison, which it crosses at the mouth of Roubideau's Creek. A sketch of the ford is given, showing width and depths in September. In spring and early summer this ford is too deep to be practicable. The bottom is of pebbles and is perfectly hard. There are plenty of cottonwoods on each shore for the construction of rafts. There are good camping-places on each side of the river at this point; also all along the Uncompahgre.

Three miles beyond this ford there is a small stream of running water, but no wood.

At twenty-two miles from the ford the road crosses Kahnah Creek, a fine stream of excellent water, where there is good grass and wood.

Thence to the ford of the Grand River is 13 miles. From the crossing of the Gunnison to this place the road follows the general course of the Gunnison, keeping from one to three miles from it on the east side. There are two or three steep hills. The course of the road in this section might be changed to advantage in several places, with a gain both in distance and grades.

The Grand River is bordered on the south side for several miles above and below the ford by precipitous bluffs. The road follows down an arroyo, the only one for miles which cuts to the level of the river, and which reaches the river most opportunely at the end of a long riffle. The ford is on the head of this riffle. A sketch of it is given, showing the widths and depths in September. This ford can be used all the year, except, perhaps, during the spring freshets. The bottom is perfectly hard, being of pebbles. On the north bank, which is low, there is plenty of wood, but grass is scarce.

From the ford the road follows the Grand pretty closely for 20 miles; along this portion of the route the river is in a broad bottom, where wood is plenty, water accessible; but, except in a few places, grass is scarce. At a point 20 miles from the ford the river enters a low cañon, and for 30 miles (by the road) it cannot be reached. The road winds among the hog-backs 2 or 3 miles back from it. Where the river can be reached there is plenty of wood, and a mile or thereabouts from it good grass, but little or none at the river. Then there is another drive of 15 miles before the river can again be reached, and here wood and grass are both scarce. At this point the main wagon-road finally leaves the Grand, striking off in a course generally west toward the Green River, which is distant 65 miles from the Grand at this point. A branch of the road, however, continues down the river 12 miles farther, to a point where water is accessible and there is plenty of good grass and wood. Thence by a northerly course this branch rejoins the main road.

Between the Grand and Green Rivers there is no permanent water along the route. Still rain-water is found at several points in holes, where it remains for several days. Grass, also, is very scarce along this portion of the route.

At the ford of the Green there is plenty of wood and grass.

A sketch of the ford is given here. Most of the year it is an easy ford, but a slight deviation from the route takes one into deep water. The deepest part is on the east of the sand-bar, where, in November, the water nearly reaches the hubs of the wheels. The bottom is of pebbles, and perfectly hard.

From the ford the road follows the old Spanish trail up an alkaline creek, the water of which sinks and rises several times. At 15 miles from the ford the water in this creek is good, and there is wood and grass. Fifteen miles beyond there is water in large pockets or holes, never failing, with wood and good grass. At 12 miles from the last point there is water in a cañon on the south side of the road, with good grass, but little wood. In 15 miles more the road crosses the first branch of the San Raphael River, known as Huntington Creek, where are good water, grass, and wood. Three miles beyond, it crosses Cottonwood Creek, another branch of the San Raphael, where also are good camping places. And 12 miles farther on it crosses Ferron's Creek, a third branch of the San Raphael, where is a good camp, but wood is scarce. In 12 miles from Ferron's Creek, over a blue clay-soil, which in wet weather is bottomless, the road reaches Quichepan Creek, where there are good water and grass, but little wood. At 6 miles farther is Muddy Creek, where there is good water, but little wood or grass. Six miles beyond is Seep Creek, where there are all the requisites of a good camp; thence it is 6 miles to Ivy Creek, at the foot of its cañon, where the same conditions prevail. From this point to Salina is 40 miles. Wood, water, and grass are abundant on this part of the route, and the road is good, with the exception of one very long, steep hill, near Salina, which is ascended by teams going westward. The ascent of this hill is 2,000 feet. Between Ivy Creek and Salina there are ranches at short intervals.

From the Uncompahgre agency to the Green River, the soil is, almost everywhere, a stiff clay, which, when dry, forms an excellent, hard road, but, when wet, is heavy, deep, and very tenacious, making traveling with loaded wagons next to impossible.

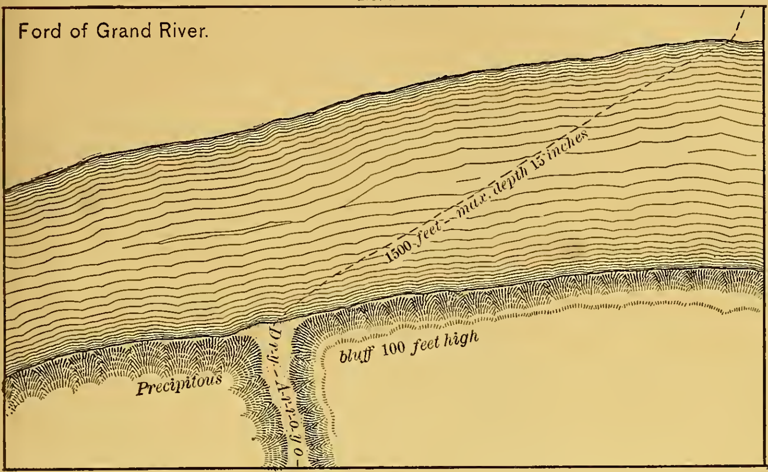
Summing up the distances given above, the distance from Ouray—

	Miles.
To the Uncompahgre agency	28
To the ford of the Gunnison River	70
To the ford of the Grand River	102
To the ford of the Green River	232
To Salina, Utah	374

The elevation above sea-level of—

	Feet.
Ouray	7,640
Uncompahgre agency	6,400
Ford of the Gunnison River	4,925
Ford of the Grand River	4,600
Ford of the Green River	4,100

North Side



North Side

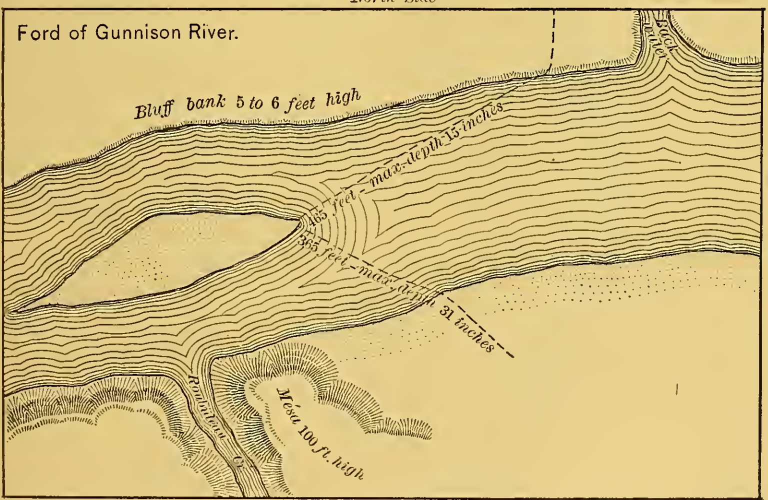


PLATE LI.

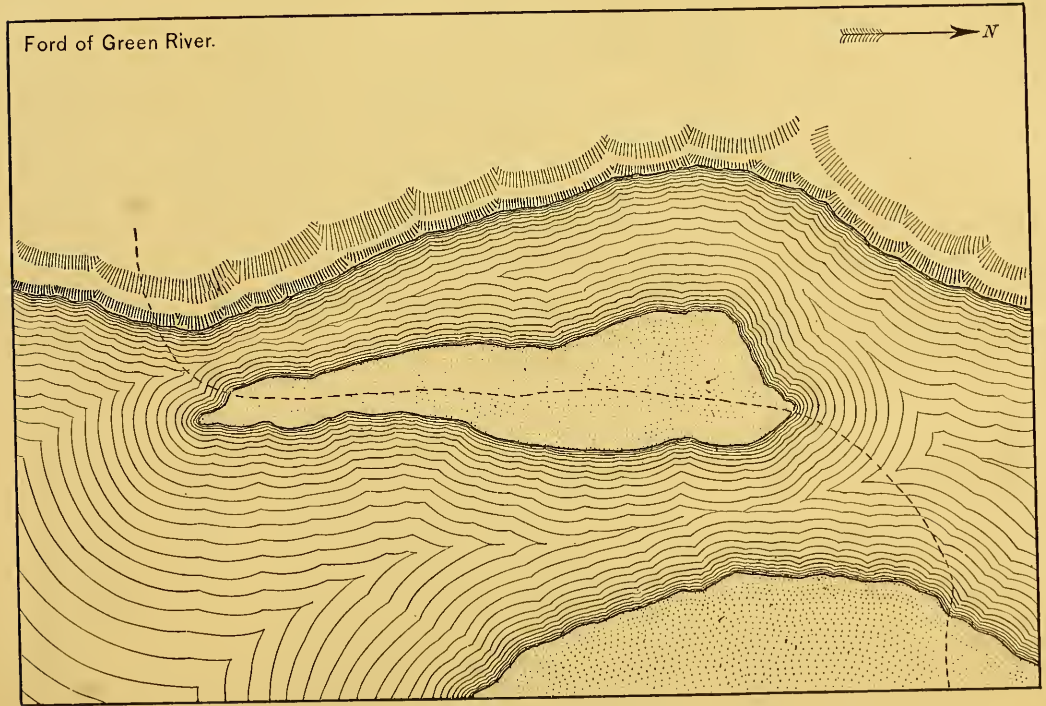


PLATE LII.

REPORT OF GEORGE B. CHITTENDEN, TOPOGRAPHER OF THE SAN JUAN DIVISION, 1875.

LETTER TO DR. F. V. HAYDEN.

WASHINGTON, D. C., *April* 30, 1877.

SIR: I have the honor herewith to submit my report as topographer of the San Juan division of the United States Geological and Geographical Survey of the Territories.

This division, under the immediate charge of Mr. William H. Holmes, left Denver on the 7th day of June, and returning reached the same place on the 22d day of September, in that time completing all but a very small area of the whole district at first allotted to them for survey.

In this report I have considered the general, and when necessary the detailed, topographical features of the season's work, and, besides the character of the country and vegetation, have given a list of altitudes and the method and accuracy of their determination, the fall of the rivers, total and per mile, and also the methods employed in the topographical work.

Trusting with this report and maps I have covered the whole ground in a way which will prove satisfactory to you,

I remain, sir, your obedient servant,

GEO. B. CHITTENDEN,
Topographer.

DR. F. V. HAYDEN,
United States Geologist-in-charge.

TOPOGRAPHICAL REPORT ON THE SAN JUAN DISTRICT.

The area of country assigned to me for topographical work in 1874 consisted of two distinct districts, the first a narrow belt of the plains and "hogbacks" on the eastern edge of sheet No. 83, and the second and main portion an area in Southwestern Colorado from 108° west longitude to 109° 30′, and between 36° 45′ and 37° 51′ north latitude. These boundaries carried the work 15′ into New Mexico and 30′ into Utah, with a rectangle 15′ by 30′ in Arizona.

The first district lay west of 104° 30′ west longitude, and principally between that and 104° 50′, its southern limit being 38° 00′ and its northern limit 39° 15′ north latitude. The two districts combined contained about 7,000 square miles.

The southwestern or main portion lying some three weeks' march from Denver (our base of supplies,) and the strip of plains being directly in the course, it was determined to work this field on the outward march and leave nothing unfinished for the uncertain weather of the fall. This precaution proved to have been wise, since unlooked-for complications in the summer would have rendered the working of this area at the close of the season almost impossible.

Since all that portion of sheet No. 83 outside of the granite mountain-mass has been worked by myself within the last two years, I shall consider here the plains and connecting topography to the foot-hills; it being characteristic of the whole eastern base of the Rocky Mountain system.

The plains sloping up from the Mississippi and Missouri Rivers with an extremely gentle rise, have only local disturbances of their generally flat and slightly rolling character, and are only cut by the main great rivers, as the Arkansas, Platte, and their principal branches, but as the mountains are neared the plains in many cases feel the influence of the mountain's upheaval and show greater evidence of recent erosion, so that for ten and even twenty or more miles from the actual mountain-base we find broken, low plateaus, isolated buttes, and quite marked ranges of hills and deep valley depressions. The numerous mountain-streams too, which here flow out through the plains at almost every mile, add to the detail of this peculiar topography.

The small detail of much of this topography and the slight range of altitude before the mountains are reached render a good expression of it in our adopted scale of 200-foot contours often impossible, and in the plotted map I can only hope to give a general idea of its change in character. In the higher mountain portions of Colorado 200-foot contours, at our scale of 4 miles to an inch, often become almost unmanageable from their closeness. It seems unadvisable to interpolate for the low country; we were, therefore, obliged to satisfy ourselves with the best results attainable with this wide range of height between our horizontal planes. The whole face of the Rocky Mountains rises with great abruptness from the plains, marking with all its bays and outstanding points a clearly-defined shore-line to the greater prairie-sea to the eastward. The general trend of the mountain-base in Colorado is a little east of south and west of north, and through the whole State, from Wyoming to New Mexico, it offers an unbroken front to the approach from the plains. It is only on penetrating the first foot-hills that the broad parks would be imagined to exist. The streams flow out generally from deep cañons, and in many cases the very foremost mountains of the mass extend above the timber-limit. To give a better idea of the extreme abruptness of the change, I give a section through Cheyenne Mountain from the eastern border of the sheet. It is a marked case, but thoroughly characteristic, and gives an average specimen of the small breakings of the plains.

In a northerly and southerly direction the topography of this sheet is not at all marked, although it includes the divide between the Arkansas and Platte waters. Denver, on the Platte, has an altitude of 5,200 feet, and Pueblo, on the Arkansas, an altitude of 4,700 feet, while the divide between the two attains 7,400 feet in height. The rise from the rivers to the summit is, however, extremely gradual, especially on the Platte side; so much so, indeed, that the most trained eye, when near the summit, is utterly unable to determine the direction of the slope. On the Arkansas side the character is different, being steepest near the summit and becoming extremely gradual as the river is neared.

A change, however, much more noticeable than the change of topography, is that of vegetation. On the north or Platte side of the divide there is a most luxuriant growth of grass and only isolated patches of timber; but immediately the actual summit is reached, a most dense growth of yellow pine is entered, which continues in a narrow and almost uninterrupted belt from the mountains far out into the plains. This timber-line is generally as clearly defined as it could be cut with an ax, and follows pretty closely the summit of the ridge. There are, indeed, considerable patches of timber around the Plum, Cherry, and Kiowa Creeks, but it makes at the summit a very marked and noticeable change in the character of the two slopes. This "divide-timber" has already proved of great value, from its ready accessibility and good quality, and through it all saw-mills are now, and for years have been, constantly working. West of 104° 30′ there are perhaps somewhat over 100 square miles of it, through which much of the best timber has already been used. When cut over it springs up quickly and thickly in a young and vigorous growth, and promises, as far as its area permits, a constantly recurring supply.

The climate of the divide is, from its altitude, much colder than any of the better-known places on either side. The height of 7,000 feet at this latitude in Colorado is certainly very nearly to the limit at where cattle may be wintered with any safety. Ranchers, however, near the summit have told me that they have wintered their herds there without loss.

The lower altitude and greater amount of water in the vicinity of the Platte, and even nearly to the summit of the divide, makes the whole district valuable for both stock-raising and farming. The same may be said of the Arkansas side. As soon as the timber-belt is passed, the rich grass region again commences and continues uninterruptedly to the river. On the slope almost every drop of available water is already used for irrigation. The Arkansas still contains an immense amount, requiring long ditches to throw it on to the plains. The amount of farm land at any distance from the main rivers cannot now be greatly increased in this portion of Colorado for lack of water. Windmills may be used to some extent for irrigation, but will not furnish a very large amount. I found them used in several places for watering stock, and with great success, throwing the water into reservoirs to obtain a constant supply.

Stock men are already complaining of the over-crowded condition of the range, but in my opinion the number of cattle and sheep it will eventually support will be vastly greater than the present amount.

Throughout this whole plains-area roads are almost innumerable, bisecting the country in every direction. Wagons may run regardless of roads across the plains in almost any place, so new paths are constantly being made. On the map I have drawn in roads wherever I could trace them, but when not located on the land-survey maps, I have no accurate plot of their detail. They will, I believe, however, be found accurate enough for the purpose of travelers, and to show route of communication.

The three principal towns in the districts are Colorado Springs, Pueblo, and Cañon City, all of them thriving, well-to-do cities, with ample railroad communication and a considerable trade from the mountain country beyond. The Denver and Rio Grande Railway connects all these cities with Denver and the east, while the Atchison, Topeka, and Santa Fé, coming up the Arkansas Valley to Pueblo, makes a second trunk line to the Atlantic States.

In productions, cattle and sheep raising is the principal industry and must always remain so; corn and fruit are raised in the lower portions; potatoes and other farm-products generally, where water will afford irrigation. Without artificial supply of water no crops are raised excepting, perhaps, in a few places on the summit of the divide and near the base of the Greenhorn Mountains. In climate I need say nothing of the general healthfulness; it is already well established. I will, however, add a short table taken from the Signal-Service reports and from our own observations at Cañon City, showing some mean monthly temperatures at these places, when compared with those of well known cities in the East.

At Colorado Springs the Signal-Service observations did not commence until December, 1873. I have therefore introduced the means from the 1874 observations. This will not give an accurate comparison, but will not, I think, seriously mislead. At Cañon City, observations are wanting for May and June, 1874. To furnish a ready means of comparison of temperatures I have chosen Chicago, New York, and Washington, and included their temperature means with those of the western cities. At Pueblo I have no observations either through the Signal-Service or from our own work, and can only say that it has a temperature considerably higher than that of Denver, but probably somewhat less than that of Cañon City, from its more exposed location.

Monthly mean temperatures from July, 1873, to June, 1874, inclusive, showing relative temperatures of Denver, Colorado Springs, and Cañon City, compared with Chicago, New York, and Washington.

	1873.						1874.						
	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	Mean.
Colorado Springs..	73.2	70.3	56.7	49.9	37.9	26.9	30.3	25.5	34.5	38.5	58.6	68.9	47.6
Denver.	71.4	70.8	59.7	45.2	40.6	22.4	31.5	24.7	36.4	43.1	61.9	70.0	48.2
Cañon City........	78.4	78.2	68.4	55.5	52.5	42.4	40.9	36.9	39.9	45.6	......	......	......
New York	73.9	71.4	65.4	55.6	37.9	36.9	34.7	31.5	38.3	41.6	58.6	70.4	51.3
Chicago..........	71.2	71.7	62.4	49.1	34.4	32.4	29.1	31.5	36.3	38.7	58.5	70.2	48.7
Washington	80.3	74.9	68.3	55.3	41.4	40.9	40.5	36.4	44.6	47.8	64.3	77.2	55.8

Aside from the temperature there is of course great difference in the climates of those western cities as compared with the east. The rainfall is not more than one-third that of the Atlantic coast, cities and the general dryness of the atmosphere in a like proportion.

The general rule of decrease of three degrees of temperature per 1,000 feet of altitude, though far from an unvarying law, may give an approximation to the general temperature of the divide, and give an annual mean of some 43°, something less than that of Buffalo, N. Y., and nearly equal to that of Milwaukee, Wis.

By an examination of the table it will be seen that Cañon City at about the same latitude as Washington, but with altitude of 5,300 feet above it, has practically the same temperature. Relative humidities would show an immensely greater evaporation at the former place. Cañon, though less than a degree of latitude south of Denver and at nearly the same altitude, has a much warmer climate, averaging some ten degrees. This is owing greatly to the peculiarly protected position of the city. It lies in a deep bay in the mountain base, and is thoroughly surrounded on three sides by mountains; its only exposure being toward the southeast. Denver temperatures very nearly approximate those of Chicago, and slightly lower than New York, and slightly higher than Colorado Springs. Colorado Springs, though lying a degree south of Denver, is nearly 1,000 feet above it in altitude, readily accounting for the increased cold. Other years' observations, published by the Signal Office, retain nearly the same relations between the temperatures of these cities, making this table a fair criterion of what more extended observations would tend to show.

With this slight discussion of the climate of the district I will close the consideration of this portion of the work, leaving to a study of the maps of the survey the more careful understanding of its whole topographical features.

Dr. Hayden, Dr. Peale, and Mr. Holmes have all written of it in their geographical reports, while a great amount of Colorado letter-writing has been devoted to this belt of country which forms the line of junction of the mountains and the plains.

The second and main portion of our district, lying west of the one hundred and eighth meridian, with boundaries as given in the first part of this paper, was entered on the 29th of June, the first topographical station being made on the east side of the La Plata River, and looking down and across it to the south and west.

This southwestern district is divided naturally into two portions by its two distinct drainage systems; the first, that of the San Juan, and second of the Dolores. The San Juan drains the whole southern and western portions and empties its waters into the Colorado River, something more than a hundred miles below the junction of the Green and Grand. The Dolores drains only the northeastern portion of the district. It rises in the southern face of the San Miguel Mountains, flows first to the south and southwest for about 34 miles, and then turning sharply back flows in a northwesterly direction till it joins the Grand, 50 miles above its junction with the Green. At the bend the Dolores would require a cut of less than 200 feet in depth to turn its waters into the San Juan, in what, from the configuration of the country, would seem decidedly to be the natural course of the drainage. But the river, planned in other times, comes from a deep cañon out to find this low divide, and then, disregarding the tempting offer, plunges again into a narrow gorge and finally loses it in the Green 150 miles from where the San Juan finds its mouth.

The whole area being divided into two systems, the San Juan division may be again subdivided into four, which, beginning on the east and naming them in their order, are the La Plata, the Mancos, the McElmo, and the Montezuma.

The San Juan flows from east to west along through the northern point of New Mexico and, crossing through the far northeastern corner of Arizona, enters Utah, and still holding its general course joins the Colorado in that Territory.

All these sub-drainages which I have named flow in a generally southerly direction to join the main river, the La Plata and Mancos being the last streams with any considerable running water which are tributary to it.

The San Juan River in this part of its course is a broad, slowly-flowing stream, with long stately bends and rich bottom-lands. Terraces and low plateaus line it on either side and stretch for some distance back into the country. The water is almost universally muddy, and subject to sudden rises not only from mountain but from local storms. Its tributaries are so few and small, that its size constantly decreases till it carries quite noticeably less water when we last saw it in the west than at the mouth of the Animas, near our eastern line. This is partially caused by the drinking up of the water by the sandy bed, but more must be laid to the extreme dryness of the atmosphere and consequent rapid evaporation under the burning summer sun. The temperature of the river is extremely high, being by one measurement near the western line 78°, and by another, made by Mr. Jackson, still farther down, 84°, near the center of the stream. The water of the river is exceedingly soft and pleasant for bathing, and its effect on the rough, bruised hands of all the party was very noticeable after some two days camping by it. Its softness was also very noticeable in the washing of clothes.

As I have said, heavy storms in the mountains or along its shorter tributaries cause sudden rises in the river; they also make it filthily muddy; great masses of mud seem carried along by its waters; it is absolutely thick with the solution, so horribly dirty that the hot, thirsty mules would turn away from it, braying dolefully with their disappointment. For our own use, a little practice taught us to filter it to some extent and render it comparatively drinkable. Water dug from the banks only a little way from the running stream was so decidedly alkaline as to be unfit for use; we preferred the muddy water of the river. We found no Indians (with one exception) along the river, and very little sign that they were in the habit of camping there to any great extent. The badness of the water, and one other fact—that every heavy shower may flood the river-bottom land—may account for this. Certain it is that we found Utes and Navajoes settled by some little uncertain alkali springs, cultivating their patches of corn and melons with but small returns, while the broad, rich bottom-lands of the San Juan were entirely deserted.

There is very little grass away from the river all through this portion of its course; the terraces and bluffs are generally covered with a low sparse growth of sage and weeds, with here and there scattering bunches and patches of grass; there is no timber excepting the cottonwoods, which line the river-banks.

The Navajo reservation in Northern Arizona and New Mexico extends east only a little beyond the mouth of the Rio Chaco, but the Indians range all along the south side of the San Juan to some distance east of this place. In as far as the Ute and Navajo reservations join each other, they join on the Southern Colorado line, but practically the Indians take the river as the boundary, and we seldom see signs of either tribe except on their own side of the river. All south of the San Juan, and especially around the Carriso Mountains, the Navajoes live in quite considerable villages, and are an industrious, cleanly set of people. They raise large supplies of corn and melons, work quite steadily at weaving blankets, and herd fine droves of sheep. They had also the finest horses I have ever seen among the Indians, many of them large, well-built American stock.

These Indians have a mania for trade; they will swap for anything; but are especially fond of leather: an old boot-leg, an extra bridle-rein, or some ornamental piece from the saddle would be eagerly sought after. They refused $5 for a sheep, and finally traded it for a couple of pounds of flour and a piece of saddle-leather readily replaced for 75 cents. Green corn and melons they brought us constantly for trade, and always seemed satisfied with the sharp bargains which they drove. They beg very little, but pilfer constantly and with great cunning; no small, loose article seemed safe for a moment within their reach. Aside from this habit of petty stealing, they are not disagreeable around camp, being generally quiet and unobtrusive.

The Carriso Mountains, around which the Navajoes are settled, are a flat-topped mass of volcanic matter of about 130 square miles in extent, and rising to an altitude of 9,000 feet. They have several trails running up to their summit valleys, and have no peaks so sharp that a mule may not be readily ridden to their tops. There is very little water running out of the mountains, although there are very numerous springs both at the summit and base, and almost daily showers upon them throughout the summer season. There is most excellent grazing on the rolling top of the mass, with springs to furnish water and timber enough for all necessities; the Navajoes have both horses and sheep there during the summer, building little huts and corrals for the use of the herders. I noticed one of these in crossing the mountains, not at all dissimilar to what a white man would have built under similar circumstances. The trails which the Indians use in ascending the mountains are almost the only means of access to the summit, the trachytic mass being formed in palisades much of the way around and always rising boldly from the plains. The trails, however, are good and, once found, make the crossing of the mountains an easy task. I was on top of the mountain mass three times, but only twice found the weather sufficiently clear to accomplish all my work.

Aside from the mountains, we found no continuous running water south of the San Juan River; Mr. Jackson, who went much farther south and west than our division, found none. He traveled clear to the Moquis villages, crossing both Gothic Creek and the Rio De Chelly, and found no running water excepting immediately after heavy rains. The only water found for hundreds of square miles, through Northern Arizona and New Mexico, is in springs and accidental places in the beds of dry washes, where an underlying current is forced to the surface, or sometimes in "pockets," either in clay or rock, where it has caught from heavy rains. There are, of course, the few main rivers, but all their minor branches are but dry beds. Heading in almost rainless deserts, they have often a large water-shed to drain. But the extremely slight rain-fall and high rate of evaporation leaves no water for the streams to carry off.

Below the San Juan River there is much more grass than on correspondingly situated and characterized country to the north of it; this I suppose to be owing to the fact that the numbers of sheep and horses pastured by the Navajoes on the south side keep down the weeds and sage, and invigorate the growth of grass. Doubtless close grazing with burning would increase the growth of grass on the plains north of the river.

As I have said before, the San Juan system of drainage in this district is naturally divided into four subsystems; the first of these from the east, the La Plata, although the shortest stream of the four and containing the smallest drainage-area, carries the most water. The La Plata rises in the little group of mountains which have the same name with it and flows in the most direct possible course to join the San Juan. It flows for its entire length, after its first break from the mountains, through an open terraced country. The whole length of the stream is something over 50 miles. It has a drainage-area of 750 miles and outside of the mountains an average fall of 50 feet to the mile. The fall is very rapid near the mountains and gradually decreases as its mouth is neared. There is but one single branch containing water (Cherry Creek), but besides this there are no less than twenty gulches emptying themselves into it, always dry except in case of sudden and heavy rains. Two of these gulches have lengths of 18 and 20 miles each, and others are more than half as long. Their washes are clearly defined for their whole course, but their beds are entirely dry.

In 1874 the only settlement in the whole district was on the La Plata, at its head. It was at that time a very embryotic mining-town, containing two log houses and a third in the process of erection. It is called Parrott City, and since that time has grown quite considerably, having been made the county-seat of La Plata County and supplied with a regular mail. Its support comes from the mines at the head of the stream, which consist of both quartz-lodes and placer-diggings, and have been pronounced quite valuable. There are two routes of access to Parrott City, of nearly equal length, the one by the south from Tierra Amarilla, open both winter and summer, and the other the direct route to the San Luis Valley, by way of Howardville and Silverton, to Del Norte. This latter route is impracticable in winter, owing to the high mountain-passes. The northern route is the one by which the mail is regularly brought in, but the southern one is the road for all supplies and freight.

The vegetation of the La Plata is varied. In the vicinity of Parrott City the river is bordered by terraces covered with a rich growth of grass and on the east side by a large mass of yellow-pine timber. Ten miles below the city the grass almost entirely ceases and the bordering country is covered with a heavy growth of sage. About 25 miles below the town the river crosses the Colorado line into New Mexico, and from there to the mouth has no large sage, and a considerable growth of grass on the bordering terraces.

Parrott City is in what is known as the "San Juan purchase," the southern line of the cession crossing the La Plata 10 miles below the city. At the town the altitude and closeness to the mountains renders the winter climate quite cold, but by the time the river enters the reservation-limits it has fallen so much in height that the Indians raise corn and melons every summer, and find very little snow to trouble them in the winter season. On the La Plata, near the line of the purchase, is quite a large Indian farm, which they supply with water by rough irrigating-ditches, and raise a considerable quantity of corn. The Indians during the growing-season of the crops confine themselves pretty closely to the village and watch their corn with great solicitude. They have considerable herds of ponies, goats, and some cattle. There is almost no game in the low country, unless—as seems quite probable

—it runs down there during the winter to escape the snow. The almost entire absence of elk or deer horns would, however, indicate that even then it is there in no large quantities.

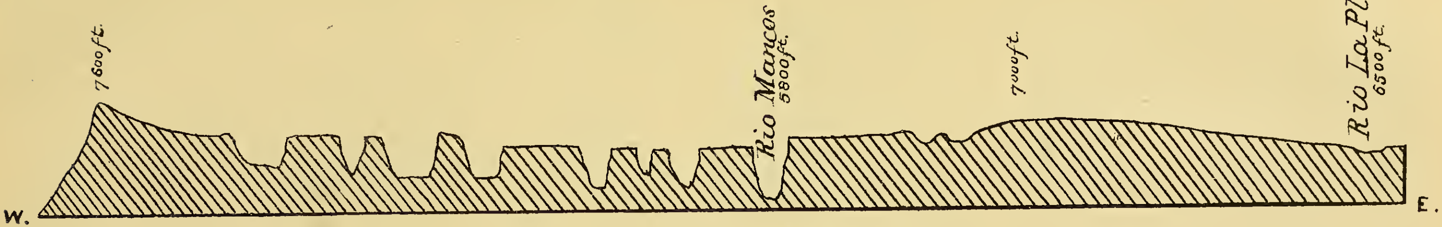
In the whole drainage area of the La Plata there is not, to my knowledge, a single spring or drop of running water, excepting of course the river itself, its heads, and the immediate vicinity of Parrott City. The irrigating power of the stream is probably not greater than would suffice to water its own bottom-lands, so the low bordering terraces must still remain in their present barren state.

Next west of the La Plata, and flowing into the San Juan from the north, comes the Mancos. It rises on the northern and western fall of the La Plata Mountains, is something less than the La Plata in size, has a length of about 70 miles, and enters the San Juan 50 miles below the mouth of the former stream. Unlike its sister river, which for its entire length flows in open country, the Mancos is nearly all its course in cañon. Its main branch starts in cañon as it leaves the mountains, flows in a narrow rocky cañon till near its junction with the other branches, and then, after a few miles in open fertile valley, plunges into the Mesa Verde, and, in a rugged winding cañon, flows through its very heart. The Mesa Verde is a high plateau or table-land which rises gradually from the La Plata on the east till it reaches an altitude of about 500 feet above the river-level, then runs almost perfectly flat on top until it jumps off on the north and west and south in steep and inaccessible bluffs. Through the heart of this table-land the Mancos cuts its way, the walls rising on either side to heights of 1,000 to 1,800 feet. To the south and east of the river the plateau is but very little broken, but the northern part is gashed by a perfect net-work of side cañons, the beds of all of which are dry.

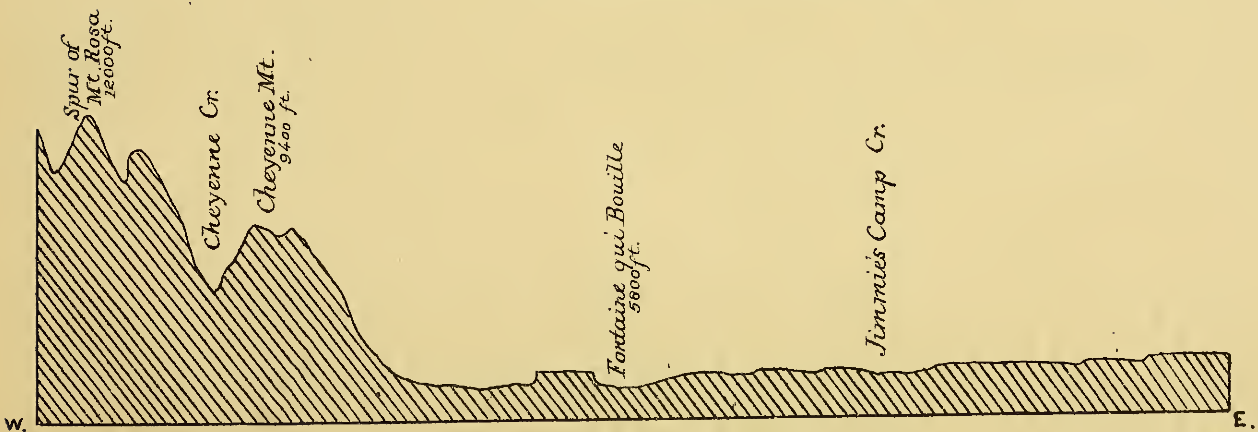
I give (Plate LIII) a section through from the La Plata to its western edge, which will show better than I can describe its form. North and south the section would not materially differ, except in being steep at both its ends.

In the cañon the valley of the Mancos is quite narrow, very seldom being more than a quarter of a mile wide, and often very much narrower. The cañon walls and valley bottom-lands are lined with ruins—particularly described in Mr. Holmes's report—which show that the valley has been thickly inhabited and probably cultivated by ancient tribes, although the present Indians do no work anywhere upon it; in fact, there is but a very indifferent trail up and down the cañon. Corn, potatoes, melons, or any vegetables may be raised on the Mancos for its entire length. In the broad valley below the forks there is a considerable tract of good farm-land, all within the purchased area. The reservation begins soon after the river enters the deep Mesa Verde Cañon. Unfortunately the Mancos does not carry enough water to irrigate but a small portion of the available land. If white men were to irrigate al that could be covered above the reservation limits, there would be but little water left for the agricultural pursuits of the red man below. Below the forks of the Mancos there is only one branch containing any water; this fork is in some seasons dry, and never carries any large amount. All other washes—and they are as numerous as the branches of the La Plata—are entirely without any water. I think it probable that in the drainage which comes from the cañons of the Mesa Verde north of the Mancos there may be some water, as it starts close to the northern edge of the plateau. I have never examined these heads, but in the bluffs opposite them on the northern face of the mesa I found quite numerous springs of alkali water.

Plate LIII.



Section through Mesa Verde



Section through Cheyenne Mt.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

To the west of the Rio Mancos there are still two well-defined drainage-systems tributary to the San Juan, the McElmo and Montezuma. The two systems together contain about 2,100 square miles—the McElmo 700, the Montezuma 1,400. The McElmo is about 50 miles long in its longest branch, the Montezuma 60 miles, and yet neither of them has for any distance in its course running water. All the heads of these dry rivers except the western branch of the Montezuma originate in a nearly level sage-plain, flow for some distance without an appreciable valley, then cut their way for their middle course through a steep and generally impassable cañon, and finally, for the latter part of their way, run through a comparatively level or low broken country to the river.

What may have been the original history of these dry rivers is more in the province of the geologist to inquire into than in mine. I am, however, safe in saying that for hundreds of years the character and amount of rain-fall has not materially changed. Heavy rains pour in perfect torrents down their beds and are gone, as they came, in a day, and the hot sun leaves in a few hours afterward their washes as dry as before. The whole country seems incapable of holding water. It runs directly off. It does not seem to any great extent to soak in.

In support of what I say about the present dryness having been of long standing, I notice that among all the ancient ruins found in this whole area there are none which are not situated at places where at present there are not at least strong indications of water. Undoubtedly at the time those ruins were inhabited there was slightly more water than at present, for we find some large remains now utterly unsupplied; but it has unquestionably always been a dry country, whose inhabitants were obliged to group themselves around its scanty water-holes and build reservoirs to equalize the uncertain supply.

This whole portion of the country is now and must ever remain utterly worthless. It has no timber, very little grass, and no water.

There are to be seen around the base of the Abajo Mountains several springs and some short strips of running water. There are probably, also, little springs at the heads of very many or all of the McElmo and Montezuma Cañons. I have followed up so few of them that I am uncertain to what extent this may be true. Mr. Gardner and Mr. Gannett found some such springs in the fall, but such uncertain and limited and inaccessible supplies amount to very little in watering a country, and leave it really a broken, ragged desert, supporting no animal life but reptiles and only a stunted growth of vegetation.

The Dolores water-shed is radically different from those last considered, both in character and climatology. The river runs in deep cañon, but the plateau through which it cuts is well watered and richly covered with either grass or heavy timber. The narrow bottom-land of the Dolores, as the river winds through the cañon, will afford some most excellent farm and hay land at an altitude of only 6,500 to 7,200 feet, while the area inclosed by the great loop to the south made by the river will afford most ample grazing in the summer-season. As beautiful a piece of park-like distribution of grass and wooded belts and patches as I have seen anywhere in Colorado is found on the east side of the Dolores, in the vicinity of Lost Cañon and between it and the West Fork of the Mancos. We rode through mile after mile of open grassy lawns and clumps of sheltering timber, ready for the pasturing of large herds or the supplying of great quantities of hay for the settlers at the lower altitudes. The San Juan purchase includes nearly all this country, as will be immediately seen by reference to our published maps.

The map will show one curious feature—that is, that the Dolores, from

Lost Cañon clear past the heads of the Montezuma, receives almost no drainage from the south. The gulches of the McElmo, Hovenweep, and and Montezuma head clear up against the cañon of the Dolores; so completely do they do this that you may ride up one of these gulches and, without leaving its valley, look down upon the Dolores below.

I have now described, as well as I might, the general topographical peculiarities of this southwestern area. Taken as a whole, it is by far the poorest district yet worked by this survey. Of the 5,500 square miles covered by the season's work, not more than 75 square miles is irrigable, and not more than 500 in any way available for supporting population. The greater portion of the good grass-land, I might say all the good grass-land, is at too great an altitude for a winter-range for stock, and I am inclined to think the danger from sudden floods will be a great drawback to the value of the broad bottoms of the San Juan. The most valuable portions of the district have become open to settlement by the San Juan purchase, and the opening of the mines will, doubtless, rapidly fill up all the available places with thriving ranchers, who will find many desirable locations within the grant.

I give in the following table a collection of heights through the district, which may prove valuable to persons not likely to study the contour-map:

Table of altitudes.

	Feet.
Camp under Lone Cone	9,093
Dolores River, camp below mouth of Bear	7,427
Dolores River, camp midway between forks	7,758
Dolores River, camp at Lower Burial Place	6,555
Dolores River, camp at main bend	6,948
Disappointment Creek, below Lone Mesa	7,091
Hovenweep Creek, at Castle	5,239
Helmet Peak	12,042
Hesperis Peak	13,159
Hermano Peaks	9,014
La Plata River, above Indian farms	6,213
La Plata River, at mouth	5,297
Lone Cone	12,761
Merritt's ranch	7,398
Mancos River, camp at head of main cañon	6,306
Mancos River, near mouth of main cañon	5,326
Station 56, opposite mouth of Navajo Creek	5,268
Thompson's Park	7,576
Unaqua Spring, (Dolores Plateau)	8,141
Ute Peak	9,884
McElmo, at head	7,000
McElmo, at Pegasus Spring	5,838
McElmo, at mouth	4,566
Montezuma, at head	7,000
Montezuma, at main forks	4,600
Mouth of Recapture Creek	4,446
Navajo Creek, camp above Navajo Village, East Fork	5,672
Navajo Creek, camp near village, West Fork	5,468
Navajo Creek, mouth	4,780
Navajo Mésa, eastern end	6,590
Parrott City	8,611
Pastora Peak, Carriso Mountains	9,332
Plateau on trail between Hovenweep and Montezuma	5,554
Station 8, Pinon Mésa	6,269
Station 9, between La Plata and Animas	6,066
Station 11, bluffs above mouth of Animas	5,899
Station 12, bluffs below mouth of La Plata	5,401
Station 15, south edge of Mésa Verde	6,587
Station 25, summit of mésa, mouth of Mancos Cañon	6,877
Station 27, summit of mésa, middle of Mancos Cañon	6,350
Station 35, north edge of Mésa Verde	8,532
Station 36, plateau edge, north of Ute Peak	6,979

	Feet.
Station 43, butte south of San Juan	5,430
Station 45, butte on San Juan below Recapture Creek	5,298
Station 50, butte on Navajo Creek	5,321
Station 54, west mésa, Carriso Mountains	8,042
Station 55, bluff above West Fork of Navajo Creek	5,659

The above altitudes are all based on the leveled altitude of Colorado Springs, though the main part of them are computed from the Parrott City base, which was itself computed from Colorado Springs by single synchronous observations at 7 a. m., 2 p. m., and 9 p. m., between August 1 and September 4. The results of these computations I give below in tabular form, together with their variation from the mean. The difference in altitude of the two places is about 2,600 feet, and their distance apart horizontally something over 200 miles, and across much heavy mountain country. The general agreement of the results is much better than could have been expected, and speaks well for the correctness of those heights necessarily referred directly to Colorado Springs. I have taken the absolute mean of all the results, throwing out none for electricity on either side. From studies of the hypsometric work in other parts of Colorado, I am inclined to think this result *slightly too low*, but up to this time have found no law on which reliable corrections may be based.

Computation of the height of Parrott City from Colorado Springs, synchronous barometric observations, at 7 a. m., 2 p. m., and 9 p. m., during the month of August, 1875.

Date.	7 a. m.		2 p. m.		9 p. m.		Day.	
	Height.	Corr. to mean.	Height.	Corr. to mean.	Height.	Corr. to mean.	Height.	Corr. to mean.
August 1	8,551	+ 60	8,654	− 43	8,598	+ 13	8,601	+ 10
2	8,633	− 22	8,615	− 4	8,557	+ 54	8,601	+ 10
3	8,536	+ 75	8,605	+ 6	8,628	− 17	8,589	+ 12
4	8,514	+ 97	8,691	− 80	8,651	− 40	8,618	− 7
5	8,574	+ 37	8,650	− 39	8,557	+ 54	8,593	+ 18
6	8,619	− 7	8,768	−157	8,668	− 57	8,685	− 74
7	8,515	+ 96	8,598	+ 13	8,535	+ 76	8,549	+ 62
8	8,503	+108	8,587	+ 24	8,585	+ 26	8,558	+ 53
9	8,566	+ 45	8,704	− 93	8,653	− 42	8,607	+ 4
10	8,603	+ 8	8,750	−139	8,683	− 72	8,676	− 67
11	8,594	+ 17	8,701	− 90	8,607	+ 4	8,634	− 23
12	8,548	+ 63	8,663	− 52	8,559	+ 52	8,590	+ 21
13	8,607	+ 4	8,692	− 81	8,565	+ 46	8,618	− 7
14	8,551	+ 60	8,719	−108	8,573	+ 38	8,614	− 3
15	8,602	+ 9	8,657	− 46	8,572	+ 39	8,610	+ 1
16	8,639	− 28	8,651	− 40	8,563	+ 48	8,617	− 6
17	8,602	+ 9	8,699	− 88	8,702	− 91	8,671	− 60
18	8,656	− 45	8,641	− 30	8,675	− 64	8,657	− 46
19	8,582	+ 29	8,679	− 68	8,637	− 26	8,632	− 21
20	8,600	+ 11	8,710	− 99	8,669	− 58	8,659	− 48
21	8,655	− 44	8,771	−160	8,609	+ 2	8,678	− 67
22	8,521	+ 90	8,563	+ 48	8,551	+ 30	8,545	+ 66
23	8,501	+110	8,533	+ 78	8,535	+ 76	8,523	+ 88
24	8,546	+ 65	8,584	+ 73	8,514	+ 97	8,548	+ 63
25	8,494	+117	8,593	+ 18	8,520	+ 91	8,557	+ 54
26	8,544	+ 67	8,598	+ 13	8,579	+ 32	8,573	+ 38
27	8,551	+ 60	8,663	− 52	8,591	+ 20	8,601	+ 10
28	8,622	− 11	8,632	− 21	8,636	− 25	8,630	− 19
29	8,656	− 45	8,612	− 1	8,512	+ 99	8,593	+ 18
30	8,493	+118	8,536	+ 75	8,498	+113	8,509	102
31	8,514	+ 97	8,612	− 1	8,563	+ 48	8,573	+ 38
Monthly mean	**8,582**	**+ 29**	**8,655**	**− 44**	**8,595**	**+ 16**	**8,611**	**00**

The altitudes of the La Plata peaks are all slightly less than Hesperis Peak, the highest given. As nearly as I can judge from verticle angles taken from my topographical stations in the mass, there is no other summit which rises within 25 feet of this one, although the greater sharpness of some other points would naturally lead the observer to believe them at least as high.

The altitude of the Mesa Verde ranges from 6,500 feet on the southern edge to 8,500 on the northern, it being a little lower in its center than on the margin.

Pastora Peak, in the Carrisos, is very little higher than several other summits in the mass, but is slightly more prominent than any other one, and would be chosen as the culminating point as seen from either side.

I have taken several angles of elevation and depression at the "Needles," south of the San Juan, in New Mexico and beyond our district. My distances were so great that the results have a considerable range, but a mean of what seem to be the best results give a height to these pinnacles of 1,680 feet above the level plain. These needles, standing out sheer and alone from the plains, make a wonderful topographical feature, distinctly seen for a hundred and more miles, the black rock of which they are composed standing out with peculiar distinctness against the dull brown of the plains. Mr. Holmes made several sketches of the group, one of which I give herewith, showing very clearly its size and prominence. (Plate LIV.)

In closing my discussion of altitudes, I give a table of fall, total and per mile, of the principal streams and gulches, commencing in case of the Mancos and La Plata at their exit from the mountains.

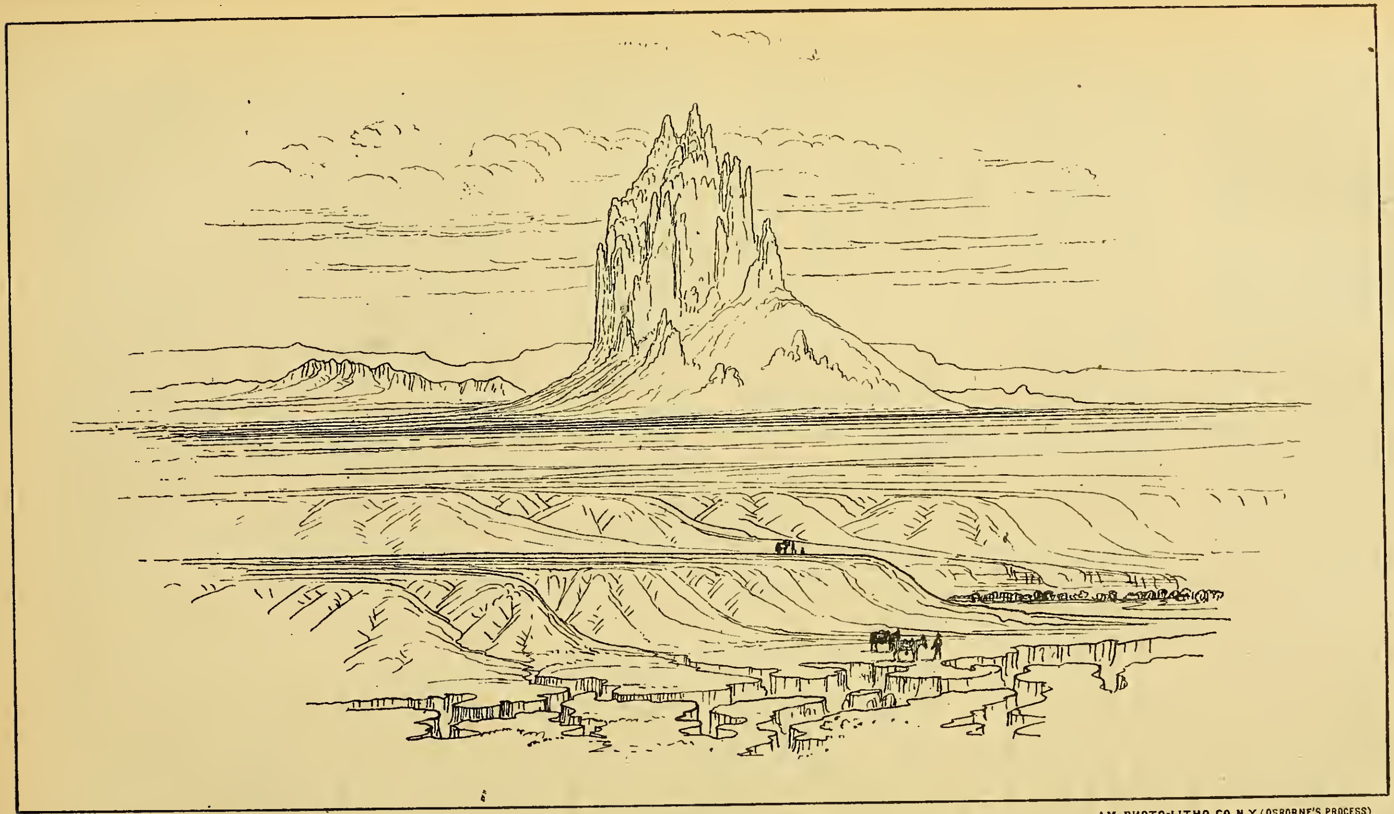
Stream.	Total fall.	Fall per mile.
	Feet.	*Feet.*
Rio San Juan	1,000	11
Rio La Plata	3,300	68
Rio Mancos	4,200	64
Rio Dolores	2,000	31
McElmo Creek	2,450	44
Montezuma Creek	2,500	42
Navajo Creek	900	90

In pursuing this work I have employed principally a plane-table system, with a simple portable form of instrument, constructed under the direction of Prof. Thompson.

The instrument is of very simple construction, and entails very little extra carrying upon the topographer. The table itself is constructed, like a form of field writing-desk in common use, of narrow strips of wood, firmly cemented to heavy face of cloth, so that it will roll up into a compact cylindrical form for carrying, and spread out is secured by cross-pieces on the back, giving a firm, smooth surface on the covered side. This table-top is made to set upon the tripod of the gradienter (our instrument for angle measurement) and to clamp firmly in place.

The alidade is a simple rule of wood or metal with raised sights, which in carrying rolls in with the table and paper, entailing only the extra bulk of a canvas bag two feet long and five inches in diameter to give the topographer a complete plane-table outfit. The method of working must of course be almost entirely of intersections, since the distances are so great as to render actual measurements ordinarily impossible.

Unwilling to trust the accuracy of this crude instrument, I have made from each station separate topographical sketches, and employed the usual *vis à vis* system of this survey. Had I known, however, in the field the accuracy of the plane-table locations as they were checked in



AM. PHOTO-LITHO. CO. N. Y. (OSBORNE'S PROCESS.)

The Needles.

Plate LIV.

the office, I should generally have omitted the auxiliary sketches. The accuracy was such that, starting from the eastern edge of the sheet with rather badly-conditioned points for location, and running by the plane-table alone to the southwestern corner of the sheet, the maximum error was slightly over a mile, a really small amount when distributed through fifty stations and carried over a distance of more than a hundred miles, and when copied by small areas utterly inappreciable in the drainage.

The district through which this work was carried is well suited in every way to this system of working. But I would not by any means recommended it in a very level or in a mountainous district, in the first for lack of near "points," and in the second for the multitudinous detail and advantage of distant sketches. In 1871, while learning the use of the plane-table, the great difficulty to beginners in immediately assuming the correct point from a given triangle of error attracted in our party considerable attention, and many attempts were made at the determination of a graphical method for the solution. One member of the force, Mr. D. H. Pierpont, advanced a method which I have often employed during the season to facilitate locations, and always found it of great assistance.

Since the time of our working together Mr. Pierpont has died, and I am indebted to his family for the demonstration given below, which I hope may be found useful, at least, by some who, like him, are beginners in the use of this chief of topographical instruments, or by older hands in reconnaissances where it is impossible to assume at first sight a close approximation to the true position, or where it is impossible to obtain well-conditioned points for location.

The problem of the three points offers five cases, depending on the relation of the point sought to the three given points. The cases may be stated as follows:

Case 1. *When the required point is within the triangle formed by the three givin points.*

Case 2. *When the required point is without the triangle but within the circle of the three given points.*

Case 3. *When the required point is without the circle and the central point is nearest.*

Case 4. *When the required point is without the circle and the central point is the most distant.*

Case 5. *When the required point is on the circle of the three given points.*

If the table be put in approximate position and lines be drawn through three plotted points from the direction of their respective signals, they will unite in forming a triangle of error, each angle of which will be on a great circle through the required point and two of the given points.

These three great circles, each containing the required point, they must intersect in this point.

The absolute construction of these circles would be impossible in the field. It then remains to find some means of quick determination of sufficient arcs of these circles to satisfy the needs of the location.

If, after determining the triangle of error by resection, the table be moved slightly by the tangent-screw and lines be drawn as before, a new triangle of error will be found, which, since the angles are necessarily equal, will be exactly similar to the first. The similar angles of these triangles will in each case be on the same great circle, and if these two angles be joined by a right line, this line will be the chord of a great circle of the known and required points, and within a small arc will sensibly coincide with the circle itself. If the other similar angles be joined in the same way, we will have three chords of three required great circles, which will closely correspond to the circles themselves. These chords will join in the required point. Or if the triangles are too large compared with the great triangle, slight allowance may be made for the curvature or a third triangle of error be formed, and the required point be determined with the greatest exactness.

To locate by this method, then, orient the table as nearly as possible and form a triangle of error, shift then slightly the position of the table, and, forming a second triangle of error, join the similar angles of the two triangles. The required point will be at the intersection of these lines.

The five cases are represented graphically on Plate LV, and the details of the third case are shown in construction, while in the following figures are shown the relations of the triangles of error under the different conditions.

In regard to the accuracy of the locations under the different cases, it may be said in general when the arcs of the great circles intersect at large angles with each other, the location may be considered good, and also where the intersections of the lines of the outside points intersect acutely and the middle point is near, the location will be good. But when the lines from the outside points intersect acutely and the middle point is far off, accuracy decreases, and directly in proportion as the middle point is more distant than the other two. The reason of this fact may be readily seen by a construction of the circles of location.

Case 5 being on the great circle of the three points, will be indeterminate, for the circles of location must necessarily ccincide.

As I said earlier, I often found this simple device of great aid in quickly determining my location, especially when my points were badly conditioned, and have little doubt but that under certain circumstances it would be found useful by most any plane-table worker.

In constructing the drainage of this district so that the rivers and main water-courses might be of greater accuracy, I have run time-meanders of them all, swinging in by very numerous locations along the route. In this way I have run out the La Plata, Mancos, San Juan, McElmo, Montezuma, Hovenweep, and greater part of the Dolores, and from the closeness of the checks am very well satisfied with the results of such time-meandering.

By continuous riding of the same animal, and careful watching of his gait under differing circumstances, a very even pace can be obtained, which, when checked at every six or ten miles by absolute location, will not bring in appreciable errors on a scale of 4 miles to 1 inch. The topographer is furnished with a system of primary triangulation on which to base his work. This system has sides of length varying from 15 to perhaps 50 or 60 miles in length. Within this main system, which is developed with great care, the topographer carries on his own secondary with side of much shorter extent, connecting, as far as possible, his stations with a continuous chain of closed triangles. The angles of those triangles, as well as all those used in topographical locations, are read with the gradienter—a single-minute instrument of compact form, rather large circle and extremely powerful glass. This instrument was first made for the Coast Survey, but is exceedingly well adapted to our purposes, and is readily carried for a whole season with but slight danger of derangement. It has but one horizontal movement, that of the limb, and will not reverse; it has, however, a segment of a vertical arc which will read to 20° of elevation or depression, enough for all ordinary topographical purposes. I append a drawing (Plate LVI) of this

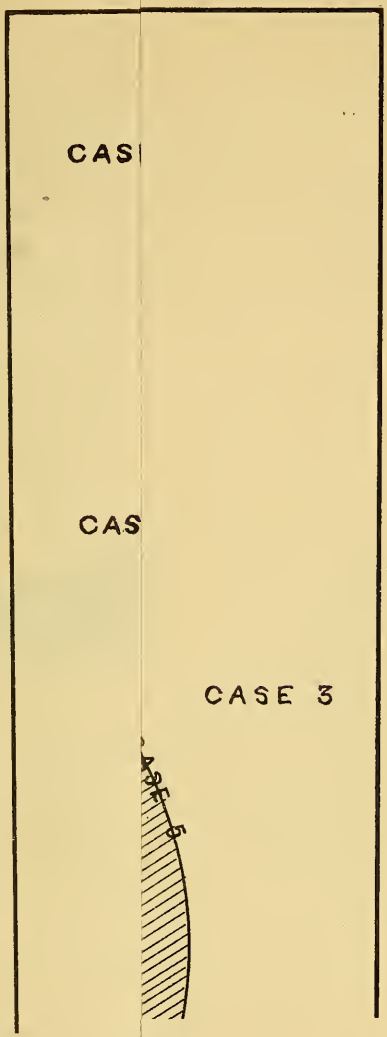
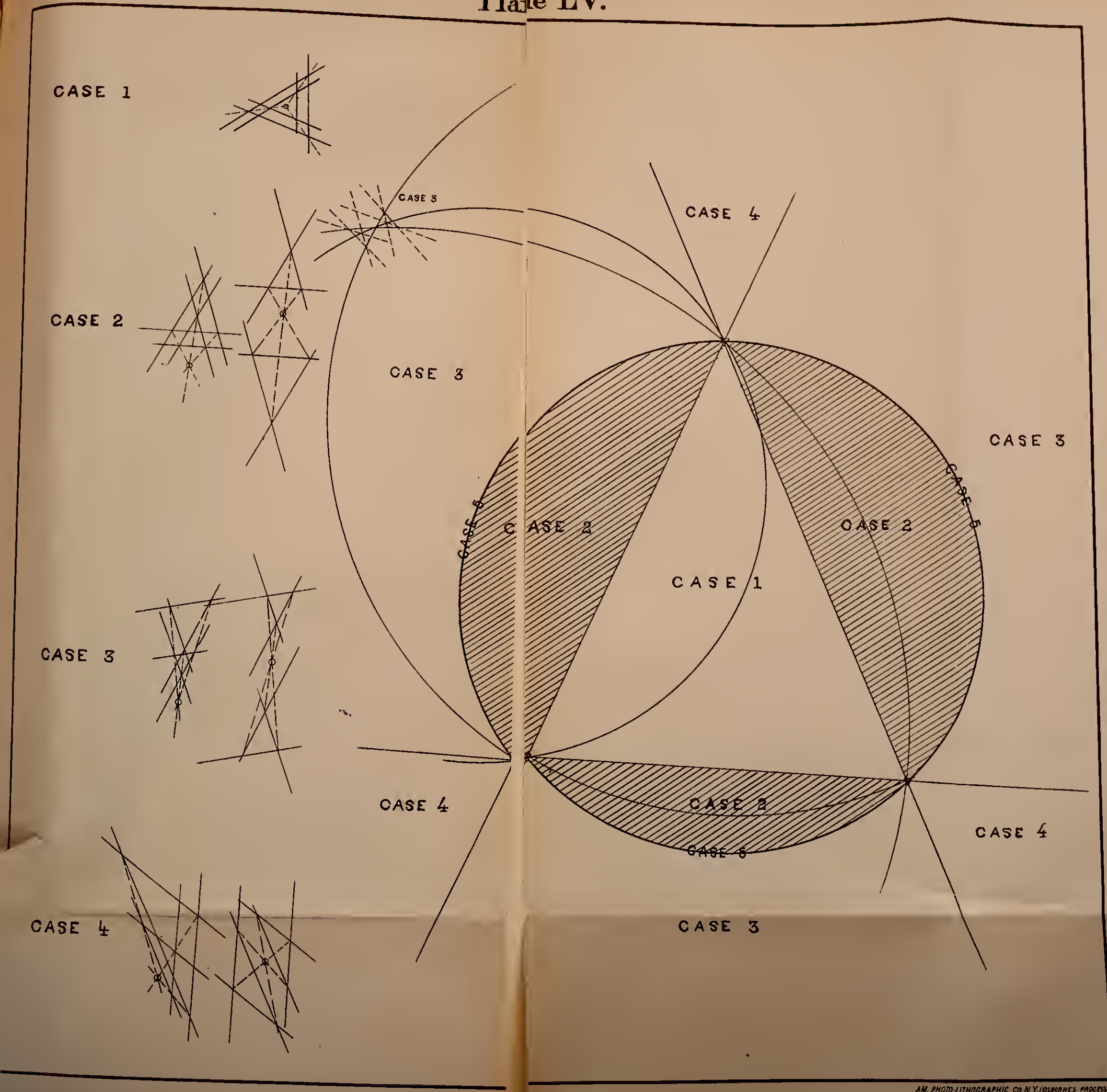

CAS
CAS
CASE 3

Plate LV.


CASE 1
CASE 2
CASE 3
CASE 4
CASE 3
CASE 4
CASE 3
CASE 5
CASE 2
CASE 1
CASE 2
CASE 3
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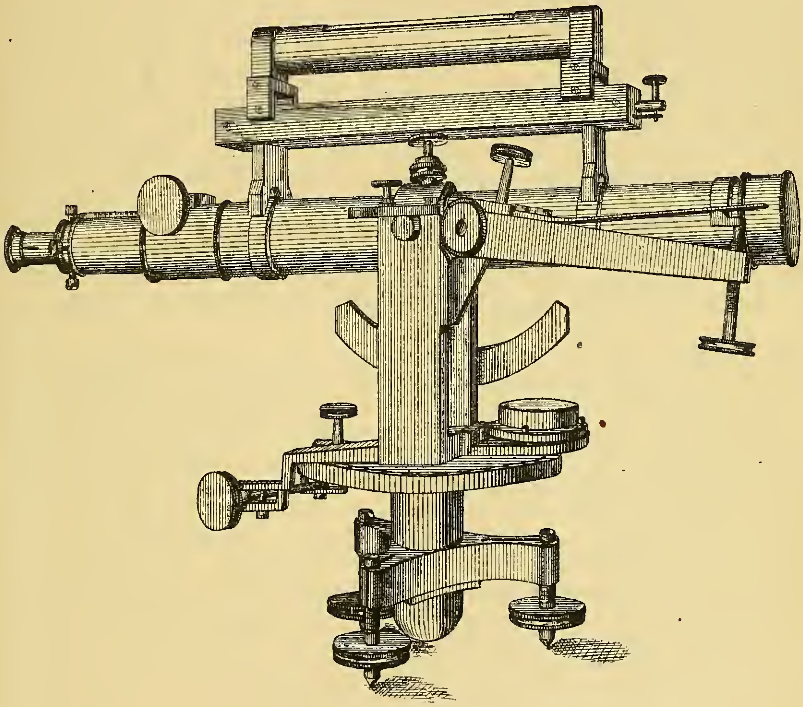
CASE 4
CASE 2
CASE 5
CASE 4
CASE 3
AM. PHOTO-LITHOGRAPHIC CO N.Y. (OSBORNES PROCESS)

Plate LVI.



THE GRADIENTER.

Instrument for Topographical purposes.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS)

instrument as a simple answer to an often preferred request for a description. The view is so simple that it requires no comment.

Broken in upon by trouble with the Indians of the northwestern portion of our district, we were obliged to leave unworked a small portion of that corner of the sheet. Our last station was made on the southeastern peak of the La Plata Mountains, on September 3, and the party dividing up with that of Mr. Gannett. marched out in two sections, reaching Denver on the 21st of September, having surveyed about 6,200 square miles and marched to and from the work a distance each way of 400 miles. But for the interruption of the fall, the whole area assigned would have been easily covered, and the party brought home but little behind its actual arrival. As it was, the season was an extremely successful one, and brought out all the main results which were anticipated from the first.

One point more to which I will call attention, the question of absolute locations of latitudes and longitudes through the district. All such determinations in this area are carried from the telegraphic communications on the eastern base of the mountains through the primary-triangulation system across the territory. A study of the methods employed and character of the results will satisfy any one versed in the subject that absolute locations through this system will be subject to extremely slight change. The location then of monuments and the boundaries of political divisions becomes an important practical advantage of the survey. In this particular district there lie 58 miles of the southern boundary of Colorado and all the southwestern portions of the boundaries of the San Juan purchase. Since completing my map, I have obtained through the General Land-Office copies of the plots of the surveys of these boundaries and compared them with our own locations.

As might naturally have been expected, I find the latitude agrees very perfectly with that of our trigonometrical locations, and the topography, especially of the State boundary, remarkably like our own in detail, but the longitudes are very considerably out in both cases. On the State line, all the work being shifted about 3½ miles to the *eastward* and on the purchase, although the measurements do not agree so closely with ours, there is an error in the southwest corner of slightly over 4 miles, it being located *too far west*, making a discrepancy between the two surveys of 7½ miles. This condition of things is only what must be expected from the difficulties of longitudinal locations away from the lines of telegraph and fixed observatories, and future determinations of territorial limits should never be attempted where the best of astronomical determinations cannot be had, at least for the initial point of the survey. The waste and complications arising from these false locations cannot be too highly estimated, while many of the lines already run must be as soon as possible rerun to attain any approximation to correctness. These same remarks apply in a great measure to the detailed work of the General Land-Office. It is to aid them in the better determination of initial points for their linear surveys that monuments are established at the well-determined points of our triangulation system. The whole geographical work of the far west opens a wide field for mutual assistance, which with the improved methods and constantly-increasing carefulness of working will render expensive mistakes in the future much less liable to occur.

In closing my report of the topographical work of this division, I would acknowledge the great assistance I have constantly received in the mapping from Mr. Holmes' accurate sketches and his intimate knowledge of the country surveyed. Mr. Brandigee, who, together with his duties as botanist, acted as my assistant throughout the season, filled both places with exceeding ability. He has made so exhaustive a report on the botany that it would have been useless for me to enlarge upon it by any further remarks on the vegetation. His collections and his report both show him to have studied the country thoroughly.

Mr. C. E. Aldrich, who had charge of the supply-camp and of the barometric and thermometric work at the Parrott City base, has furnished a set of observations whose even character and unbroken series show them to have been taken with great care. He has always furnished every assistance in his power.

REPORT OF GUSTAVUS R. BECHLER, TOPOGRAPHER, 1873,-74',-'75.

LETTER TO DR. F. V. HAYDEN.

WASHINGTON, D. C., *April* 30, 1877.

SIR: I have the honor herewith to submit my report, the result of three years observations in such districts as you have from time to time assigned to me as my fields of labor. In conformity with my employment in the field, the report comprises a discussion of the orographic and topographical features of those sections of country surveyed by myself during the period above mentioned.

Some portions of this country have at various times been described by topographers and geologists on your staff, but it has not as yet been treated of in any way approaching completeness, owing partly to a lack of time and partly to the numerous duties of the writers.

Having been for four years continually employed in making topographical explorations and preparing the maps resulting therefrom, it has been impossible for me heretofore to find time for any careful orographic description of the district surveyed during each succeeding year.

It is not intended that the subjoined report should represent a thoroughly exhaustive treatise on the orographic character of the region under discussion, all of which lies within the borders of the Rocky Mountains. I am fully aware of the large amount of additional work and close observation that would have been necessary for the preparation of a report meeting in every respect all requirements.

Comparisons of orographic and hypsometric features, in order to present entirely satisfactory results, necessarily demand more time and more labor than could be bestowed upon the regions examined. It is not too much to say that the devotion of a life-time would be but adequate to a solution of all questions involved in so complicated and mountainous a country.

It has been my endeavor to furnish in the annexed notes, as completely as could be obtained from the data at my command, an approximation of the relative orographic and hypsometric conditions of mountains and valleys in those regions so full of interest.

Very respectfully,

GUSTAVUS R. BECHLER.

Dr. F. V. HAYDEN,
United States Geologist-in charge.

GEOGRAPHICAL REPORT ON THE MIDDLE AND SOUTH PARKS, COLORADO, AND ADJACENT COUNTRY.

INTRODUCTION.

During the years 1873, '74, and '75, it has fallen to my lot to survey the area bounded by the Arkansas, Eagle River, and Park Range on the west, and the Foot Hills on the east, and extending from parallel 38° 45′ 0″ north to 40° 30′ 0″, the whole area comprising 8,500 square miles; but not until the present time have I been able to write such description of its features as I could have wished.

In this paper I have concluded the whole area of the three seasons' work, and connected its study, as its topographical features are connected, in one united system.

A complete orographic description has never been given of that part of the Rocky Mountains which constitutes the mountain system from the southern part of the Wyoming down to the Pike's Peak group, forming, as it does, some of our most impressive mountain portions of Colorado, full of scenic effect, particularly in regard to its numerous cañons and cañon-shaped valleys. In order to understand them fully, it becomes necessary to describe their forms in their manifold shapes and configurations, state by figures their height, depth, and breadth, as well as geological formation, including an estimate of mountain slopes in their respective localities, and also the system of drainage; and to note furthermore, the departure of subridges from the main or central range, and to give, as far as possible, a detailed description of subordinate spurs both of the central and subranges.

The nomenclature for topographical objects in our Rocky Mountain territory is very inadequate, as we lack names for hundreds of remarkable peaks, as well as for large streams, high sub-ridges, saddles, spurs, and topographical objects in general.

The difficulty for an orographic description of that zone is therefore increased. Over a large mountain area, with the crest or the main water-shed of 200 miles in length dotted with hundreds of peaks, we have only a very few names for landmarks or points of recognition, which have become familiar with everybody. These few are principally Long's Peak, Pike's Peak, Gray's Peak, Mount Lincoln, and perhaps Mount Evans.

The introduction of names like Audubon, James, Guyot, Silverheels, Yale, Harvard, &c., is comparatively of recent date, and the people have not yet become familiar with their location. This applies, and with greater force, to the comparatively few names which the Geological and Geographical Survey has seen fit to introduce during their four years of exploration in Colorado. Names like Park View, Vasquez, Byers, Arapahoe, Whale, White Face, Corral, Williams, Blue River Peaks,

&c., are still more recently introduced names, and therefore, as to their location, even less fixed in the people's mind.

In describing the features of this district I have occasionally referred to valleys, mountains, and mountain-chains as belonging to first order, second order, third order, &c. In the category of first order I include such mountain chains or ranges as form either continental water-sheds, or, as in the case of the Park Range, by its great dominating height as well as long extent, form also a geographical barrier or subdivision of a certain zone. In the second order I would range such mountains as, though they may not be any or not much inferior in height to the former, are of comparatively short extent, and take no prominent part in subdividing the country at large into distinct zones, like Kanoska, Tarryall, and William Ranges. Among the mountain ridges of the third order I would class those that are not simply spur-extensions of higher mountains, but bearing all the characteristics of a detached or distinct range, in extent long enough perhaps to bring forth subdivisions of smaller zones, as in the case of Vasquez Ridge, and perhaps Troublesome Ridge. We might even recognize a fourth order, such as the parallel Trachyte Ridges in the South Park.

Of valleys of first order we have but few, if any, in the whole Rocky Mountain districts, as none of them have any broad, expanded, bottom area like the large rivers of the East. The first-class valleys in the Rocky Mountains are hardly anything but depressions or basins, such as those of the Grand River in the Middle Park and the South Platte River in the South Park.

For these high altitudes different conditions exist in valleys from those in the middle portions of the continent. If we classify the valleys of the Rocky Mountains in first, second order, &c., it is done with the proviso that we have to adopt for this high region a different scale for classification. Among valleys of first order would necessarily be classed such as Grand River while in Middle Park; Muddy, Blue, and South Platte Rivers while in South Park. Valleys of second order might perhaps be called such as North Fork of South Platte River, Tarryall, Frazier, and Williams Rivers. Third order, such as Twin Creek, Manitou, Deer, and Elk Creeks. Valleys like Monument and Plum Creeks belong already partially to the plains. No valley form accompanies the eastern-slope drainage, all the rivers and streams flowing in cañons, and assuming valley features only where they enter the plains like Platte River.

With this simple explanation of the plan of my study, I will proceed directly to the consideration of the features themselves, beginning with the main or Colorado divide.

CHAPTER I.

THE CREST OF THE MAIN ROCKY MOUNTAINS FROM LATITUDE 40° 30′ TO TENNESSEE PASS (130 MILES).

RANGE OF FIRST ORDER.

Long's Peak, the highest point in Northern Colorado, is detached 1½ miles east of the Colorado or Front Range. Its precise location is longitude 105° 37′, latitude 40° 15′. The trend to the north of the Front Range from near Long's Peak is directly north 45° west. This course is unchanged for 20 miles until the range approaches the western limit of the district to be described in these notes, viz, 40° 30′, where a sudden turn changes its direction to the west until the range abuts against the Medicine Bow Range in longitude 105° 54′ and about latitude 40° 30′. The part of the Front Range referred to here represents perhaps the most rugged and extensive mountain mass in the whole Front Range. The immense spurs which are detached all along from the range in the direction of the Grand Lake and Grand River resemble in their massiveness short but powerful separate ranges. The drainage on the western slope flows in deep and rugged cañons toward the Upper Grand River. To the north of Long's Peak and 6,000 feet beneath its lofty summit lies that beautiful valley area called Estes Park, with a chain of huge mountains and peaks encircling it on nearly all sides in a grand amphitheatral shape. The average height of the mountain crest north of Long's Peak is 12,250 feet, while the mean elevation of the peaks is 12,600 feet. The east side of the crest is much eroded, and the spurs thrown out in the direction of Estes Park are, particularly in their upper and middle portion, sharp and serrated. Their bold and weather-beaten appearance adds much to the impressiveness and magnificence of the scenery which we obtain from Estes Park in a western direction.

Directly west of, and only 2,640 feet distant from, Long's Peak lies a saddle, with an elevation of 13,000 feet, and only 1½ miles west of Long's Peak rises another lofty point with an elevation of 13,800 feet. This latter peak attaches itself again to the main crest which trends from here almost due south in the direction of the Arapahoe Peak.

The distance along the crest from Long's Peak to Arapahoe Peak is 21 miles, while in a straight line it is only 16 miles. The number of prominent peaks and points to be seen on the crest amount to thirty-one, having a mean height of 12,800 feet. Fifteen more peaks and prominent points exist on eastern side spurs, reaching a mean elevation of 12,600 feet. The saddles have a general height of 12,200 feet. The highest portion of this crest is much eroded, particularly on the east side. Large mountain amphitheaters with a chaotic accumulation of *débris*, and immense snow-flats, characterize the upper portions of those mountains. The water accumulates from these snow-flats in small, narrow, and rugged mountain cañons, impenetrable to most men, in which the turbulent and ever-foaming water is hurried down with great rapidity into the larger cañons below. These streams sometimes fall from 3,000 to 4,000 feet within a very few miles. For about 12 miles south of Long's Peak the western side spurs of the Colorado or Front Range are more massive, more numerous, and of greater length than those on the east side. Heavy, rugged spurs, all of them above timber-line, with thirty-five dominating points and peaks, averaging a height of 11,700 feet, are detached from the range, to slope toward the north-eastern part of the Middle Park, and powerful mountain streams have carved between these spurs fantastic and dusky-looking cañons, in which their turbid waters are rolled down into the Grand River.

Near Arapahoe Peak there is a displacement in the axis of the mountains, which causes an abrupt turn to the west for a distance of 6,000 feet. The first saddle-depression beneath and west of Arapahoe Peak is 12,225 feet elevation, and down to this saddle the west slope of Arapahoe Peak descends 1,000 feet within the short distance of one half mile. On either side of this saddle originates an important stream—the south prong of North Boulder on the south side, and the east fork of Grand River on the north side.

The length of the main crest from Arapahoe Peak to Boulder Pass is 9 miles, and within that distance we can count twelve peaks or points with a mean height of 12,560 feet on the main escarpment—the most elevated ones being 12,800 feet, while the saddle between the peaks shows a mean elevation of 11,110 feet. The eastern slope of this mountain portion from Arapahoe Peak to Boulder Pass is extremely eroded, with an abrupt descent toward the bank of Boulder Creek. Among the many weather-beaten spurs we find numerous mountain amphitheaters, snow-flats, and little mountain lakes, from which the North Boulder receives a large share of its waters.

The western slope shows only in a few locations a sudden descent, the steepest slope being seen adjacent to Arapahoe Park. The remainder of the slope shows a gradual descent toward the Middle Park, and the spurs leading thereinto have in genearal a bulky and massive character.

From Boulder Pass to James Peak, we have a mountain crest of 6½ miles in length. The escarpment here represents a very regularly formed crest, with only one prominent peak 12,000 feet high, besides some few insignificant nipples. The eastern face of the mountain is here even more destroyed by erosion than that part lying between Arapahoe Peak and Boulder Pass. Precipitous sides fall off immediately below the main escarpment, while the western sides of the mountains slope gradually toward Hay and Moses Creeks, which are tributaries to the Frazier River. The mean height of the crest of this mountain portion is about 11,600 feet. When this crest approaches the proximity of James Peak, it rises suddenly to the height of over 13,000 feet.

James Peak is not an isolated peak, but, together with its neighbors, Little James, Mount Parry and Mount Flora, forms a cluster of which James Peak, with an elevation of 13,280 feet, is the loftiest point. The latter is in this locality the most commanding point, and among the peaks and points on the massive mountain walls which surround Middle Park in the southeast portion, it is, with its surroundings, the most imposing in height and scenic effect, particularly when seen from the Middle Park.

James Peak has otherwise a geographical importance, in so far as it stands in the extreme northeast end of that great mountain bend which the Colorado or Front Range makes from here in a western direction. On the northeastern slope of James Peak the two principal branches of South Boulder Creek take their rise, while on the northwestern slope Moses Creek, a tributary to Frazier River, originates.

From James Peak to Gray's Peak the distance along the crest is 27 miles. The figure which the range describes between the two peaks resembles a semicircle, with its open side toward the east, which forms a sort of a *cul de sac*, in which the principal sources of Clear Creek take their origin. On the northern half of this semicircle lies Berthoud Pass, as well as the two trail passes, Jones's and Vasquez's, all leading from the upper Clear Creek Valley into the Middle Park. A few miles south and west of James Peak the crest of the range, with an average height of 12,100 feet, assumes, comparatively speaking, a broad and bulky character, and very few points rise above the average level of 12,000 feet, until it nearly reaches its westernmost tangent point, near the headwaters of Williams River, where the crest not only rises again abruptly, but shows also a much more serrated escarpment. The points and peaks here attain an average altitude of 12,700 feet. The eastern and southern slopes of the range, that is, the Clear Creek drainage side, descend more abruptly than the northern side, which slopes gradually into the Middle Park. Deep cañons, however, have been carved from the snow-flats on the brink of the mountains through which the drainage passes down into the Middle Park. About 12 miles west of James Peak, or nearly half way to Gray's Peak, a subridge is detached from the main range, which bears almost a due northern course for 25 miles, until it reaches its terminus near the Hot Springs, in the center of the Middle Park. From the fact that Vasquez Creek rises close to the intersection of that ridge and the main ridge, and because it drains for many miles the eastern slopes of its highest peaks (Beyers and Vasquez), we have named that ridge, for the sake of conventionality, Vasquez Ridge.

Only 2½ miles south of the intersection of Vasquez Ridge with the main or Front Range, the latter rises again to an altitude of 12,700 feet, and for a distance of five miles we have not only an extremely sharp and serrated crest, dotted with several sharp-pointed peaks, with an altitude of 13,200 feet, but the west side of that part of the range shows an extremely steep slope of 50°. In some places the sides beneath the main escarpment appear almost vertical. Equally abrupt are the sides of the several spurs which are here detached from the main range, sloping toward the main channel of the Upper Williams River. The immense power of erosion is, perhaps, elsewhere not more clearly demonstrated than here, where over a district of, perhaps, 100 square miles we become almost confused at the sight of those labyrinthic cañons which the several principal branches of the Williams River have carved in the rocky structure, and that too at the very cradle of their existence.

The high and extremely sharp and eroded portion of the Front Range, as referred to above, is only five miles in length, and at its southern extremity another subrange, Williams Range, is detached, which first leads off for 4 miles in a western, and after that in a northwestern direction, forming the eastern barrier of the valley of the Blue, as well as the western wall of the Williams River, down to the junction with the Grand River.

From this point of intersection (of the Williams Range with the Colorado or Front Range) the distance to Torrey's Peak is but 7 miles. Here the mountain crest is depressed, and no dominating peaks or nipples of any consequence attract our attention. Heavy bulky spurs stretch westward toward the little Snake and Blue River Valley. When the main crest approaches near the slopes of Torrey's Peak, it rises from its general height (12,100 feet) suddenly to the lofty elevation of 14,336 feet. Torrey's Peak is only 3,900 feet distant from Gray's Peak, and connected with the latter by a saddle. The peaks along the crest between James and Torrey Peaks are limited to the number of about 24, which are of an average height of 12,700 feet.

Gray's and Torrey's are the center peaks or culminating points of a mountain mass concentrated at that point. From this center a great subridge, an imposing huge mountain mass, is sent forth in an easterly direction, of which Mount Evans, 14,130 feet in height, and distant from Gray's Peak 10 miles, is the culminating point. From the latter peak, subridges of a second and third order are again detached, which press forward toward the plain, between the different subdrainage systems of Clear Creek, Bear Creek, Turkey and Deer Creeks. Gray and Torrey, with an absolute height of 14,336 feet, stand also in the center of bold, rich, and varied mountain scenery, the reputation of which has already gone beyond the borders of our country.

From Gray's Peak to Mount Lincoln, the length of the crest of the main Colorado Range is 42 miles. Only 2½ miles east of Gray's Peak lies Argentine Pass, 13,000 feet in height, over which the highest known wagon-road in Colorado crosses the Rocky Mountain Range from Georgetown to mining settlements in and about the head of Blue River Valley. Others, such as Hand Cart, Georgia, Hamilton (sometimes called Breckenridge), and Hoosier Passes, cross the divide between Gray's Peak and Mount Lincoln. The average height of this crest is 12,570 feet, which shows a higher average for the crest than in any previous described part of this range, and numerous peaks of the first order, among them Whale Peak, Mount Guyot, Mount Hamilton, and Silverheel Mountain, confer no monotonous character on the escarpment of this part of the range.

About 15½ miles south of Gray's Peak a subrange departs in a southeast direction, which leads toward Kanosha Pass, and connects immediately beyond that pass with the Kanosha and Tarryall Ranges. From Whale Peak, 13,104 feet, the main Colorado range takes its course in a due southwesterly direction, until it reaches the Silverheel group, from whence its course is due westward across the Park Range to Tennessee Pass and Homestake Peak.

From Argentine Pass to Whale Peak, a distance of 15 miles, the crest shows a succession of peaks, which nearly all average the height of 13,000 feet. Southwest of Whale Peak, a slight depression occurs on the range which finds its minimum altitude at Georgia Pass, 11,500 feet, from which point, however, the slopes of Mount Guyot rise again to 13,565 feet. Mount Guyot, as well as Mount Hamilton, lies in the center of the Rocky Mountain escarpment. Both are of nearly equal height, yet they are different in form and aspect, Mount Guyot assuming a pyramidal shape, while Mount Hamilton takes a huge and singularly shaped hogback form, with an axis running north and south. Both mountains are separated by a saddle depression of about 1,500 feet, and both are of a commanding appearance and are easily recognized points, particularly from the north and northwest. We find on the north slope of the main Colorado Range, between Argentine Pass and Hamilton Pass, a total of mountain spurs, which represent a length of 58 miles, linear measure, while on the southern slope the mass of spurs amount to 68 miles. From Whale Peak a spur with eight peaks, varying from 12,400 to 12,600 feet in height, spread in zigzag form toward Snake River, with many smaller wings branching off to the right and to the left. One of these wings is crowned with three peaks. One of them, Glacier Peak, with 12,654 feet, stands directly above the town of Montezuma and the reduction-works of St. Johns. Another spur, with an average height of 11,400 feet, connected with the latter, presses forward between Keystone and Buffalo Creeks in the direction of Snake River. Again this last spur detaches still another branch with a mean elevation of 10,400 feet to the north and east of Swan and Blue Rivers. From Mount Guyot a spur descends down, between Swan River and French Gulch, which also terminates near the Blue River Valley. The latter shows an average elevation of 11,000 feet, with a relative height of 1,600 feet above Swan and Blue Rivers. The most western extremities of this latter spur have only 1,000 feet relative height above Swan and Blue Rivers, and are principally composed of drift, which furnish abundant material for hydraulic mining.

One mile west of Hamilton Peak the main crest falls off again from 13,200 feet to the height of 11,800 feet. At this point Hamilton Pass lies, which affords communication between the Middle and South Park. From this pass the range again rises to over 13,000 feet, and continues for several miles increasing in height, until at Silverheel Mountain it reaches its maximum of 13,650 feet.

The range descends from Silverheel Mountain with a moderately steep slope down to Hoosier Pass, 12,364 feet in height, which is the communicating pass between the mining towns of Fairplay and Breckenridge.

From Hoosier Pass the range takes a direct westerly course, and after ascending again to the altitude of 13,800 feet crosses the Park Range at a right angle, distant from Mount Lincoln only 4 miles. Mount Lincoln rests on an eastern side-spur of the Park Range, and 1½ miles distant from the axis of the latter. A person standing on the point of intersection of the Park and Main Range, and not familiar with the topography of the country, would be tempted to judge from the bold mountain-range running in a north and south direction and bristling with so many lofty peaks, that in either one or the other direction of the Park Range the main chain would take its course, but instead of the latter the main crest of the continental divide goes still farther westward, and after crossing the Park Range descends nearly 2,000 feet within 4 miles, but only to rise again at Mount Arkansas to the height of 13,647 feet, 6 miles distant from the point of crossing.

The distance along the continental divide from a point of crossing on the Park Range near Mount Lincoln to Tennessee Pass is 10¼ miles. Mount Arkansas stands directly above and only two miles east of Tennessee Pass. Its position appears isolated, as it rests between two saddle depressions, Ten Mile and Tennessee Trail Passes. It is more a a mountain-group than a peak, and has a crest 2 miles long; and, with an elongated escarpment lying north and south, it resembles Mount Hamilton, and even Silverheels. Its position is commanding, as it lies directly at the head of the Arkansas and Eagle Rivers, and no rival peak is in very close proximity, at least not within 6 miles, to detract its bold appearance. Tennessee Pass is yet only a trail pass, but the gentle slope on either side of the pass would offer no great obstacle for a wagon-road. This would particularly apply to the Arkansas Valley up to its headwaters and the immediate vicinity on the Eagle River side of the pass. But as for the Eagle River Valley, the obstructions would be more numerous and greater, and the country along and about the Eagle River would have to be in a more advanced state of development to justify the construction of a wagon-road along the latter river.

SUBRANGES.

RANGE OF FIRST ORDER.

Park Range, southward from the point of crossing with the main divide.

The Park Range, a subrange of the first order, crosses the main range, in meridian 106° 8′ and parallel 39° 21′, at a right angle. Its length, as far as it pertains to our district, may be considered equal to the mountain-belt that girds both the Middle and the South Park on the west. Its heights as well as general characteristics vary with the locality. While the northern portion may be regarded as a range, with almost undisturbed strata, the middle portion (the Gores Mountains), as well as the southern portion of it, is full of exposures, and rivals any portion of the main range as to ruggedness and bold forms, and excels the latter even in mean height. The highest elevations are to be found about the environs of Mount Lincoln on the point of crossing with the main range.

Mount Lincoln itself, with an elevation of 14,297 feet, rests on one of the eastern side-spurs of the Park Range. We have at least four mountains on the Park Range, not more than 4 miles distant from each other, reaching an altitude of over 14,000 feet, namely, Quandary, Lincoln, Bross, and Buckskin. Southward from Buckskin Mountain toward Weston's Pass, we can count, within a distance of 21½ miles along the crest, 26 peaks and points, with an average elevation of 13,250 feet. The mean saddle-height, amounting to 12,650 feet, shows a superiority of height against the escarpment of the main range from Gray's Peak to Mount Lincoln, and the average height of peaks in this portion of the Park Range exceeds the peaks of the main range in the localities referred to above by 170 feet.

There are, besides the 26 peaks resting on the main crest, 18 peaks or prominent points resting on side-spurs. The upper portions of the mountains are much eroded, and in some localities on the west side are equally as much if not more eroded than on the east side.

Weston's Pass, with an elevation of 11,676 feet, represents the lowest depression in this mountain-range from Ten Mile Peak to the Buffalo Peaks, a distance of 50 miles. South of Weston's Pass the Park Range lessens considerably in altitude. As far as Marmot Peak, which is situated 3 miles south of Buffalo Peaks, a total distance of 16 miles, the average height of the escarpment is 11,750 feet, which shows a decline in the elevation of 900 feet. With the exception of the group called Buffalo Peaks, which reach to the elevation of 13,541 feet, the average height of the others is only 12,550 feet, showing, like the escarpment, a marked difference from the elevation of the middle portion of the Park Range.

The number of peaks and prominent nipples both on the escarpment and on spurs are limited to the number of 16. From Marmot Peak, a point which shows an elevation of 11,600 feet, the Park Range in its course farther to the south declines so rapidly that only 8 miles to the southeast Trout Creek Pass shows but an elevation of 9,346 feet, while the main crest of the depressed range near Trout Creek Cañon shows but an average altitude of 10,400 feet.

At a point where the old historic California emigrant trail descends from the Park Range down into the Arkansas Valley, a split takes place in the Park Range. The eastern branch, which leads to Trout Creek Pass, and which forms the dividing barrier (though not the prin-

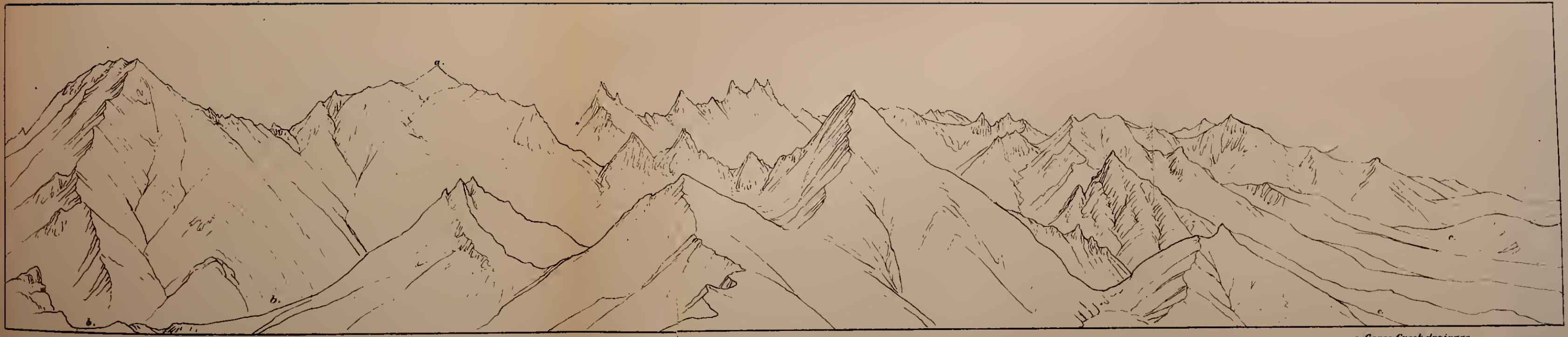
cipal one) between the South Park Basin and the Arkansas Valley, dis-
... flattens out as it approaches the extreme southwest corner

c. Gores Creek drainage.

AM PHOTO-LITHOGRAPHIC CO. N.Y. (OSBORNES PROCESS)

... teristics which the Park Range has exhibited hitherto. Only an experienced eye will discover, beyond the depressed mountain portion, northwest of Ten Mile Cañon, how gradually the axis of that range emerges and develops again by degrees into a shape and altitude more becoming to that great mountain-belt.

Several miles south of Red Peak the Park Range again attains a height of 11,750 feet, and two peaks, one with an elevation of 11,962 feet and the other 11,800 feet, appear on the escarpment. Near the



b. Piney Creek.

a. Mt. Powell.

c. Gores Creek drainage.

View of a Part of Gores Range from West of Mt. Powell.

Plate LVII.

cipal one) between the South Park Basin and the Arkansas Valley, disappears or flattens out as it approaches the extreme southwest corner of the South Park basin, while the main Park Range continues on for 25 miles in a straight southward course, across the Trout Creek Cañon, and it again increases in elevation as it approaches nearer to the Arkansas River at a point where the great Arkansas Cañon takes its commencement. South of the Arkansas the Park Range continues as the same upheaval but with the name changed into Sangre de Cristo Range.

RANGE OF FIRST ORDER.

Park Range, northward from point of crossing with the main range to Ten Mile Creek Cañon.

The length of the Park Mountain escarpment from its intersection with the main range north to Ten Mile Creek Cañon is 18½ miles. The features of the crest and the upper portion of the range remain rugged during its whole length, and correspond in characteristics precisely to that part of the Park Range which is the highest portion, lying in the neighborhood of Quandary, Lincoln, and Buckskin Peaks.

The crest is much serrated, and in consequence sharp and rugged on the eastern face, as well as on the western. The peaks are singularly sharp and many of them totally inaccessible. The number of peaks resting on the main escarpment, with a mean height of 12,900 feet, amount to 23. Fourteen peaks, with variable heights, rest on side-spurs. The average elevation of the crest is 12,150 feet.

There are many rectangular spurs detached by the range toward the Blue River, but they are short, as the axis of the range is but 4 miles distant from the center of the Blue River Valley.

The immense quantity of *débris* in the higher portion of the amphitheaters indicates a rapid disintegration of the crest. The spurs are extremely sharp for about half-way down in their descent to the valley of the Blue. The timber-belt that girds the lower part of the mountains on the eastern slope is narrow and broken, while on the western slope we can hardly speak of a timber-belt at all, the mountain-range appearing as a solid rocky structure, with very few outrunners or spurs. It compares more with a massive wall with needle-like points rising here and there above the general crest.

A general derangement or displacement seems to have taken place in that portion of the Park Range which lies between Ten Mile Cañon (or exit of Ten Mile Creek) and Red Mountain, a point 10 miles to the northwest. The imposing mountain-wall which stretches in an unbroken northward direction for 19 miles from Mount Lincoln, and which is covered with so many lofty peaks, comes suddenly to a stop at Ten Mile Cañon. The eye searches in vain for a visible point of connection or an unmistakable trace of the continuation of the axis of that range, but, though we find low mountain masses and spurs in abundance on approaching Ten Mile Cañon, yet they are totally devoid of the characteristics which the Park Range has exhibited hitherto. Only an experienced eye will discover, beyond the depressed mountain portion, northwest of Ten Mile Cañon, how gradually the axis of that range emerges and develops again by degrees into a shape and altitude more becoming to that great mountain-belt.

Several miles south of Red Peak the Park Range again attains a height of 11,750 feet, and two peaks, one with an elevation of 11,962 feet and the other 11,800 feet, appear on the escarpment. Near the most southern of these peaks the Eagle River Range connects with the Park Range.

At Red Peak a new division of mountain characteristics is introduced. Surrounded by several peaks of nearly equal height stands Red Peak, with an elevation of 12,382 feet, and directly at the main source of the Gores Branch of the Eagle River. A sharp saddle of 11,700 feet in height connects Red Peak with the Gores Range. This remarkable range,* which is a portion of the Park Range, measures about 21½ miles along the crest from Red Peak to the Front Peak, or a peak 2 miles north of Mount Powell. The peculiar conditions of this mountain portion are that, for several thousand feet downward from the crest, the range in its main structure as well as spurs is thoroughly exposed and disintegrated, and nowhere, that is on neither face, is it clothed with any mantle of verdure. A mountain-range more barren and more absolutely exposed and subjected to erosion in every form, will hardly be found elsewhere. It is in a state of rapid decay, its crest being serrated like a saw, and the general appearance of points or peaks not unlike upturned icicles. Only in the huge and more or less flattened amphitheaters that lie between the sharp-crested and barren spurs, and along the terraced offsets that lead through cañons up to the amphitheaters, have forest trees a chance to vegetate up to its allowable altitude. Only with difficulty and by means of at least two hundred and thirty angles, taken from various positions, have we been able to arrive at an approximate average calculation of the altitude of the saddle or main escarpment, which was found to be about 12,350 feet. I have recorded, for the main crest of the Gores Range, thirty-seven peaks, with a mean height of 12,750 feet. For the side spurs the record gives fifty-four peaks, with an average height of 11,800 feet.†

The spurs on the eastern slope, which run toward Blue River Valley, fall off suddenly when within one-third of their distance from the main escarpment and the Blue River Valley. From the lower base of the *débris* slope, the spurs flatten out and descend in terrace-shape toward the valley. The flattened spurs consist principally, in the lower parts, of glacial drifts, and they constitute a sort of a foreland, covered with dense pine forests, which, together with the fallen or dead timber, baffle any common attempt to approach the mountains from the flank. The rise of the *débris* slope or foreland is about 1,200 feet within 4 to 5 miles. The relative height of the mountain crest above Blue River is about 4,350 feet; on the west side the relative height is about 4,500 feet above the junction of Gores Creek with the Eagle River. Abundant evidences of glacial action are found on the middle and lower portions of the spurs leading toward Piney River. The cañons formed by the steep slopes of the spurs as well as by the face of the main mountains on the west side, constitute a perfect labyrinth of giant fissures with steep walls, often 2,000 feet high on either side. We are amazed, thrilled, and yet fascinated when we look down from the dizzy height into the deep chasm below, with nothing to break the silence within this barren and yet grand and sublime rocky structure, but the sound of the turbulent, rushing, and ever-foaming cañon stream.

The total length of the spurs detached on both sides of the Gores Range, is about equal to 72 miles linear measure.

*The old term "Gores Range" is retained for the purpose of distinguishing it from the other parts of the Park Range.

†Considering the inaccessibility of these mountains, the complicated arrangement of escarpment and detached side spurs, which creates often difficulty to define and separate one object from another, errors occurring in the count of peaks on that range should be judged with more indulgence than elsewhere.

A contrast exists between the Gores Range and that portion of the Park Range north of Mount Powell, as if one compared the moss-crested portions of the Alps with a hilly or undulating country. For several miles we see but a waving crest, with no break in it. From the most northern and last of the peaks of the Gores Mountains to the Gores Cañon, we have a crest-length of 21 miles. On the broad crest rests only the well-defined Lone Peak, of 11,300 feet elevation. Several rounded-off points do not rise much above the general height of the crest. The average height of the range here is 9,900 feet, while the saddles are about 9,200 feet. The axis of the range runs about 5 miles west of Blue River Valley, and the relative height of the range above it is 2,200 feet. The crest, although below timber-line, is barren except around Lone Peak, in the center of the range, at which place timber reaches nearly to its proper altitude.

The spurs running out toward Blue River Valley are broad and depressed, and have, to within 10 miles of Grand and Blue River junction, a dense forest in their middle portions.

There is only one ridge of a secondary order detached from the range, 4 miles northwest from Mount Powell, which separates Piney River from Quaking-aspen Creek, in a parallel direction with the Park Range. In characteristics that ridge exhibits on the east side that bench or shelf form witnessed so often in Tertiary formations.

Near the entrance of Gores Cañon the entire body of water constituting all of the Middle Park drainage, is united in the Grand River before the latter forces a passage through the Park Range. The cañon walls rise from the water's edge for several hundred feet almost vertical, but they recede after this in moderate steep slope up to the average altitude of the Park Range.

From Gores Cañon, along the crest of the Park Range, north to Rabbit Ears, we have a distance of 42 miles. The general appearance of the range is wave-like or undulating, with no well-defined peak breaking the monotonous crest. Its highest points do not exceed 9,370 feet in the average, while the mean depressions of the crest show an elevation of 9,000 feet. Broad and bulky spurs bench off in the direction of Muddy River Valley, the distance of which is 8 miles from the range. The same flat, undulating character exists in the western branches of the spurs leading off toward Sarvis Creek.

The main forest vegetation consists, even on the top of the range, almost exclusively of quaking-aspen, pines occurring only in small and isolated patches. The western spurs, however, are covered again with dense pine forests. On the slopes leading toward the Muddy River the grass is excellent and in abundance.

At Rabbit Ears we arrive at the northern terminus of the Park Range. Here is the point of intersection with the Continental Divide, which swings around in great curves from the extreme northeast corner of the Middle Park, or from the headwaters of Grand River, forming thereby the dividing barrier between the North and the Middle Park.

RANGE OF FIRST ORDER.

The Continental Divide or dividing range between North and Middle Parks.

In that portion of the Rocky Mountain chain which forms the division between the well-known great mountain basins, North and Middle Parks, we find different characteristics introduced from the remaining portions of that mountain range, existing as the great Continental Divide throughout Colorado Territory. These differences are first in form, and second, principally in height, for the average height of the mountain range in question is at least by 1,500 feet of inferior or lower height than any of the lowest portions of the Colorado or Front Range.

We have within 130 miles of the Rocky Mountain crest, belonging to the district described in these notes, only one pass, "Tennessee Pass," on record, so low that the height of it falls only 350 feet below the average altitude of prominent points on the range dividing North and Middle Parks, while all other passes are from 1,000 to 2,500 feet superior in altitude than the mean height of the Park Divide.

The highest elevation on that range, equal to 12,433 feet, is represented in Park View Mountain, and if that peak stands out prominent, and in general appearance would to the inexperienced compare rather favorably with some of the giant peaks on the Front Range, it is owing simply to the contrast, which must be attributed to its immediate much-depressed surroundings.

In order to acquire a proper understanding of the relative geographical position which the Continental Divide holds to the Colorado Front Range, we have to recapitulate in a few words its connection with the Front Range, and using as a base point Long's Peak.

From a point 1½ miles west of Long's Peak, the direction of the Front Range is for 12 to 14 miles northwest, thence for a distance of about 8 miles almost due north, to parallel 40° 30′, from which point the range turns abruptly westward for 6 miles, abutting against the high and rugged mountain range, claimed by some authority (?) as the "Medicine Bow Mountains," while on the advanced proof-sheet of Clarence King's map it is recorded simply as "Park Range." As the mixing up of names is not at all uncommon in different maps, made by different surveys pertaining to the western and especially to the Rocky Mountain area, we will abstain from arguing our preference to the name of Medicine Bow, on any other ground except the one that the name of Park Range has, and as I think very properly, been given to that long range which forms the western barrier along South and Middle Parks.

The Medicine Bow Range has a direct north and south trend, and from where the Front Range strikes it, extends southward ten miles "on the west side of North Fork of Grand River" to a point from where the Continental Divide assumes a general west course, its crest winding irregularly for 5.5 miles until it meets the Park Range at a point called Rabbit Ears.

On the point referred to, where the Continental Divide separates or rather starts from the Medicine Bow Range, stands a prominent peak of 12,513 feet elevation, which for the sake of locating a landmark in this region, so destitute of names, we named Upper Grand Valley Peak. This peak stands not only on the terminus of the high and rugged portion of the Medicine Bow, but is also the most conspicuous landmark of of the remote southeast corner of the North Park, and in this respect has similar geographical significance to James Peak in the Middle Park.

Eleven miles west and a trifle south of Upper Grand Valley Peak rises the Park View Mountain, with the highest elevation on this divide, and five miles east of the latter stands another peak with an elevation of 11,600, or of about 1,000 feet less height than Park View Mountain. On the east as well as on the west side of this peak lie two deep saddles, which give particularly to that part of the range a somewhat empty appearance, while it gives greater prominency to Park View Peak as well as to its neighbor.

Near these two saddles, as well as on the west slope of Upper Grand

Valley Peak, originate the principal, at the longest branches, of the North Platte River, flowing immediately north and beneath the two peaks, in a basin-like area.

The western slopes of Park View Mountain descend, within 2½ miles, 1,800 feet into a deep saddle; which on the north side gives rise to another large tributary of North Platte River, and on the south side of the saddle to one of the forks from East Troublesome Creek. A half a mile west of this saddle a sharp peak rises 1,000 feet above this saddle, and 3 miles west of that another one of 200 less height, 11,400, makes its appearance. From this last peak which stands between the sources of the two forks of the Troublesome Creek, "on account of which we gave the name of Troublesome Peak to it," the Continental Divide makes an angle again to the north 15° west.

Following along this crest for 2 miles we again come to a peak of 11,600 feet in height, and still 2 miles farther we arrive at the fourth one on the crest since Park View Park, which we called Basalt Peak, 11,906 feet, from its center position in a large capping of basaltic lava.

From this last peak, which also rises a little over 11,600 feet, the crest turns west again, exhibiting from there more the character of high, terraced table-land, descending lower and lower toward the valley of the Muddy, as well as between the latter and West Troublesome.

From Basalt Peak, a formidable even-topped but high mountain mass 6 miles long goes forward in direction north 15° west, and breaks with its broad and bulky spurs the units of the Upper Basin area of the North Park.

That broad, massy table-land between the headwaters of the two rivers, Muddy and Troublesome, shelving toward the south, pushes a bulky, flattish spur between the two last-named rivers, which exhibits on its faces toward the Muddy much-eroded slopes and terraces.

Before reaching Rabbit Ears Butte we see at the head of the valley of the Muddy once more an object of prominency rising, not so noticeable for its great height as for its sharpness. The Upper Muddy Butte, "a sharp pyramidal structure of basalt", with an altitude of 9,848 feet, lies but 5 miles southeast of Muddy Pass, a saddle-depression that offers, evidently, from its easy access as well as very moderate altitude, every advantage for communication between the northwestern portion of Middle and southwestern portion of the North Park.

The intervening mountain area of the Continental Divide, between Muddy Pass and Rabbit Ears, exhibits no features of prominence. The mass of which it consists is broad and bulky, with strongly-marked terrace features facing the Muddy. Its crest is crowned with numerous little buttes, composed of basaltic lava, which explains their preservation, among that otherwise so softly organized material in that particular neighborhood.

We can state the crest-length of the Continental or Park Divide to be about 55 miles; from the Upper Grand Valley Peak, westward to Rabbit Ears Butte, 10,719 feet. The mean elevation of high points in general is about 10,750 feet, while the average saddle height will amount to about 10,180 feet.

RANGE OF SECOND ORDER.

Eagle River Mountains.

The mountains that constitute that short but massive range rise between Ten Mile Creek and Eagle River Valleys. It is a parallel range to the Park Range, but different in character. The entire district that we named Eagle River Mountains is confined to an area that extends from the headwaters of Gores Creek to the headwaters of Eagle River and Ten Mile Creek; or from its southern connection with the Gores Mountains to its northern connection with the main range near Mount Arkansas. The entire crest of this range is 22 miles long. The southern portion of the crest differs in appearance with the northern portion; the northern part being broad, bulky, and undulating, while the southern portion of the crest presents about 10 points of which several appear as prominent peaks when seen from the Eagle River or from the west side. The erosion has not been so destructive to the eastern slope as to the western.

The highest peak, a peak of prominence in that district, is Eagle River Peak, which rests on a spur 2¾ miles east from the axis of the range, and nearly 7 miles northeast of Mount Arkansas. The elevation of the latter is 12,648 feet. The next highest reaches only 11,988 feet, while the third highest shows an elevation of 11,783.

Several prominent spurs branch off the Eagle River Mountains in a western direction toward Eagle River Valley. One of them branches off from a point on the crest where Good Harbor Creek rises. Its entire length is 7 miles. Another spur presses between Two Elk Creek and Gores Creek Valley, which has an elevation of 2,600 feet above Gores Valley, and a length of 7 miles. Between Two Elk Creek and Weary Man's Creek, a spur of 5 miles in length and 2,400 feet relative height branches off toward the Eagle River Valley. The total extent of spurs leaving the main crest in all directions amounts to 52 miles in length, with a relative height of 2,200 feet. There, where the range connects with the Gores Range, the bulky, flattish character of the mountains disappears and receives expression again, by the close neighborhood of mountains like Red Peak and its neighbors.

The principal creeks that rise in the Eagle River Mountains are the following: On the eastern slope, McNulty Creek, Good Harbor Creek and its tributaries, and Cañon Creek. On the western slope we have Resolution Creek, Weary Man's Creek, and Two Elk Creek, besides many smaller ones.

RANGE OF SECOND ORDER.

Williams Range, or Blue River Range

The character of this range is plain and simple, except a small shifting of its axis two miles south of Ute Peak, which causes the depression over which Ute Pass leads. There is no striking irregularity in the range from its point of intersection with Colorado Front Range to its terminus near the Grand River Junction. Two bends, one in the upper portion near its intersection with the Cororado Range, and the other near Ute Pass, are the only cases where the Williams Range deviates from an almost direct northwest course. It constitutes the dividing upheaval between the Blue and the Williams Rivers, and shows a crest-length of 35 miles from its separation from the main range to a point 7½ miles south of Grand River. The Ute Pass affords the only facility to cross from the Blue River Valley into the Williams River country or *vice versa*. In the upper part of Blue River Valley the axis of the range is about 4 miles distant from the river, but 4 miles north of Ute Pass Blue River crowds close to the slope of the mountains, and leaves only a distance of 2 miles from the river to the axis of the range. When 10 miles farther down the valley, the mountains recede again eastward to a distance of about 3 miles. Ute Peak towers directly 2 miles to the south of Ute Pass up to a height of 12,800 feet; it is the highest point on the Williams Range. Another peak named Williams Point, with an elevation of 11,700, rests on the northern portion of the range about 4 miles north of Ute Pass. We cannot properly apply to any points on the northern part of the range the term peak, for none of them project visibly and bold enough above the crest, which is in its totality only wave-like from Ute Pass to the Grand River. A bolder character prevails south of Ute Pass in the mountain structure as well as in the peaks. Fifteen projecting points which I counted among the peaks show an average of 12,400 feet, while the mean saddle-height will not be less than 12,000 feet.

The average relative height of Williams or Blue River Range above the mean height of Blue River Valley is 3,000 feet. The western slopes of range, or the slopes facing Blue River Valley, are rugged and terraced, and show occasionally a very sudden descent, while the eastern slopes of the northern portion of the range, that is, north of the Ute Pass, show a gentler descent. These slopes show also good pasturage from Williams River Valley up to the lower margin of the timber-belt.

Viewing Williams Range from the northeast it affords an imposing sight in spite of the undulating character of its crest. When approaching its northern terminus the axis of the range is 7 miles distant from Williams River, and but 3 miles from the Blue River.

RIDGE OF THIRD ORDER.

Vasquez Ridge.

Vasquez Ridge is detached from the main or Colorado Range, about nine miles northwest from Gray's and Torrey's Peaks. Vasquez Creek drains the eastern slope of the upper or higher portion of the ridge, while tributaries of the Williams River drain the western slopes of the upper and higher parts of that ridge. The axis of the latter has a due northern course, and leads directly to the center of the Middle Park, or to the hot sulphur springs, where its topographical features terminate.

Close to the intersection with the Colorado Range is the highest portion of the ridge. Its characteristics there are equal to any high mountains of the first order, equal in altitude and surpassing in ruggedness even the neighboring parts of the main or Colorado Range, which latter is more broad planed than otherwise. The Vasquez Ridge retains these characteristics for six miles north. Four peaks of nearly equal elevation, among them Mount Byers, 12,778 feet, crown the top of that ridge in this upper region. For about 800 to 1,000 feet downward the slopes of the peaks descend very abruptly, and show weather-beaten faces east as well as west.

Directly west of the ridge heavy spurs branch off, the sides of which slope into deep cañons, and which constitute a portion of that greatly-eroded cañon district at the head of Williams River. The spurs leading off to the northwest descend rapidly and soon become a mass of complicated, undulating, and heavily-timbered branch spurs, which are almost completely flattened out as they approach nearer to Williams River. The slopes leading down to Vasquez Creek are heavily timbered and rapidly descending. The sharpness of the spurs give each drainage-channel between them the character of a cañon. Four miles north of Mount Byers there is quite an offset in the mountains, which forms also a point or line of division between the different characteristics of the northern and southern portion of Vasquez Ridge. Down to this offset or saddle the slopes of the northern portion of Vasquez Ridge descend from 11,700 feet suddenly to 9,800 feet, which is about the general altitude of the northern portion of Vasquez Ridge down to its terminus near the hot sulphur springs, a distance of 10 miles. Two low spurs start on the west side close to the offset and run parallel to Vasquez Ridge, between Beaver Creek and Williams River, down to the Grand River below the cañon. There is little complexity in the northern part of Vasquez Ridge. Besides the two spurs mentioned above, we find on the east side a detached cluster of hills connected with the ridge by a low saddle, and occupying part of the space between Vasquez Ridge and Frazier River, and among that cluster of hills Camp Creek takes its rise, which is tributary to the Frazier River.

MIDDLE PARK MOUNTAIN GROUPS NORTH OF THE MAIN GRAND RIVER.

On the north side of Grand River, that is between the main Grand River and the Park Divide, and between Troublesome River and the valley of the upper or north Grand Fork, lies an area of 410 square miles of formidable mountains, which area is commonly allowed to constitute a portion of the Middle Park district, and if we grant the Continental or Park Divide to be the division-line between the North Park and the Middle Park district, then it virtually must be counted in its area. But at the same time that area of 410 square miles do not contain full 10 square miles of park area, under which term we understand a flat, low, basin-like area, either surrounded by or between variously-shaped mountains. The largest creeks that drain these mountains and separate them into several groups are Troublesome and Willow Creeks, which both have their sources in the highest portion of the Continental or Park Divide, and 18 miles distant to the north of Grand River.

Besides the two streams mentioned are two lesser streams, Corral and Stillwater Creeks which head in the middle portion of these mountains, Corral Creek having a direct length of 9 miles, and Stillwater Creek a length of 7 miles. This mountain area divided into distinct groups by the channels of the Troublesome and Willow Creeks may be designated thus: Troublesome Ridge, Corral Peak Cluster, and Willow Creek Mountains.

TROUBLESOME RIDGE

Is formed by a huge spur coursing south from the Park Divide and separating the two branches of the Troublesome River in east and west branches. The west branch of the river flows at the base of the western slope of the ridge, while the east branch emerges from among the spurs of Park View Mountain and its neighboring peaks, and before it unites with its brother, the western branch, forces a passage through that ridge and forms thereby a cañon of nearly 2 miles in length. South of the cañon the ridge continues on for 3 miles in its average height and ruggedness, after which it flattens out and assumes a terraced character before it terminates near Grand River. The terraced character predominates for about 4 miles northward from the Grand River.

The eastern slope of Troublesome Ridge is well timbered, which is particularly the case north of the cañon and up in its higher portions, where the ridge connects with the Park Divide. White pines are the predominating forest-trees, and they become largely mixed with tremuloides at an elevation below 9,000 feet.

Troublesome Ridge does not show particularly well-defined peaks, but its highest points are 10,200 feet high, and its general saddle-elevation reaches about 9,600 feet. The relative height of the ridge is about 2,200 feet above Troublesome River.

CORRAL PEAK CLUSTER.

Corral Peak and White Face Peak are the principal points in the Corral Peak Cluster. The two peaks are 3 miles distant from each other and connected by a saddle which is from 800 to 900 feet lower than the peaks, which show an elevation of 11,333 feet. Corral Peak, the most northern of the two, is particularly sharp and rugged, and has as well as White Face Peak a thick capping of eruptive basalt. From Corral Peak the slope descends very gradually for 6 miles in a northern direction where a low saddle exists and tributaries from Willis Creek and the Troublesome have almost a united source. That saddle has about 9,000 feet elevation, and from it the southern spurs from Park View Mountain begin to rise, for the first mile very gradual, and after that change very suddenly into an abrupt ascent.

The two peaks, Corral and White Face, form a concentric point, from which numerous long spurs diverge in almost every direction, to the Troublesome and Willow Creek as well as toward Corral Creek and Grand River. Many streams, in particular those on the eastern slope, have washed deep ravines, and in most of the tributaries to the Willow Creek, at least the cañon features are strongly expressed.

From White Face a spur runs directly eastward, toward the junction of Willow Creek and Grand River, gradually lowering from 11,493 feet to 10,000 feet altitude.

During a distance of 4 miles, the southern face of that spur presents toward the Grand River, in three subspurs, such remarkable terrace features, and so peculiar in their characteristics, that the causes of their structure have prompted the late Mr. Archibald Marvin, assistant geologist, to make them the object of a particular treatise. This Corral Peak and White Face Mountain Cluster presents itself apparently as a column of independent mountain upheaval. The deep saddle to the north, the two cañon-like defiles of Willow Creek on the east and Troublesome on the west side, besides the valley of the Grand River on the south, would be apt to suggest such a theory.

WILLOW CREEK MOUNTAINS—EXTENSION OF THE MEDICINE BOW RANGE.

From near Grand Valley Peak, at the extreme southern end of Medicine Bow Range, and from where the Continental or Park Divide takes a western course, a heavy mountain ridge detaches itself from the main divide. It presses, in peculiar zigzag winding, within a very few miles from the Grand River near its junction with Willow Creek, and forms, by its characteristics, a group by itself. With a crest of 20 miles in length, its curves are not unlike a sign of interrogation (?), producing thereby on its upper sling a big amphitheater, in which the east branch of Willow Creek rises.

The aspect of that coil of mountains is massive, which will be easily understood when explained that this 20 miles of mountain crest, together with 40 miles of side spurs, are compressed into a small area of 100 square miles. There are four high points on the crest, which attain an altitude of 12,000 feet, and ten or twelve other well-defined nipples of 11,600 feet average height. This ridge is, for the most part, well covered with timber, and its subspurs extend, with considerable ruggedness and massiveness, toward Willow Creek, where, by their sudden slope and corresponding steep faces on the opposite side of Willow Creek, they give the latter stream the unmistakable appearance of a cañon.

In a direct southern direction toward the Middle Park the slopes are more gradual, while again toward the valley of the Grand the slopes are abrupt. The highest points of this mountain mass show a relative height of 4,200 feet above the valley of the Upper Grand River, while the average crest height is 3,600 feet above the latter valley.

I append here two tables with reference to this locality, the first showing the geographical positions and altitudes of prominent points on the crest, and the second of all of the most used passes.

Approximate geographical positions and elevations of prominent points on the crest of the main Rocky Mountains, from latitude 40° 30′ *to Tennessee Pass.*

Names.	Latitude.			Longitude.			Elevation above sea-level.
	°	′	″	°	′	″	
Long's Peak	45	15	19	105	36	37	14, 271 H.*
Mount Audubon	40	5	48	105	37	26	13, 173 H.
Arapahoe Peak	40	1	13	105	38	39	13, 520 H.
James Peak	39	51	10	105	41	9	13, 283 H.
Mount Parry	39	50	20	105	42	32	13, 133 P.
Torrey's Peak	39	38	5	105	49	0	14, 336 H.
Gray's Peak, subrange	39	38	5	105	48	46	14, 341 H.
Mount Evans	39	35	21	105	38	20	14, 330 H.
Glacier Peak	39	34	0	105	52	18	12, 654 H.
Whale Peak	39	30	0	105	51	28	13, 104 H.
Mount Guyot	39	28	0	105	56	0	13, 565 H.
Mount Hamilton	39	26	25	105	58	7	13, 800 H.
Mount Silverheels	39	20	0	106	0	0	13, 650 H.
Quandary Peak, Park Range	39	24	0	106	6	0	14, 269 H.
Mount Lincoln, Park Range	39	21	8	106	6	25	14, 297 H.
Buckskin Mountain, Park Range	39	20	0	106	8	0	14, 022 H.
Mount Arkansas	39	22	15	106	15	0	13, 647 H.

Passes on the crest of the main Rocky Mountains from latitude 40° 30′ *to Tennessee Pass.*

Boulder Pass	39	36	15	105	41	0	11, 613 H.
Berthoud Pass							11, 462 P.
Jones Pass							12, 513 P.
Argentine Pass	39	37	50	105	46	30	13, 100
Georgia Pass	39	28	0	105	55	0	11, 487 P.
Hamilton Pass	39	24	35	105	58	0	12, 370 R.
Hoosier Pass	39	21	40	106	3	30	11, 314 W.
Tennessee Peak	39	21	30	106	18	0	10, 418 H.

* The letters designate the authority: H stands for Hayden; P stands for Parry; W stands for Whitney; R stands for Ruffner.

THE ORDERS OF MOUNTAIN RANGES.

Ranges of first order.—*a.* Main or Colorado Range, including Continental Divide; *b.* Front Range, from Pike's Peak to Platte Cañon; *b.* Park Range; *b.* Medicine Bow Range.

Ranges of second order.—*a.* Evans Ridge; *b.* Kanosha Ridge; *b.* Tarryall Ridge; *b.* North Platte River Range; *b.* Williams Range; *b.* Eagle River Range.

Ridges of third order.—Vasquez Ridge, Troublesome Ridge.

Ridges of fourth order.—Trachyte parallel ridges in South Park, Hogback system along the Foot Hills.

THE ORDERS OF VALLEYS.

Middle Park, or Pacific waters.

Valleys of the first order.—Grand River Valley, Blue River Valley, Muddy River Valley.

Valleys of second order.—Frazier River Valley, Williams Valley, West Troublesome Valley, East Fork of Grand, (lower portion.)

Cañons of first order.—Clear Creek Cañon, Boulder Cañon, Saint Vrain's Cañon, two branches, Big Thompson Cañon.

Cañons of second order.—Bear Creek Cañon, Turkey Creek Cañon, Ralston Creek Cañon, Coal Creek Cañon, Four-Mile Creek Cañon, Jim Creek Cañon, Left-Hand Creek Cañon, Little Thompson Cañon, Deer Creek Cañon.

MIDDLE PARK CAÑONS.

Cañons of first order.—None.

Cañons of second order.—Gores Cañon, Frazier Cañon.

Cañons of third order.—Willow Creek Cañon, (central portion of the creek,) East Troublesome Cañon, Upper part of Snake River, Ten-Mile Cañon.

CAÑONS IN THE SOUTH PARK ZONE.

Cañons of first order.—Upper Cañon exit of South Park, Lower Cañon exit of mountains.

Cañons of second order.—Middle South Platte Cañon, Tarryall Cañon, extending from its mouth to 3 miles west of it, Lost Park Cañon, Wigwams Cañon, West Pike's Cañon.

Cañon of third order.—(A part of) Creig Creek.

MIDDLE PARK, OR PACIFIC WATERS.

Valleys of third order.—Camp Creek Valley, Stillwater Valley, Lower Snake River Valley, lower portion of Willow Valley, Swan River.

WEST OF THE PARK RANGE.

Atlantic waters.

Valleys of first order.—Upper Arkansas Valley, Eagle River Valley.*

Pacific waters.

Valleys of second order.—Gore's Creek Valley.

SOUTH PLATTE RIVER DRAINAGE, OR ATLANTIC WATERS.

Valleys of first order.—South Fork of Platte River, "while in the South Park."

Valleys of second order.—North Fork South Platte River, Tarryall Valley.

Valleys of third order.—Manitou Creek Valley, Twin Creek Valley, Deer Creek Valley, Elk Creek Valley, Fountain qui Bouille.

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* Part of Eagle River is cañon.

EASTERN SLOPE.

Atlantic waters.

Valley of the first order.—South Platte River.

MOUNTAIN GROUPS.

Group of first order.—Pike's Peaks.
Group of second order.—Puma Hills.
Group of third order.—Basalt Hills.

CHAPTER II.

THE MIDDLE PARK—ITS DRAINAGE AND CHARACTERISTICS.

The term "park" cannot be given, in an abstract sense, to that depressed area which is generally considered to constitute the Middle Park, for it is neither a unit in park-like features, nor is the depressed basin-area in any way proportional to the great bulk of mountains that crowd into the center to break its unity. Whatever there is of this area that might be brought under the denomination of "park" exists in more or less disconnected and fragmentary patches.

Immediately north of Frazier River Cañon, or about the junction of Vasquez, Moses, Hay, and Ranch Creeks, lies, perhaps, the most perfect portion of park-area in the district called Middle Park. A like portion is found in a small patch in the vicinity of Camp Creek, a tributary to Frazier River; and still another lies east of the junction of Grand and Frazier Rivers, including a small district about Stillwater Creek. The broad-molded valley of Williams River and narrow strip west of the Troublesome Creek are also fragmentary portions of it. The river-bottoms of the Grand and Muddy and about 9 miles of the lower valley of the Blue may be added to the actual park-area; but the remainder is of terraced, waving, and mountainous character.

The slopes of hills, ridges, and ranges that either gird the Middle Park or crowd into its district are timberless to a great extent, but exhibit more or less a covering of grass. This, when seen from one of the high passes over which we approach the park, produces the impression that before us lies an extensive basin surrounded by mountains in diversified order. The idea disappears, however, when we descend into the basin and examine the area more closely.

However deficient the Middle Park may be in regard to absolute park-area, one thing must be admitted, that, in regard to quantity and regular distribution of water, this district cannot be excelled anywhere. The drainage is remarkably well balanced for so extensive an area; and what adds additional value to the drainage-system is the fact that at no time of the year do we find parched beds of water-courses, or empty channels instead of flowing water.

The North Fork of Grand River has its sources in the vicinity of longitude 105° 49′ and latitude 40° 30′. Its sources, its tributaries, and its valley lie in a pocket caused by the main Rocky Mountain Chain and the Medicine Bow Range. The mouth of this pocket is directed toward the south. The center of it is occupied by a spacious valley of at least 6 miles in length, and in places a mile in width. This Upper Grand Valley (as the proper name would be) has but little fall for many miles, and numerous mountain-streams coming down from both sides of the ranges have turned the entire valley into an extensive beaver-meadow. Where the valley approaches the vicinity of Grand Lake, and where it naturally should become wider, it is closed up to a great extent by morainal deposits and dense timber, leaving only narrow passages for the river.

The North Fork of the Grand does not enter Grand Lake, but passes the same about two miles to the west, and is joined by the outlet or Lake Fork when 2 miles south below the lake.

The Lake Fork is in size and volume of water at least equal, if not superior, to the North Fork. The basin of the Grand Lake owes its existence to moraine benches deposited before the mouths of two large cañons, and it serves as a reservoir for the waters of two streams that come down from the western slope of the Front Range in the vicinity of Long's Peak.

We may consider Grand Lake and the environs of the junction between Lake Fork and the North Fork of Grand River as the extreme northeast corner of the Middle Park, as the mountains to the right become very much depressed, and though the river is not absolutely freed from impediments in the way of morainal ridges and terraces, yet the opening of the country in general points to the fact that we approach nearer to the Middle Park proper. Three and a half miles south of the junction of the two northern branches, Lake Fork and North Fork, the Upper Grand River receives another of its principal tributaries, namely, the East Fork of the Grand, which has its sources on the western slope of the Colorado or Front Range and northwest of Arapahoe Peak. This stream is 14 miles long, and, commencing at its sources, flows for about 8 miles close to the basin of the Front Range, being principally inclosed in a cañon. The mountains rise on the east side, with a slope angle of 25°, while on the west side the angle is much less, but the west side immediately near the creek is steep. Before the East Branch joins the main Grand, it meanders for 3 or 4 miles in a comparatively open valley bottom, inclosed on either side by precipitous cliffs. The tributaries of note which this stream receives on its way are not very numerous; there is only one coming from the west side, while on the east side two cañon-streams emerge out of dark gorges which are characteristic features to that portion of the western slopes of the Front Range. The spurs between the lateral mountain-streams average about 2,000 feet in relative height above the mean creek-level. The average fall of the East Branch is 228 feet per mile, and the total fall amounts to 3,200 feet.

The location of the junction of the two branches of the Upper Grand River is, longitude 105° 50′ and latitude 40° 9′ 30″. Down to this point the North Fork meandered a distance of 22 miles from its very sources in a direct southern course, but from the junction of the two branches its direction changes into a western one with a variation of 22° to the south, which course the river maintains for 18 miles, not including the curves and smaller variations of its bends.

Not quite a mile below the junction of the two forks of the Grand two smaller streams enter into it, one coming from between the granite spurs from the south, bearing no name, and the other from the north. The latter one, named

STILLWATER CREEK,

is 12 miles long, and has its sources in Williams Creek Mountains, which may be virtually considered the extension of Medicine Bow Range. Stillwater Creek flows near its lower end in a broad-molded valley or basin, and carries not only abundance of splendid mountain-water, but its margins, as well as the very moderate hill and terrace-slopes, are well grassed. Its average fall per mile is 192 feet.

Only half a mile below, where Stillwater Creek intersects the Grand, the river enters a granite cañon and remains in it for a distance of 1½ miles. The granite bluffs along this cañon are of a height of 100 to 150 feet, and constitute the end portions of a spur coming from the huge and bulky granite masses which lie directly west of Arapahoe Peak.

Four and a half miles below Stillwater Creek we arrive at the entrance of

WILLOW CREEK.

This stream, with a total length of 26 miles, has many smaller tributaries but no important side branches. It has its origin in two branches, the main one in that mountain amphitheater in Willow Creek Mountain 4 miles southwest from Upper Grand Valley Peak, and the lesser beneath Willow Creek Pass, in a depressed basin east of Park View Mountain. In its circling course toward the Grand, many smaller gulch and cañon streams coming from Corral Peak and Whiteface Cluster unite with it. The middle portion of Willow Creek, within a distance of 6 to 7 miles, is in cañon, or nearly so. Its course is not direct but crescent-shaped, following at first a southwestern, then southern, and after that a southeastern, course. When the creek approaches within 2 to 3 miles of the Grand River, the mountain-slopes to the left of Willow Creek become greatly depressed, and the country still lower changes gradually into a gentle terraced country, which extends all along the north side of Grand River and eastward up to Grand Lake. There is an Indian-trail along Willow Creek leading from that portion of the Middle Park over a low pass into the North Park. The average fall of Willow Creek is 92 feet per mile, and its total fall from its source about 2,400 feet. Again, 4½ miles down the Grand from the junction of Willow and Grand, another important branch of the Middle Park drainage enters into the river from the southeast, viz,

FRAZIER RIVER.

This river, together with its tributaries, forms a distinct drainage-system of a separate area, or subzone, which constitutes at least one-fifth of the Middle Park area. The boundaries of this area extend from the crest of the Colorado Range, near Arapahoe Peak, 14 miles across to the crest of Vasquez Ridge, and from the Grand River south to the crest of the Main Range, which circles from James Peak around to Gray's Peak. The drainage area of the Frazier River Zone comprises about 320 square miles, or 204,800 acres of surface.

The slopes of James Peak, as well as those of Vasquez Peak, and the whole length of 14 miles of slope between these two mountains, comprising the northern slopes of the big bend with its rugged cañons and long-stretched spurs, furnish tributary water to the common channel of Frazier River. Again, the whole of the western slope of the Main or Colorado Range from James Peak north to a point 2 miles west of Arapahoe Peak, and the whole of the eastern slope of Vasquez Ridge, pour their accumulated waters into the bed of Frazier River.

There exists a natural division in the Frazier River Basin which breaks its unity and divides the latter into upper and lower basin. The cause of this break is to be attributed to an orographical feature that exists about 7 to 8 miles south from the Frazier and Grand River junction. West of Arapahoe Peak, and also still west of the Main or Colorado Range, lie huge masses of granite mountains, bulky and more rounded than otherwise in their forms, and although they are connected with the Main Range, yet the fact of their extending out from the regular order of mountains more than usual in that region makes them appear detached from the mountain chain. This massive mountain mass crowds its spurs more forward into the Frazier River district, as well as north in the direction of the junction of the East and North Forks of the Grand, than any other mountain mass in that particular region. A western extension of spurs from that mass descends down into Frazier River Basin a few miles below its natural center, and, though getting lower and still lower, runs even across the basin, forming, at last, a flat, broad swell, showing at its lowest portions an altitude still 200 to 250 feet above Frazier River. This outrunner of a granite mass has separated Frazier River Basin into a lower and upper district, and has compelled the united drainage of the upper basin to force a passage through this granite structure and cause a cañon with sides 600 feet high.*

The creeks and streams of the Upper Frazier River Basin, of which the principal names are, Moses, Vasquez, Hay, and Ranch Creeks, besides several tributaries that issue into Vasquez and Moses Creeks, out of rugged cañons from the main range, come from three sides down from the mountains to concentrate at a point, longitude 105° 50′ and latitude 40°, which is almost immediately before the mouth of the cañon. The cañon is impassable, and very likely will remain so for a while, for we have not been able to proceed further than 1½ miles in exploring it. Below the cañon, Frazier River meanders for nearly 5 miles in a level, terraced country, with its level district principally to the right, admitting only one more stream of note, "Camp Creek," into its channel before entering Grand River.

CAMP CREEK

has a length of about 10 miles, and originates among a cluster of small hills between Frazier Cañon and Vasquez Ridge, forming a small subbasin by itself, which character is particularly strongly expressed in its middle and lower portions, near its intersection with Frazier River.

For 8 miles below Frazier River junction the Grand River receives no side streams of any consequence, save such little mountain-brooks as rise on the slopes of hills 3 or 4 miles to the right or left of the river. The Grand River leaves the open country below Frazier junction for a distance of 9 miles down to the end of the cañon below the Hot Sulphur Springs. From Frazier junction to the Hot Sulphur Springs, a straight distance of 5¾ miles, the river flows pretty nearly all the way in a valley with surroundings of peculiar geological interest.† A group of hills, with a diameter of 4 miles east and west, and with a walling of a very hard rock ‡ on their western and eastern faces, and a softer material in the interior of that group, produced the existence of two rocky gates through which the river passes, one at the entrance of this rocky inclosure and the other 4 miles down the river, at the point where the river leaves that group of hills with its rocky walls. Inside the two gaps the river has molded in the softer material with greater freedom here and there pretty valley-bottoms. Sometimes, however, the continuity of these pretty valley-

* Frazier River did not break or wash out this cañon where the depression of the granite swell or upheaval that runs across the basin is lowest, but a mile and a half to the east of it.

† See Archibald Marvin's Geological Report, 1873, pp. 166, 167.

‡ Dolcritic breccia (see Archibald Marvin's Report, 1873).

patches is broken by some terraces or benches crowding and pressing closer to the river.

To the north as well as to the south of the Grand River the country recedes in a series of terraces, constructed with astonishing regularity, yet of most peculiar configuration. The terraces are cut longitudinally by a series of gulches or fissures produced by erosion, and are formed by them into a tier of spurs parallel to each other, and all the spurs having features in every way analogous. That group or cluster, with its terraces, terminates as well as culminates at a point 3 miles south from the river, with an altitude of 9,600 feet and 2,000 feet above mean river-level. Northward the hills recede 4 miles in the direction of Whiteface Mountain, and up to the crest of that big mountain spur which Whiteface Peak sends eastward in the direction of the junction of Willow and Grand Rivers.* Passing the western gap of this hill-cluster, Grand River enters that small park-area which lies immediately east of the Hot Sulphur Springs, almost in an exact center of the Middle Park district. Passing close to the springs, the river plunges one-fourth mile west again into a cañon of 1½ miles in length, out of which it emerges half a mile below the entrance of Beaver Creek. This cañon near the Hot Springs is caused by a spur of granite rock, which connected in remote times uninterruptedly the end of Vasquez Ridge at its terminus with that upheaval of which Mount Bross, 1½ miles northwest of the Hot Springs, is the culminating point. This spur, now broken or washed through by the Grand River, divided once perhaps more effectually than now the Middle Park area into two separate divisions, in an eastern and a western one, for below the cañon the valley of the Grand spreads out unimpeded and meanders at leisure in a wide bottom until it reaches the western boundaries of the park, where again the united efforts of the Middle Park waters were necessary to force a passage through the Park Range.

BEAVER CREEK.

Only little can be said in relation to that stream, that intersects the Grand near and a little above the lower end of the cañon, except that its sources are along the western slope of the most northern portion of the Vasquez Ridge, and that its length is about 12 miles and its approximate total fall about 1,400 feet. One mile below Beaver Creek enters still another one, but without name. This creek, which is running parallel to Beaver Creek, originates and flows between two low subridges, which the Vasquez Ridge has detached from its own mountain mass,† about 14 miles to the south from Hot Sulphur Springs. The next and more important tributary to the Grand, entering the latter 2 miles below Beaver Creek and only one mile below the cañon, is

WILLIAMS RIVER.

This river gathers its waters about 7 miles northwest of Gray's and Torrey's Peaks, among the high mountains near the connection of Williams Range with the Colorado or Front Range, and also among the western slopes and outrunners of the highest or southern portion of Vasquez Ridge. It receives its principal volume of water through four main branches coming out of cliffy cañons‡ in the high mountain portion re-

* See orographic notes.
† See orographic notes, Vasquez Ridge.
‡ See orographic notes on main crest.

ferred to, which unite in a deep valley directly beneath Ute Peak and only two miles east of it. That branch, which might be considered the main branch, flows along the eastern base of Williams Range from its very intersection with the main range down to the vicinity of Ute Pass. All the branches as long as remaining in the upper region are confined and inclosed within cañons, and only when Williams River arrives at the parallel of Ute Pass it is freed, as well as the other tributaries, from a too close proximity of the mountains. This is at least the case on the west side of the river, where, from the Ute Pass downward, the slopes of Williams Range approach the river with a more gentle descent than above. The right bank of Williams River, or the east side, is bordered by the outrunners of granite spurs coming from Mount Byers and the upper region of the Vasquez Ridge. This feature exists all along the middle part of Williams River during a length of 7 to 8 miles. The left or western river-bank gains continually in width from the time the river leaves the vicinity of Ute Pass, and when it arrives at a point in the valley about 10 miles south from its junction with the Grand, the Williams Basin attains its greatest width and retains the same for 8 miles further down the stream. Gentle terraced and grassy slopes run from the river-bed gradually westward toward Williams Range, the backbone of which lies about 6 miles from the river. All along from near its sources Williams River has followed a northwest course, but when arriving within a few miles of the Grand it makes a sudden turn to the right or east, and in breaking through a connected ridge of buttes or high terraces which border the southern margin of the Grand, forms a cañon for 2½ miles, which ceases when very close to its junction with the Grand. The total length of Williams River is 34 miles, and, including the higher mountain district where great fall exists, its average fall amounts to 112 feet, but from the vicinity of Ute Peak down to its junction with the Grand, a distance of 18 miles, Williams River has hardly an average fall of over 60 feet per mile.

There is another creek coming from the north which faces Williams River and enters the Grand only a half mile below the junction of Williams and the Grand, which is named

CORRAL CREEK.

This stream has a length of 12 miles, and originates between Corral and Whiteface Peaks. The principal characteristics of this stream are those of a mountain-creek with a comparative rapid descent during its whole course. This rapid descent shows at once the improbability of the development of any regular valley feature. While in the mountains, the narrow valley shows grassy margins, and during its whole course here and there very small patches of bottom-land. Its course is very direct, and nearly north and south. Its average fall is about 200 feet per mile and the total fall 2,400 feet.

Six miles and a half below Corral Creek the Grand receives another tributary, namely,

THE TROUBLESOME RIVER.

The eastern and western forks of this stream join about 8 miles north of its junction with the Grand. The eastern branch has two prongs near its headwaters; the source of one drains the western and southern slopes of Park View Mountain, and the other originates among the peaks and spurs detached from the Continental Divide several miles west of Park View Mountain. After their junction, the river flows southward for 5 miles in a very close valley, bearing pretty much all the characteristics of a cañon,* showing only here and there, and in places where side gulches come down from the mountains, little patches of a few acres of comparatively level bottom. When just half a mile below a point where a direct line 3 miles west from Corral Peak would strike the Troublesome Creek it makes a sudden turn westward, breaking through the Troublesome Ridge, forming thereby a cañon for 2 miles with steep sloping sides from 800 to 1,000 feet, where the axis of the ridge would cross the river.

Immediately outside of the cañon the East Fork is joined by the West Fork, which heads about 15 miles north on the southern slopes of the Continental Divide. This branch of the Troublesome is at first inclosed by rugged and high mountain country, but soon frees itself from it and enters an almost open district. A gentle sloping country characterizes the western margin of the West Troublesome Fork, while immediately from its right bank the steep slopes of the ridge dividing the two streams rise to an altitude of 1,600 to 1,800 feet within 1½ miles. After the two forks of the Troublesome have united, the course of the stream remains unchanged for 4 miles; that is, it keeps an almost southerly direction, which the West Fork has maintained for 7 miles previously. When within 3 miles from the Grand, the Troublesome turns abruptly southwest, and joins the Grand River 4 miles below the bend. The country west of the united Troublesome continues to exhibit these flat, gradually rising terrace features, which culminate 3 miles west or half the distance across to the Muddy River.

At the junction of the Troublesome with the Grand the valley-bottom assumes its maximum width, perhaps a full mile. It is, indeed, a splendid stretch of valley, that lies for several miles east and west of this junction. It may with all propriety be called the garden-spot of the Middle Park. Some quite extensive cottonwood groves can be found along this rich river-bottom. A belt of occasionally broken terraces, with an average altitude of 600 feet above mean river-level, borders the river-bottom on the south as well as on the north side. In some cases buttes of several hundred feet elevation tower above the terraces, as, for instance, near the junction of Williams River and on the southeast side of the Grand, Blue, and Muddy junction. The latter butte rises 1,400 feet above Grand River, and appears as it stands to have been a once connected but now detached part of the Williams Range. From the Troublesome and Grand River junction the Grand sweeps in big curves through its bottom toward the united junction of all the Middle Park waters, where two or more powerful streams, one from the north and the other from the south, come to join.

THE MUDDY RIVER AND ITS VALLEY.

There are no other rivers (not only in the Middle Park district, but in South Park and on the eastern slope of the Rocky Mountains) where the valley features are more decidedly expressed than along the Muddy and the Blue, and with the latter more so than with the former.

The Muddy River, which, by the way, has rather a milky but by no means a muddy color, starts its first waters in one branch near Rabbit-Ear Butte, in the remote northwestern corner of the Middle Park; another branch comes from the south, and in a direction facing each other these two then unite. Both branches pick up little gulch-streams as they flow along the eastern slopes of the Park Range. They unite at a point,

* The name of Troubleseme Creek dates back to the time of the first hunters and prospectors, who found great difficulty in proceeding along the creek.

longitude 106° 35′ and latitude 40° 18′, which lies 5½ miles west and a few degrees south of the Upper Muddy Butte, the most prominent landmark in that region. From this junction the Muddy, already a stream of respectable size, bears almost directly east for 4 miles, inclining but little to the north, pressing in one or two places through small cañons, where spurs and terraces crowd close to the river, and when arriving 1½ miles west from the Upper Muddy Butte it gradually swings around and assumes for about 5 miles a general southeastern direction, after which the trend of the valley is nearly due south, with but little eastern deviation.

After leaving the vicinity of the Upper Muddy Butte, the river meanders in a broad bottom, closing and widening more or less alternately. The valley-bottom proper is framed all along with a string of terraces shelving up as the country recedes to the right and left, the lower one close to the river and especially well-defined on the western side, being about from 60 to 75 feet high. On the east side of the river these terraces have been greatly destroyed in their totality by erosion, for the grass covering is on that side either very thin or frequently absent, and as the soil consists of a very soft substance, it is easily dissolved and broken by rain, snow, and heat. Some of them, however, have resisted longer, and we are able to witness among them grouping of terraces of most peculiar arrangement and order. The gulches coming from that side are mostly dry but very numerous, and are just the cause of the greater destruction to the slopes. The crest of this upheaval is about 3 miles distant from the river, and while the side fronting the Muddy is greatly eroded, the eastern side, leaning toward the Troublesome, presents a softly descending elevated plain.

The western side of the Muddy presents a different aspect, rising gradually into well-grassed slopes, which are at intervals interrupted by terraces ascending from the valley to the summit of the broad-molded Park Range, the axis of which lies about 7 to 8 miles distant from the valley. The streams that come down this slope flow in more well-defined beds, the bluffy sides of which are not so frequently broken down and absolutely eroded. About midway up the slope we find in most cases a dense growth of quaking aspens, with scattered patches of pines, while on the top of the Park Range, as well as on the western slopes, the pines predominate altogether.

About 5 miles in a direct line from Grand and Muddy junction, the river passes a large butte on the left, called the Lower Muddy Butte. This butte, the highest one of a number of buttes in that vicinity, is of a commanding appearance, as it stands over 1,800 feet above river-level. It is partially covered with pines, and has a cap of lava like the Upper Muddy Butte, to which fact its present well-preserved shape is owing. On the west side of the river the slopes of the Park Range assume also a more rugged character than shown before, though in its general character they still represent a gradual sloping; but the streams are here cut deeper from their being larger, and therefore more destructive; the terraces are more abrupt, and the belt of pines descending lower in the gulches than farther up the river.

From the Lower Muddy Butte the river winds in huge curves toward the junction of the Grand, being accompanied to the right by high, almost upright, standing terraces to within 2 miles from its entrance into the Grand. The length of Muddy River, its large bends included, is 38 miles; its fall for the last 24 miles is hardly perceptible; at least it will not exceed much 10 feet to a mile.

THE BLUE RIVER AND ITS VALLEY.

1. *Drainage and characteristics of Upper Blue River and tributaries.**

We may locate the commencement of the Upper Blue Valley at longitude 106° 3′ and latitude 39° 23′, a point where the road descending north from Hoosier Pass strikes the Blue River. As its main source we may designate that amphitheater directly south and beneath Quandary Peak, where from the snow-banks and alpine lakes the first stream originates, which, flowing for 3 miles between rugged mountain-spurs, descends to a point in the upper valley above mentioned.

The course of the Upper Blue Valley is due north down to the junction of Blue, Snake, and Ten Mile, a confluence which to call it Three Rivers Junction might not be inappropriate. For the first 5 miles the valley features are yet in their infancy—just wide enough to enable us to dismiss the name of cañon. To the right the Blue River admits mountain-streams from the Silverheel Group, and on the left those coming from the Park Range.

At a point 5 miles down the valley a branch stream comes down from Hamilton Pass, and alongside of it the road which leads over the pass to connect Hamilton in the South Park with Breckenridge, in the valley of the Blue. Only 2½ miles below this intersection lies the mining-town of Breckenridge, a small village serving as a supply-depot for miners that are scattered around in the mountains. Below Breckenridge the valley assumes already greater range, and in its course down to the Three River Junction the drainage of the Upper Blue is nowhere seriously embarrassed by obstacles. The distance from Breckenridge to the junction of Blue, Ten Mile, and Snake is 9½ miles, and on its way down are admitted two streams of importance, namely, French Creek and Swan River. French Creek may be considered rectangular to the Blue, and enters the same only half a mile below Breckenridge. Its headwaters rise on the northern slopes of Mount Guyot, and between the latter and Mount Hamilton it is 6 miles long and flows between high spurs, passing the small mining-village Lincoln, about midway from its sources to its intersection.

Four miles down the river from Breckenridge Swan River joins. This stream has a length of about 9 miles, and obtains its main body of water from three branches that join about from 5 to 6 miles up the valley. The southern branch from Georgia Pass, which lies east of Mount Guyot; the Middle Branch heads west of Whale Peak and joins the Georgia Pass Creek near a dilapidated mining camp or village named Georgia, from which place a road leads over a heavy spur into the French Gulch. Only 1 mile below the junction of Middle and Georgia Pass Branches, the third tributary, coming from 2 miles south of Glacier Peak, enters, and completes Swan River as to its main volume of water. There are a very few small streams coming down the mountains, but of not enough importance for giving them a complete description. We can hardly speak of the Swan River as in a valley, and yet it is not in a cañon; it is a mean between the two. There was considerable mining industry once along Swan River, but it stagnated at the time of our being there, though efforts were made and great hope entertained by a few individual miners. Swan River, like French Creek, enters the Blue at right angles. Next in importance to Blue River itself is

* We include in the drainage of the Upper Blue Valley and tributaries the following: The main stream of the Blue, Ten Mile Creek, Swan River, French Gulch, and Snake River, with its tributaries.

SNAKE RIVER,

a powerful stream of 15 miles in length. Its main importance thus far consists in facilitating the communication between Clear Creek Valley and the Blue by means of the road which leads from Georgetown over the Argentine Pass into the Snake River Valley.

The sources of this stream are found below the steep slopes descending from Gray's Peak on the south side in an amphitheater. In standing on the brink of Argentine Pass, with face southwest, we look down into the very sources of the Snake River, consisting of snow flats—an amphitheater with a small lake in its center. From the point where the road touches the valley, after descending down along the steep sides of the mountains from the Argentine Pass, the Snake, with a gentle swing to the south, assumes at once a straight course westward for 12 miles, and only 2 miles before its intersection with the Blue it makes a deviation to the northwest.

Where the Argentine Pass road touches the valley-bottom the valley proper has its beginning. Down from here the valley is narrow, and the road is far from being an easy one. Three miles down from the head of the valley the Snake receives a tributary through a powerful mountain-stream, coming directly from the western slopes of Gray and Torrey Peaks, and 2 miles still farther down the river another, Montezuma Creek, enters.

MONTEZUMA CREEK

is of about 6 miles in length, and, coming from the south, collects its waters in three branches on the northern slopes of the main range. These branches unite near the small mining-village Montezuma, which lies only 1½ miles above the creek's junction with the Snake River. The most eastern of these branches is the one along which the trail going over the Hand-Cart Pass leads. The middle branch, flowing to the east of Glacier Peak, has, to my knowledge, no name, but the western branch I suppose is named Bear Creek. It comes down in that amphitheater west of Glacier Peak, wherein considerable mining industry has caused the erection of the St. John's reduction-works.

During the 3 miles below the entrance of Montezuma Creek the Snake is still so wedged in between high and rugged mountains that the name of valley seems inappropriately flattering. At the end of its 3 miles of close confinement the Snake enters a somewhat broader scope of country, and the valley widens as it advances. A large tributary enters here from the northeast, and 2½ miles down the valley another one arrives from the southeast, and 2 miles still farther below Keystone Creek enters, along which considerable amount of placer-mining has created quite a settlement of miners. From the latter creek it is but 2 miles more down to the junction of the three streams. The Snake Valley is once more limited respecting scope of valley bottom during the whole of that distance, yet the road has plenty of room to avoid embarrassment.

TEN MILE CREEK

is, next to Snake Creek, the most important tributary to Blue River. Its sources are located near the same saddle where the East Fork of the Eagle River takes its rise. Ten Mile Creek follows in two large curves the western base of the Park Range until it effects its exit through a cañon immediately below the most northern of the Ten Mile Peaks, from which point it meanders without impediment, in a comparatively open country, for 4 miles in a northeastern direction, to the Three River Junction. The name of Ten Mile Creek is doubtless derived from the supposed distance which this creek at its intersection with the Blue was supposed to be from the mining-town of Breckenridge. Its total length is 22 miles, with an average fall of 127 feet to a mile, and a total fall of 2,800 feet.

There are four tributaries to Ten Mile Creek, which all come from the eastern slope of Eagle River Range. Good Harbor Creek, with a length of 7 miles, is the most prominent one. This creek takes in four small tributaries. Higher up in the mountains, near the head of Ten Mile Creek, McNulty Gulch, a mining-gulch, comes in as a tributary, and near the mouth of the cañon a creek named Cañon Creek intersects, which comes from the southern slopes and spurs of Red Peak and its neighbors. This latter creek has a length of 6 miles.

At the junction of Ten Mile Creek and Snake and Blue Rivers we may venture to say is one of the prettiest localities on the Blue River Valley. From here we have mountain scenery of every desirable form and shape. As we look up the Valley of the Blue, our eyes meet on the horizon the sharp peaks about Hamilton Pass, and several miles east of them we see Mount Guyot dominating over lesser peaks and rugged mountains, while, when we look down the valley of the Blue, our eyes are arrested by the huge mountain-masses of the Gores Range, with its countless lofty peaks and its sharp spurs.

2. *The Middle Blue River Valley.*

In Northeastern Colorado we will hardly be able to find another river apparently with more distinctly expressed valley features than that of the Blue River, commencing from the junction of the Three Rivers down to the junction of Grand, a distance of 35 miles. This excludes a stretch of perhaps 3 miles before we arrive on a line with Ute Pass, and one of 5 miles below Ute Pass, where the river is crowded in the first case from a big spur coming from the right or Williams Range, and in the second case from high terraces and low depressed spurs descending from the Gores Range. But deducting this 8 miles of valley obstruction, there still remain some 27 miles of valley features that have no comparison elsewhere in the northeast of Colorado. But looking at it in the spirit of an agriculturist, we find, in spite of its valley appearance, in it the lack of one very important condition—that is, the absence of a level bottom, a fault which many if not most of our Rocky Mountain valleys share. The river-channel is carved in an average from 40 to 60 feet below what would constitute the main space of the valley; the actual bottom is very narrow, hardly representing the space of one more river's width. Moreover, the flattish-appearing valley space to the right and to the left is composed mainly of terraces and gentle descending flattened spurs, with deep narrow gulches between them, a circumstance which would make irrigation very costly, difficult, and perhaps ineffectual.

The middle portion of the Blue River Valley commences at the Three Rivers Junction, and may be regarded as extending down to the Blue River Valley Butte, 24 miles distant to the southwest. Only $1\frac{1}{2}$ miles below the above-named junction we enter a broad sage-patch on the east side of the river, which is over 1 mile in width, and here quite a large tributary (Rough Creek) enters, coming along the southern slopes of Williams Range from the vicinity of a point where it branches from the main or Colorado Range. This creek possesses for several miles upward a well-grassed valley, but which comes abruptly to a close and bears all the way up to its headwaters after that all the features of a cañon. This cañon-stream, which is about 9 to 10 miles long, together with its lateral branches, constitutes the only break in that mountain district belonging to the Upper Williams River Mountains. Indeed, in compactness of mass Williams Range has no equal in the district described in these notes, for during its whole length down to the junction of the Grand neither the western nor eastern mountain-sides are marked by deep cuts from drainage; it compares, except that portion about the Ute Pass, where a shifting of the axis exists, with a solid, unbroken mountain chain. An explanation of this fact is simple enough, for the axis of that range is not far from either the Blue or Williams River, and the drainage in its sudden descent has no time for slow, laboriously deep washing, but in the rapid descent leaves in most cases only gulches to mark its course.

Opposite the Upper Williams River Mountain portion, and across the valley westward, is also the beginning of the rugged Gores Range. The axis of that range lies farther off—18 miles from the river, and the streams come out of deeply-eroded amphitheaters and through sharp-crested rugged spurs.

I have in the preceding chapter, when speaking about the Gores Range, alluded to the characteristics of spurs in their descent from the base of the *débris* slope down to the valley. This flat, depressed area between the river and the commencement of the steep slopes of rugged spurs are morainal deposits, covered with a dense growth of pine timber, forming a sort of a foreland between river and mountains. Generlly the first mile near the river consists of slow-rising grassy terrace country, after which we encounter the morainal benches, occupying a space often for several miles upward.

The broad patch of sage-bottom referred to below the Three Rivers Junction extends several miles down the Blue River, which in this upper part of the valley has not yet carved a very deep channel. The river itself bears for 17 miles a direction of north 30° west, and though it keeps a general uniform course in the middle of the valley, it approaches sometimes nearer the base of Williams Range and crowds the road which lies on the east side of the river-bank several times against inconvenient steep places. However, in such cases it soon turns westward again, and leaves repeatedly long stretches of good bottom.

When within about 7 miles from the entrance of the Pass Creek, the Blue makes a bend to the west through a cañon, caused on the east by a big rounded spur coming from the Williams Range, and lying right across the valley. This bend is about 4 miles long, and after that the river proceeds due north for five miles until on a line with Ute Pass, where the Ute Pass Creek enters. From this point the river turns sharply into a due-northwest course, and remains at least for 7 miles close to the base of Williams Range, the abrupt terraces of which rise pretty close from the river's edge, while on the west side bulky broad terraces, caused by lake-deposits, press close on to the river.

The road, which from the Three Rivers Junction has remained all the way on the east side of the river, is obliged to cross near Ute Pass Creek, and remains on the left bank for about 7 miles, meandering through sometimes very inconvenient terraces and benches until some 3 miles from the Blue Valley Butte, when it again crosses the river, to remain hereafter on the east side until it crosses over into the Middle Park.

During the 7 miles of distance from the Pass Creek down to this point, where the road recrosses to the east side of the river, the axis of Williams Range lies closer to the river than elsewhere. A little northwest of Ute Pass it is but 2 miles, while 7 miles below it is 3 miles distant from the river. The relative height of the Williams Range along here is 3,200 feet above mean river-level, while the mean absolute height of the river is about 7,800 feet.

On the west side of the Blue River the features are just reversed from those on the east side.

The slopes of the Gores Range rise in a gradual rather bulky and irregular-shaped character toward the Gores Mountains, the axis of which is from 8 to 10 miles distant from the river. Powerful streams continue to come out of the amphitheater and dark-looking gorges, and pursue with swiftness their course through the densely-wooded district of the moraines.

Three miles east of Blue River Valley Butte, the river changes from a northwest into a due-west course, and turning around that butte, the base of which it washes, assumes from this point a course north 16° west. The butte, standing in the center of the valley, is connected with the Williams Range by a very low saddle, over which the road passes. It produces a singular scenic effect. It is a trachytic uplift, with steep faces toward the river and moderate descent toward the low pass, which connects the contours of the butte with those of the Williams Range.

The northern end of the rugged group of the Gores Mountains, with Mount Powell as its most elevated point, lies about nearly south, and about 9 miles distant from the Blue River Valley Butte. From this butte the distance to the Grand River Junction is 12 miles; the Blue, as above stated, has from here, with only 16° western deviation, a pretty direct northern trend for the remainder of its course. The characteristics of the Williams Mountains indicate no material change from here. The same evenness in feature prevails which the Williams Range exhibited all the way down from Ute Pass, except perhaps a greater prominency of terrace features that characterizes particularly the slopes of those mountains from Ute Pass down to the Blue Valley Butte.

A marked change, however, takes place in the features of the Park Range, directly on a line with Blue River Peak, the last prominent peak of the Gores Mountains. This last-named peak stands on an extension, pulpit-like, about 1 mile north of Mount Powell, while the crest of the Park Range has detached itself already from Mount Powell, in order to curve somewhat toward the west, still forming a series of nipples averaging about 12,000 feet above sea-level, and causing thereby, beneath and west of Mount Powell, the last of the huge amphitheaters which are so characteristic in that most rugged of the ranges of Northeastern Colorado.

On a line almost east and west with the Blue River Peak, the Park Range (as alluded to already in a previous chapter referring to the Park Range) shows no more ruggedness in its course toward and across the Gores Cañon, but exhibits a smooth, rolling contour, showing only once more an isolated peak (Lone Peak) to break the monotony of its crest.

Though the slope-angles have greatly diminished since the commencement of the smooth contoured portion of the Park Range, the spurs still show great ruggedness in the upper portions, just a few miles north of Gores Range. Cliffy terraces line the north sides of gulches in the upper portions, and make ascent on that part of the range not only impracticable, but, together with the dense growths of pines and fallen timber, impossible. The belt of forest lies generally along the middle part of the range, and extends in abundance to within 5 or 6 miles from the Gores Cañon, after which the pines appear only in isolated patches, and the terraced slopes are covered with grass, and in the upper and middle portion of the range intermixed with quaking asps.

If we admit in the Blue River Valley the existence of an upper as well as a middle valley, the lower valley would then have its beginning at the Valley Butte, and extend to the Grand River Junction, giving it an extent of 12 miles.

The valley features are here particularly uniform in their characteristics, and correspond to the regular, gradually rising terraced slopes of its margins. The river-channel in the lower valley is cut deeper than in the Middle Blue Valley, and the first terraces that stretch along, and sometimes very close to the river, are from 50 to 80 feet high.

The whole length of the Blue River from its mouth to its sources in the amphitheater below Quandary Peak is 59 miles. The average fall of the river is $57\frac{7}{10}$ feet per mile, and the head of the valley lies 3,400 feet above its junction with the Grand.

EAGLE RIVER.

As Eagle River belongs only in part to the district of my special observation, the description will be only fragmentary, and from the fact that the whole length of this river is 60 miles from its source to its junction with the Grand River, only 22 miles, or about one-third of its length, will be contained in this description.

Where the main range, past its intersection with the Park Range,* trends westward to connect with the Sawatch Range, we find 6 miles west of the Park Range, and almost in the center, between the Lincoln cluster of peaks and Homestake Peak, a large upheaval, which we named Mount Arkansas.† To the east as well as to the west of Mount Arkansas lie two saddles, about $4\frac{1}{2}$ miles apart from each other, where the two principal streams rise which form the Eagle River after their junction. The creek starting on the saddle west of Mount Arkansas is called Tennessee Fork, because this saddle is also called Tennessee Pass.‡

The creek coming from the eastern saddle has the name of Main Fork of Eagle River, from the fact that the main valley of the Eagle River can be traced in that direction nearly up to its source.§ After a flow of 6 miles, the two young branches of the Eagle River unite at a point 7 miles north of Mount Arkansas. Where the two branches form a junction, the Eagle River assumes already the shape of a valley and retains the same for a distance of 4 miles.

The valley-bottom is here sometimes one-half mile in width, but bordered on both sides with steep walls which rise over 1,000 feet within one-quarter of a mile from their base. The bordering of Eagle River on the east is caused from spurs coming from the Eagle River Mountains and on the west from spurs coming from Homestake Peak.

The side streams that issue from Eagle River Mountains on the east enter the Eagle River at right angles and flow through narrow gulches before entering the valley of the latter. After meandering for 4 miles in a spacious valley, Eagle River is pressed into an absolute cañon, in which it remains for 3 miles, and baffling the attempt of men to follow it through its mountainous character. At the lower end of this cañon

* See main crest of range.

† See Mount Arkansas, crest of main range.

‡ See Tennessee Pass, crest of main range.

§ This branch shows evidence by its structure of being the main valley.

Eagle River is joined by Weary Man's Creek, and immediately at the junction with the latter makes a turn to the west for 1 mile, after which Homestake Creek, a powerful stream coming from the southwest, intersects Eagle River. Homestake Creek has its source among the rugged spurs of Homestake Peak, one of the highest peaks in the Holy Cross Mountain cluster. In this cañon, as well as the one in which the Roche Moutonnée Creek carries down its turbulent waters from the snowy peaks of the Holy Cross cluster, we have true types of Rocky Mountain cañons of the first order, both replete with wild and picturesque scenery. Homestake Creek has a length of 13 miles and a total fall of 4,000 feet, and its junction with the Eagle River lies about 13 miles northwest of Tennessee Pass. The peak from which the latter creek has derived its name has a relative height of 5,200 feet above Eagle River at its junction with Homestake Creek. Below this latter point the course of Eagle River is again northwest, and for a distance of 4 miles it flows in a cañon. Though the angles of the slope on both sides of the river be less vertically inclined, yet the formation within this cañon rejects every attempt of men to follow this stream along its margin. The possibility of traveling along Eagle River in this portion of its valley is confined to a rough and sometimes perilous trail along the mountain-slopes that gird the cañon on the east side.

Roche Moutonnée Creek joins Eagle River 4 miles below the junction of Homestake Creek with the latter river. Its length is about 11 miles, and the total fall will perhaps amount to 3,600 feet. The relative height of Holy Cross Peak above Eagle River is 5,800 feet. Opposite the entrance of Roche Moutonnée Creek into the valley, another creek comes from the western slope of Eagle River Range, which has been named Two Elk Creek. The entrance of this creek into the valley is hardly visible unless special notice is taken, for the narrow split or the small aperture through which it presses before emerging through the high walls bordering Eagle River might easily be taken for a common fissure in the mountain.

THE GORES BRANCH OF THE EAGLE RIVER ON GORES CREEK.

Twenty-two miles below Tennessee Pass, and 4 miles below junction of Roche Moutonnée Creek, the Eagle River receives its largest tributary, the Gores Creek, which heads 16½ miles to the southeast on the saddle, dividing the Gores Mountains from the Eagle River Range. This creek receives five tributaries from the Gores Range and two smaller ones coming from the south on Eagle River Mountains.

It seems to be characteristic to the streams that enter the valley of the Eagle from the east to be pressed into a narrow passage before they enter the valley. This interesting fact is particularly to be observed in Gores Creek, where for three-quarters of a mile a powerful sheet of water winds with apparent difficulty through a narrow cañon before its exit is effected, while beyond or in the rear of it lies a splendid open mountain-valley, surpassing by far in grandeur and beauty the bottom of the Eagle River. The mountains on both sides of this valley differ not only greatly in height, but totally in character. The slopes descending down from the Eagle River Range into the Gores Valley slope more gradually and are in terrace-shape. The tops of the spurs above are even depressed,* and the mountains proper are massive and bulky, with a bald nipple rising occasionally above timber line, while on the north

* See Eagle River Mountains.

side the Gores Range rises in such majestic grandeur, so bold and so imposing, that hardly any other mountain district in the Rocky Mountains system can surpass them. The scenery combines beauty and grandeur rarely equaled.

For 10 miles from the junction upward the Gores Valley has only an ascent of 900 feet, and possesses a free and an unobstructed valley-bottom. For the next 6½ miles, however, the mountain-slopes on either side of the creek become more abrupt and assume cañon-like shapes, and the horizontal incline of the creek-bed is greatly increased. The fall of Gores Creek for the upper 6½ miles of its course is about 2,700 feet, which includes the region of its sources, namely, up to the amphitheater beneath Red Peak. This shows a total fall for Gores Creek of 3,600 feet within a distance of 16½ miles, or equal to its whole length. There is an Indian trail along this valley, which leads from Eagle River over the Gores Pass into the Blue River Valley, and another which leads from the Upper Gores Valley over a saddle of the Eagle River Range into Ten-Mile Creek Cañon. The five tributaries that Gores Creek receives from the Gores Range are all without exception cañon-streams, the largest of them, the Red Sandstone Creek, having a length of about 7 miles. They all originate in wild labyrinthic and dark-looking gorges, beneath rugged and precipitous peaks and mountain-walls. The total fall of Eagle River from its source to the junction with Gores Creek is about 3,400 feet.

There is abundant evidence of glacial action all along the Eagle River Valley. We will point out only two cases where the result of glacial action speaks forcibly through the huge pile of bowlders and rocky *débris* that has accumulated before the mouth of Homestake Creek Cañon, which equals in size a small ridge, and which defies that stream to pursue its straight course and compels it to recoil, and, finally, by its resistance causes an abrupt turn to the north, flowing for 2 subsequent miles along this ridge of glacial deposits before it can enter Eagle River. The same features prevail near the mouth of Roche Moutonnée Creek, though not on so large a scale, but sufficient evidence can be obtained by examining the spurs that follow the Roche Moutonnée Cañon on both sides, with their very regular descent, which is hardly interrupted by a shelf-break or offset for miles toward its source.

WEARY MAN'S CREEK.

This creek is a tributary to the Eagle, and has its source on the west slope of Eagle River Range. It forms a right angle with Eagle River, and flows between two huge steep-sloped and well-timbered spurs toward Eagle River. Its length is 6 miles, and within that distance its fall is 2,000 feet. Weary Man's Creek has beside several smaller tributaries three larger ones coming from between side-spurs from the north. The most western one is named Game Creek, the middle one White Fox Creek, and the eastern one Jumping Creek. The intersection of Weary Man's Creek with Eagle River is, as stated elsewhere, 1 mile east from the junction of Homestake Creek with Eagle River. We find forest vegetation in a superb condition; healthier and finer specimens of trees cannot be seen anywhere than on either slope along this creek; in fact, all along the whole western slope of the Eagle River Range. The species are mainly of the *Abietineæ*, and of which again *Pinus picea* predominates.

Splendid patches of pasturage occur at intervals between the dense patches of pine forest, to which must be attributed the abundance of game. The good grass extends frequently up to the highest part of the spurs, which are here nearly as high as the Eagle River Range itself. Patches of timber also run in streaks, very often to the uppermost part of the spurs; but owing to the great elevation and greater exposure they degenerate in size and luxurious growth.

TWO ELK CREEK.

This creek enters Eagle River opposite Roche Montonnée Creek, has also a length of 6 miles, and forms, like Weary Man's Creek, a right angle in its junction with Eagle River. Its characteristics are the same as those which we observed in the last-described creek. The same may be said of Resolution Creek, a stream of 4½ miles in length, which enters Eagle River above the Upper Cañon between Weary Man's Creek and the head of Eagle River.

Besides the latter creek, there are six more cañon-gulches descending from the Eagle River Range down to the river, all of which bear more or less the same characteristics, except that in some places they show more eroded faces than the former, which is particularly the case in the upper portion, where they connect with the main Eagle River Range.

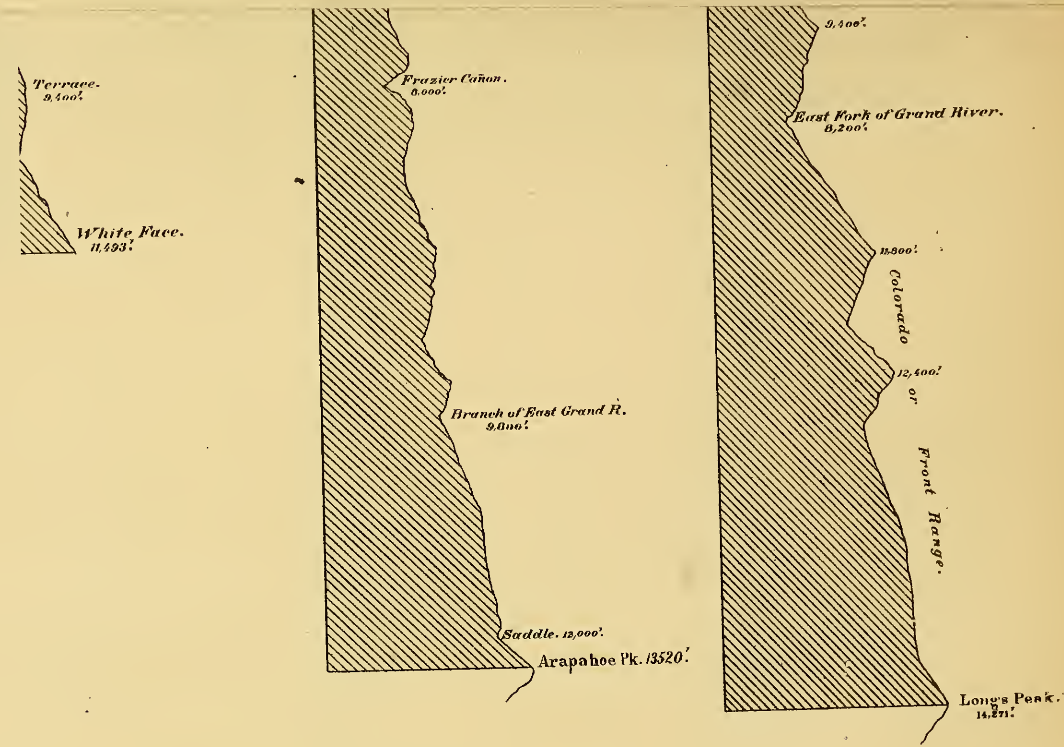
Hydrographic table, west of Park and Gores Range.

Name of stream.	Locality of source.	Length of stream in miles.	Average fall per mile.	Total fall in feet.	Empties into—
Eagle River	Northern slope of Mount Arkansas	63	85	5,360	Grand River.
Piney River	Southwest slope of Mount Powell	24	141	3,400	Do.
Gores Creek	North slope of Red Peak, Gores Mountains.	17	211	3,600	Eagle River.

Approximate geographical positions and elevations of prominent points in the Middle Park district and adjoining regions.

Names of located points.	Longitude.			Latitude.			Elevation in feet.
	°	′	″	°	′	″	
Upper Grand Valley Butte	105	55	5	40	21	23	12,513
Park View Mountain	106	7	12	40	19	12	12,43[illegible]
White Face Peak	106	7	6	40	9	11	11,493
Corral Peak	106	9	2	40	11	12	11,333
Troublesome Peak	106	14	3	40	18	7	11,500
Basalt Peak	106	15	12	40	21	11	11,906
Upper Muddy Butte	106	29	2	40	19	1	9,848
Rabbit Ears, Park Range	106	36	6	40	25	9	10,719
Mount Bross, near Hot Springs	106	6	12	40	5	3	9,468
Lower Muddy Butte	106	23	2	40	7	2	*9,180
Mount Williams	106	10	0	39	51	8	11,413
Lone Peak, Park Range	106	25	12	39	52	10	*11,200
Blue River Peak	106	20	3	39	46	9	*13,000
Mount Powell, Park Range	106	20	3	30	45	19	13,398
Blue River Valley Butte	106	18	1	39	53	10	*9,400
Red Peak, Park Range	106	11	0	39	[illegible]6	5	12,382
Ptarmigan Peak in Williams Range	106	1	7	39	42	0	*12,200
Ten Mile Peak	106	6	12	39	32	11	*11,800
Eagle River Peak	106	11	6	....			12,648
Mount Arkansas	106	15	0	39	22	15	*13,647
Vasquez Peak	105	56	13	39	50	8	12,700
Mount Byers, Vasquez Ridge	105	56	9	39	52	0	12,778
Ute Peak, Williams Range	106	4	4	39	47	10	11,968
Grand Lake, (approximate)	105	48	0	40	14	15	8,153
Junction of East Fork and North Fork of Grand River	105	50	0	40	9	15	8,123
Junction of Stillwater and Grand Rivers	105	51	0	40	9	4	*8,060
Junction of Willow Creek and Grand River	105	58	0	40	7	15	*8,030
Junction of Frazier and Grand Rivers	105	59	0	40	6	0	*8,000
Upper mouth Frazier Cañon	105	50	15	40	0	4	8,463
Lower mouth Frazier Cañon	105	53	0	40	4	0	8,088
Hot Sulphur Springs	106	5	23	40	4	11	7,713
Junction of Beaver Creek and Grand River	106	7	15	40	3	0	*7,470
Junction of the two Troublesome Creeks	106	16	15	40	9	12	....
Junction of Williams and Grand Rivers	106	11	0	40	3	5	*7,450
Junction of Troublesome and Grand Rivers	106	18	10	40	3	0	*7,380
Junction of Blue and Grand Rivers	106	23	15	40	2	15	7,180
Junction of Muddy and Grand Rivers	106	23	15	40	3	0	7,180
Junction of upper two Muddy Branches	166	35	15	40	18	0	....
Junction of Ten Mile Creek, Blue, and Snake Rivers	106	3	8	39	37	0	*8,800
Commencement of Snake River Valley	105	47	7	39	36	5	*10,800
Junction of Blue and Swan Rivers	106	2	0	39	32	5	*9,200
Breckenridge	106	2	5	39	29	0	9,492
Commencement of Upper Blue Valley	106	3	0	39	23	0	*10,400
Junction of Gores and Eagle Rivers	106	27	0	39	37	0	*7,600
Commencement of Eagle River Valley	106	18	0	39	25	8	9,100
Montezuma	105	52	0	39	35	0	....
Lincoln, (Mining Town)	105	59	25	39	29	45	....

* Approximate.



Terrace.
9,400'.
White Face.
11,493'.
Frazier Cañon.
8,000'.
Branch of East Grand R.
9,800'.
Saddle. 12,000'.
Arapahoe Pk. 13520'.
9,400'.
East Fork of Grand River.
8,200'.
11,800'.
Colorado
12,400'.
or
Front
Range.
Long's Peak.
14,271'.

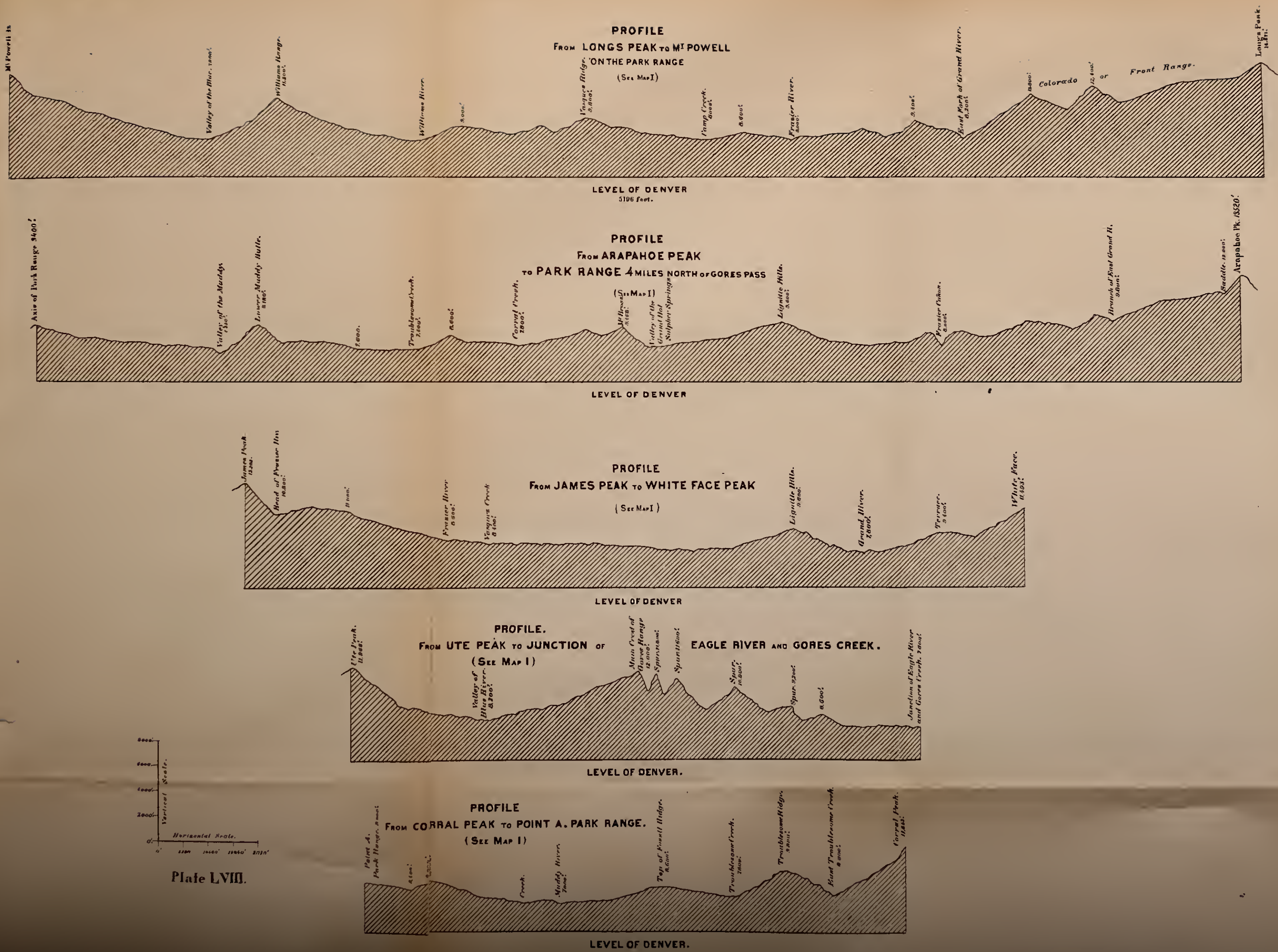

PROFILE
FROM LONGS PEAK TO MT POWELL
ON THE PARK RANGE
(SEE MAP I)
Mt Powell
Valley of the Blue
Williams Range
Williams River
Vasquez Ridge
Camp Creek
Frasier River
East Fork of Grand River
Colorado or Front Range.
Longs Peak
LEVEL OF DENVER
5196 feet.
PROFILE
FROM ARAPAHOE PEAK
TO PARK RANGE 4 MILES NORTH OF GORES PASS
(SEE MAP I)
Axis of Park Range 9400'
Valley of the Muddy
Lower Muddy Butte
Troublesome Creek
Corral Creek
Valley of the Grand Hot Sulphur Springs
Lignitic Hills
Frasier Cañon
Branch of East Grand R.
Saddle
Arapahoe Pk. 13520'
LEVEL OF DENVER
PROFILE
FROM JAMES PEAK TO WHITE FACE PEAK
(SEE MAP I)
James Peak
Head of Frasier Riv.
Frasier River
Vasquez Creek
Lignitic Hills
Grand River
Terrace
White Face
LEVEL OF DENVER
PROFILE.
FROM UTE PEAK TO JUNCTION OF EAGLE RIVER AND GORES CREEK.
(SEE MAP I)
Ute Peak
Valley of Blue River 8200'
Main Crest of Gores Range
Spur
Junction of Eagle River and Gores Creek
LEVEL OF DENVER.
PROFILE
FROM CORRAL PEAK TO POINT A. PARK RANGE.
(SEE MAP I)
Point A. Park Range
Creek
Muddy River
Top of Rasell Ridge
Troublesome Creek
Troublesome Ridge
East Troublesome Creek
Corral Peak
LEVEL OF DENVER.
Vertical Scale.
Horizontal Scale.

Plate LVIII.

Hydrographic table for the Middle Park.

Name of stream.	Locality of source.	Length in miles.	Average fall per mile in feet.	Total fall in feet.	Empties into—
Grand River	Saddle between Medicine Bow and Rocks	70 (within Middle Park.)	*49	*3, 430	(*)
North Lake Branch	West slope main range	10. 5	450	4, 500	Grand River.
South Lake Branch	West slope main range, two miles west of Long's Peak	12	334	4, 000	Do.
East Fork of Grand River	West of main range, Arapaho Peak	14	228	3, 200	Do.
Stillwater Creek	Subridge of Medicine Bow	12	192	2, 300	Do.
Willow Creek	East of Park View	26	†92	28, 000	Do.
Hay Creek	Near Boulder Pass, west slope main range	11	254	2, 800	Frazier River.
Moses Creek	Berthaud Pass	13	200	2, 600	Do.
Frazier, from junction of Vasquez and Moses Creeks.	From the junction of Vasquez and Moses Creeks	14	28	400	Grand River.
Vasquez Creek	Vasquez Pass, near Mount Byers	12	233	2, 800	Frazier River.
Camp Creek	Subridge north of Mount Byers	10	200	2, 000	Do.
Beaver Creek	Ridge north of Mount Byers	12	116	1, 400	Grand River.
Williams River	Seven miles northwest of Gray's Peak, west slope	34	‡112	4, 000	Do.
Corral Creek	West slope of Corral Peak	12	200	2, 400	Do.
East Troublesome	North Park, Rocky	18	222	4, 000	
West Troublesome	Range, continental divide	15	214	3, 250	Do.
United Troublesome	From junction of East and West Forks	9	27	250	
Muddy River	Park Range, near Rabbit Ears	38	(§)	2, 000	Do.
Blue River	Near Quandary Peak	59	57. 7	‖3, 400	Do.
Swan River	Georgia Pass, near Mount Guyot	10	220	2, 200	Blue River.
Snake River	South slope of Gray's Peak	17	167	3, 000	Do.
Ten Miles River	West slope Park Range, five miles northwest of Mount Lincoln.	21	114	2, 400	Do.

* We can hardly apply the average fall per mile to Grand River, because during its whole length while in the Middle Park, within a distance of 48 miles the total fall is only 840 feet, or 17. 5 feet per mile.

† Willow Creek, within 20 miles, has only a fall of 50 feet per mile.

‡ From Ute Peak, within a distance of 18 miles, to its junction with Grand River, Williams River has but a fall of 60 feet per mile.

§ Muddy River has the least fall of all. Within 28 miles it averages to 14 feet per mile.

‖ Head of valley.

CHAPTER III.

KANOSHA RANGE, IN CONNECTION WITH NORTH PLATTE RIVER MOUNTAINS.

RANGE OF SECOND ORDER.

From Whale Peak on the main range, (10 miles south in an air-line from Argentine Pass), a subridge branches off in direction of Kenosha Pass. Within 9 miles' distance this ridge descends from 13,209 feet to 10,226 feet elevation, which is the altitude of the pass. Two spurs from 4 to 6 miles in length detach from the ridge and lead off in the direction of Hall's Gulch and the North Fork of the Platte River. Four miles before reaching Kanosha Pass the ridge has received already its lowest depression, and loses all those rugged features that we most invariably witness in higher mountains.

Toward Hall's Gulch the slopes of the spurs fall off suddenly, and bear in consequence a precipitous character. East of the pass the Kanosha Range rises immediately again within 3½ miles to a peak, with an elevation of 12,469 feet, which is the western one of the Kanosha Twin Cones. Two more peaks of equal elevation with the former one, and only 1½ miles distant from it, stand directly east and southeast from the latter, and form an equilateral triangle with it.

These peaks are striking landmarks and are easily recognized from nearly all over the large area that constitutes the South Park district. The southern and the western of these peaks we named Kanosha Twin Cones, from their great similarity and close neighborhood.

Only 3 miles from the Western Kanosha Cone the range splits in two separate ranges, running for 10 miles parallel, and only 1½ miles apart from each other in a southeasterly direction. This fork in the mountains gives cause to one of the peculiar and interesting orographic features which we are only able to witness at so high an altitude. (See Creig's Summit Valley.)

The northern branch of these mountains is called North Platte River Mountains, from the fact that their very rugged and precipitous northern slopes front the North Fork of the South Platte River Valley.

The length of crest of the North Platte River Mountains is 20 miles. The relative height above mean Platte River level is about 3,200 feet, while the relative height above Creig's Summit Valley is only 800 feet.

There are about eleven points or nipples on that mountain branch, of which the highest one reaches an altitude of a trifle over 12,000 feet.

For the southwestern branch of the mountains, running parallel with the North Platte River Mountains, the name of Kanosha Range might be retained. The latter is not only the superior one in length, but also by several hundred feet the highest. Its crest shows a total length of 25 miles from East Kanosha Twin Cone to Freeman's Peak; while, for a distance of 10 miles, its course is due south, it deviates from a direct line for the remainder of its course.

Following the Kanosha Range from the point where North Platte Mountains separate from it, we find the crest pretty uniform in its character, not flat, but crowned with numerous granite cones or nipples three-fourths of a mile apart from each other, and rising from 200 to 400 feet from their saddles. On the northeast side the slopes descend very gradual down to Creig's Summit Valley, which lies for about 7 miles parallel to the range. As the Summit Valley descends lower in its course, and arrives at the point where the narrow cañon begins, the top of the range has become already from 1,400 to 1,600 feet high.

The western sides of the mountains resemble first gently leaning and undulating planes, and the first waters rise in broad molded depression, serving as snow-flats; but when the spurs come closer to Rock Creek, the drainage has already carved deeper channels; but real steep slopes we only see on the very borders of Rock Creek, where the latter has to meander through a rough inclosure caused by steep spurs from the extremities of the Tarryall Mountains, as well as from the Kanosha Range.

After having passed 6 miles along the crest, we arrive at the point where Tarryall Range is detached from the Kanosha Mountains. From here the range becomes depressed and falls, within two miles, perhaps 1,000 feet, and its rounded and well-wooded spurs descend first very moderately toward Lost Park; but as the range rises again to 12,200 feet at Lost Park Peak, the slopes assume abrupter forms, and become exceedingly so when directly south and west of the peak.

The character of the range is that of a mountain range of first order. Extensive snow-flats lie near and above timber-line south of the peak, and near the edges of them the slopes fall off precipitously, and are steepest when fronting Lost Park and Wigwam Creek. For six more miles the Kanosha Range maintains that ruggedness which prevails on both slopes until it reaches Freeman's Peak (11,700), from where it descends into Webster's Pass, a saddle which divides the Kanosha Range from Virginia Mountain, a splendid and imposing-looking landmark of 10,600 feet in height. From the latter, which represents the last great upheaval between the North Fork of the Platte and the South Branch, the slopes are transformed to the northeast into that broad, bulky character which a rolling and depressed granite country most generally exhibits.

About 8 miles to the northeast and in close proximity to the junction of the two Platte River forks the country rises once more along the Platte into a ridge, with a cluster of sharp granite tops about 1,800 feet above river-level.

TARRYALL RANGE—RANGE OF SECOND ORDER.

The extent of Tarryall Range is, comparatively speaking, limited, as its straight length is but 23 miles, and with its winding crest measures but 29 miles. Its position is fixed by the location of some important points given in the accompanying tables. Its course is, generally speaking, southeast and northwest, and is followed during its whole extent by the Tarryall Creek, which touches the flattened base of its slopes and follows at the foot of it, until turning around its southern extremity effects a junction with the South Fork of the Platte River. It may be added in respect to the general position of the Tarryall Range, that the extreme northern portion of it forms part of the eastern barriers of the South Park, and it is only owing to the existence of the Puma Hills, "lying on the west of Tarryall River," that the Tarryall Range does not form the greater half of the eastern border of the South Park.

Tarryall Range connects with the Kanosha Range by a saddle, from which, on the northwest side, Rock Creek originates, and on the southeast side Lost Park Creek. One of the peaks, Upper Tarryall Peak, standing at the very point of its beginning right above Rock Creek saddle, reaches an altitude just a trifle above timber-line 11,750 feet. From here the crest of the range bears a tolerably straight course for 6 miles, exhibiting on its way several lofty peaks. On the west, the slopes immediately below the crest fall off steeply with rugged offsets and deep-carved drainage-fissures, which at the middle parts of the slopes are already moderate, and become still more so as they descend toward the Tarryall Valley.

The eastern slopes fronting the mountain-valley of Lost Park are less rugged from the very beginning, and we can witness grassy willow-flats, where the creeks have their sources, in the highest parts of the mountain and but few hundred feet beneath the crest. The slopes are long, "with an occasional offset," and well timbered down into the Lost Park Valley.

At about 5 miles southeast of Upper Tarryall Creek the range assumes a bolder form, and it makes first a gradual and then a sharp bend to the east. It slopes toward the Tarryall River, becomes rough, and steeper all the way down to the valley bottom. Here sharp offsets and narrow-crested spurs multiply in number. At the end of the first bend stands the highest mountain in the range, "Bison Peak," 12,400 feet. It exhibits indeed a dignified appearance, crowned with a copping of huge granite blocks which seem from the distance like the remnants of giant fortifications. Toward the Lost Park this peak throws out the most rugged spurs imaginable, one of them reaching as far as 2 miles from the center of the peak.

From Bison Peak the crest swings around again toward the southeast, and from here the boldest of mountain features have their beginning, and remain so to the end of the range. The mountains seem to become a confused mass of larger and smaller peaks; sharp spurs crowd each other, and the almost vertical-appearing walls permit here no ascension from the valley to the top of the range.

The slopes toward the east are chopped by erosion into cliffy cañons, which are only latteral cañons to the main one, in which the Lost Park waters roar and tumble for 6 miles until the Platte is reached.

Opposite the Lost Park cañon rises another barren and rugged granite ridge, which, though less high, forms also a conglomerate of peaks, spurs, pulpits, and rocky noses. Near the lower end of his range stand many imposing and sharp peaks, the like of which we are only able to find in certain portions of the Park Range.

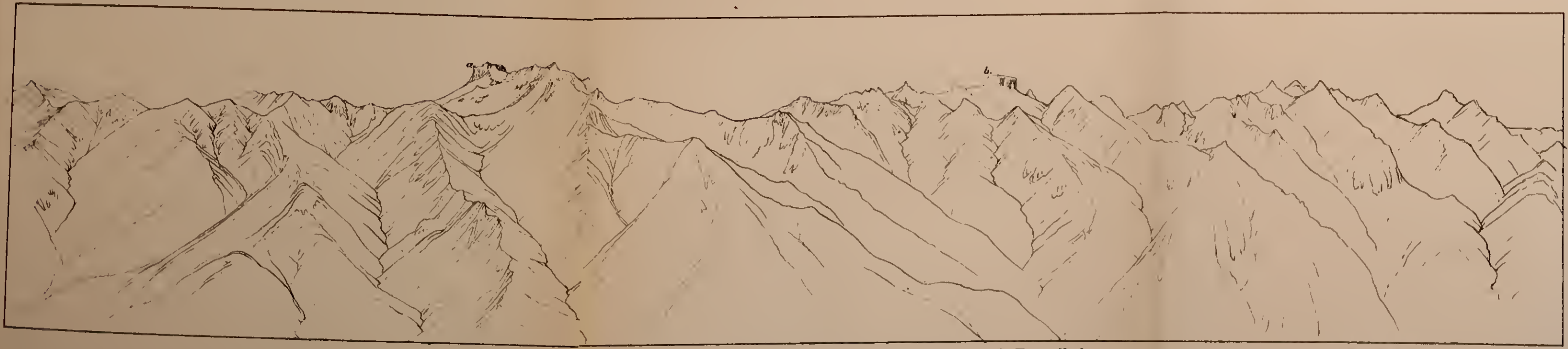
There are to the northwest of Bison Peak thirteen peaks, with an average height of 11,400 feet and a mean saddle-elevation of 10,800 feet.

Southeast of Bison Peak stand nineteen peaks, with a mean height of 11,750 feet. Seven peaks reach over 12,000 feet; and besides the above there are as many as fifteen peaks resting on side spurs on the southeast part of the range.

THE PUMA HILLS AND ADJACENT BASALTIC HILLS SOUTH.—RANGE OF SECOND ORDER.

Detached from the Tarryall Range and separated by the Cañon Valley of the Tarryall Creek lie the Puma Hills, which constitute at least one-

AM PHOTO-LITHOGRAPHIC Co N.Y. (OSBORNE'S PROCESS)



a. Bison Peak. b. Turret Knob. AM. PHOTO LITHOGRAPHIC Co N.Y. (OSBORNE'S PROCESS)

Bison Peak and part of Tarryall Range from Farnams Peak.

Plate LIX

half of the mountains which serve to inclose the South Park on the east side.

In the notes on Tarryall Creek, I have remarked that 8 miles below Rock Creek junction the Tarryall enters a narrow valley. The mountains and slopes that form the right or west side are part of those mountains which constitute the northern extremities of the Puma Hill group.

We may consider the Puma Hills to be subdivided into three different groups, though not by any means separated so distinctly that each of them would appear isolated. Between the northern and middle portion of the group is a depression about 1,000 to 1,200 feet lower than the hills on either side, and the most southerly lying group is again separated from the middle one by a pass ("Ute Pass"), over which the Colorado Springs and South Park wagon-road leads into the park.

Following along the crest of the three groups, we find it to be of a length of about 23 miles, and its winding nature produces complicated features in its topography. The highest peaks in the northern group are 2,600 feet above the Tarryall Creek and 11,400 feet total height above sea-level.

The peaks in the middle group are very little above the height of the former. The eastern slopes of that part of the Puma Hills, "after their first steep descent of 2,000 feet," assume a gradual sloping in the direction where the Tarryall Creek and the Platte River both make a final turn to connect with each other. The flat slopes just referred to may be counted among the good pasture-lands; broad grassy tongues penetrate in three cases deep into the mountains. There is, however, a want of flowing streams which decreases its value. A few springs, and they are very sparse, are the resort of cattle that roam about in this neighborhood.

The slopes toward the South Park side descend for the first 2,000 feet very abruptly, but soon assume a moderate sloping to the general level of the South Park, which in this region is about 8,800 feet. The road over the Ute Pass goes over an easy saddle, hardly more than 600 feet above Platte River level, at a point 4 miles south of Oliver's Springs. But east of the pass the road meanders among low granite spurs and outrunners from the right and left of Puma Hills toward the Platte Piver. While the road follows for the most part of the way " down to the Platte River crossing" the course of a creek, it is not totally free from difficult places, yet it is not bad for a Rocky Mountain road.

The southern group of the Puma Hills form the most rugged one in the whole series, and while its highest points are at least by 400 to 500 feet lower than those of the middle group, its rugged character exceeds the others by far. The whole space, from its very crest down to the junction of Twin Creek and South Platte River, and also in the direction of the cañon, is crowded with complicated mass of granite spurs, minor ridges, and outrunners from them.

The sides fronting the South Park down to the very bend where the Platte River turns into the upper cañon is not less rugged; in fact, the sharp, bold nature of its outrunning spurs can hardly be excelled by any other one.

All the groups of the Puma Hills are well wooded in their upper and middle portions, but the middle and northern ones more so than the southern.

Immediately south, across the Upper Cañon, the Puma Hills connect with a group of ridges, hills, buttes, and knolls peculiar to themselves. This is a region where, in an area of perhaps 20 miles east and west and 8 miles north and south, basalt predominates in the highest parts of the hills, causing mostly flat tops on buttes and very even crests on ridges and terraces.

Thirtynine Mile Mountain, "so called in early time from its distance from Cañon City", is the largest and most compact mountain mass in that vicinity. It stands only 5½ miles north of parallel 38° 45′, and shows a pretty even crest, extending about 4 miles east and west. The top of this mountain is about 2,400 feet average height above that point of the Platte River where it leaves the South Park to enter the Upper Cañon.

The southern slopes fall off steep right below its top part, but assume gentler contours when in their middle portion, and become particularly moderate in their descent when approaching those basin-shaped valleys where the headwaters of Main Oil Creek and Currant Creek assemble. The country west of Thirty-nine Mile Mountain is covered with a cluster of peaks and hills of volcanic material, which slope off suddenly and terminate into a series of low ridges and terraces near the Platte River. Five miles south of the latter group of hills lies Black Mountain, a prominent peak, 11,626 feet high, from which a spur goes westward, assuming the shape of a low ridge, which forms the southern border of the southwestern corner of the South Park, gradually lowering and finally disappearing into the level of the park area.

THE PIKE'S PEAK GROUP—RANGE OF FIRST ORDER.

The exact location of the highest point of this group is longitude 105° 2′ 26″, and latitude 38° 50′ 27″. We deem it somewhat necessary to begin with locating the center of this interesting mountain group for facilitating a more rapid comprehension of its whereabouts, which is the more necessary as this wonderful mountain cluster lies detached by many miles from the rest of the great and main mountain upheavals, which would otherwise in describing it offer some connecting link.

Pike's Peak, as the culminating point of that great massive granite cluster, stands like a huge watch-tower fronting the plains, the margin of which lies only 10 miles east of the peak.

The foot-hills that border the plains, starting from a point some 10 miles east of Pike's Peak, sweep northward, with a slight bend to the west, and swing around again to the east when 116 miles north; or, in other words, if we start from Pike's Peak and travel northward on its geographical meridian, we will travel during a distance of 40 miles for the greatest part on the crest of the Front Range and for the rest among spurs in the foot-hills. After that the margins of the foot-hills recede gradually to the west, and after another 40 miles of straight northward course, the foot-hills will be 13 miles to the west of us; and if we again proceed on for 36 miles in the same course to parallel 40° 30′, or the northern end of our district, the foot-hills have approached east again, and are only 4 miles to the west of us.

The approximate area of this formidable mountain mass of Pike's Peak proper, with its immediate spurs sweeping down from its very center, amounts to 72 square miles. This excludes 60 square miles, the remainder of that portion of mountains to which Cheyenne Mountains and Monta Rosa form culminating points, and by being attached to Pike's Peak by means of a saddle, help to complete that great mountain cluster so well known at home and abroad, and so impressive and commanding when seen from the plains.

The summit of Pike's Peak presents a somewhat flattish top, gently sloping toward south and west. Steep and rugged granite cañons, however, begin 1 mile south of the summit and stretch out 5 to 6 miles in direction of Beaver Creek.

Immediately north and east of the highest point the slopes are precipitous, and high rocky spurs and steep rugged cañons, running in the direction of Fountain qui Bouille, bisecting the slopes and the base of that mountain in that direction.

Some of the ruggedest features exist along the face of the mountain, running for several miles northwest. Sharp needle-like peaks and serrated crest of spurs are confusing to the eye of even the experienced observer.

West of the highest nipple, the gently dipping plateau has maintained itself for 2 to 2½ miles, but suddenly descends also in wall-like precipices toward the headwaters of West Pike's Creek, to connect with a still rugged but much lower and somewhat flatter granite district to the west.

The country at the base of Pike's Peak, to the southwest, is in itself a high granitic mountain district, "with Rhyolite Peak and Mount Pisgah as culminating points," which appears only insignificant alongside the imposing Pike's group, with which it is connected.

Weird and dusky looking are the reddish granite cañons that run like giant fissures into the main cañon of West Pike's, as well as into Pisgah Creeks.

The Monte Rosa group lies southeast of Pike's Peak, with Monte Rosa Peak as its culminating point, being 8 miles distant from the latter.

The Cheyenne Mountains lie from 4 to 5 miles to the east of the Rosa group and are Front mountains, falling off suddenly toward the plain.

Cheyenne Creek, with numerous branches, every one of which flows in a cañon, divides the two groups. Directly 4 miles east of the summit of Pike's Peak and across the deep depression in which the headwaters of Ruxton's Creek assemble, stands Cameron's Cone with a pyramidal capping. It rests on a huge, rugged, granite ridge which swings around to the southeast, and between it and spurs from the Monte Rosa Mountains flows Bear Creek in a narrow defile, along which the signal trail leads to the top of Pike's Peak.

Between the crest of Cameron's Ridge and Bear Creek in one direction, and Fountain qui Bouille in another direction, the space is broken up with rugged subridges and bold-looking spurs descending toward and falling off into a rolling terraced country down to the vicinity of Manitou Springs and the margins of the Fountain qui Bouille.

Down at the foot of Pike's Peak and along its northern base flows Fontaine qui Bouille, rising among the northwestern spurs of the Pike's group and Catamount Hill, from which vicinity it rushes in rapid descent down the valley toward Manitou and Colorado Springs to join the Monument Creek, a tributary to the Arkansas River.

FRONT RANGE—RANGE OF FIRST ORDER.

The mountain-slopes which rise from Fountain qui Bouille, northward, form the southern flank of the Front Range, which reaches the maximum height of its southern portion just across Fountain qui Bouille and about 8 miles north from Pike's Peak. This range lies nearly for its whole length along the line of meridian 105°, and only after reaching parallel 39° departs somewhat to the west of this line. It descends gradually toward north, in a low line of parallel ridges near the Platte River Cañon at the foot-hills. This portion has an entire length of 45 miles and its principal terminus is about a point at meridian 105° 6′ and parallel 39° 30′.

Among the characteristics of the southern portion of the Front Range, from Pike's Peak to the Platte River Cañon, we have to point out principally its level top, rising or falling within some 20 miles hardly from 400 to 500 feet, and boasting of very few prominent points which rise to the dignity of peaks.

With exception of Platte Peak, "described in the notes pertaining to the vicinity of Platte Cañon and Manitou Creek, and which holds a central position on the range," all others, though few in numbers, rest immediately on the front slopes. Though the range may in its general character be level planed, and in consequence broad and bulky, we must not infer that it is molded with equal plainness in regard of details; on the contrary, we are at a loss to compare it with any other, for, considering its very moderate height, a range more rugged or one more difficult to explore cannot be found. The main cause of this is that the range is uniformly topped, from its crest, lying as stated before, to 5 to 6 miles east of the crest, and where the tail end of the spurs "falling off very suddenly toward the plains" are nearly as high as the main broad crest itself. For instance: the highest point on this portion of the Front Range lies at its extreme southern end, and gives about 9,600 feet in height, while Blodget's Peak, situated on one of the extended spurs 5 miles to the east, gives a height of 9,340 feet, and a like relation exists all along the crest and the front spurs. The crest is very difficult to discern and we are only able to do so by exploring it.

The drainage consists in numerous deeply eroded cañons lying all parallel to each other, and, starting from its main crest, flow, "at least those on the southern part of the range," in most cases eastward or nearly so, to join the larger drainage channel of Monument Creek. Numerous deep and rugged cañons, resembling immense gorges at the approaches of the plains, are the consequence of it, and so flow all the side branches in lesser cañons which, if we take them in their totality, have chopped the eastern slopes of that portion of the Park Range entirely into a series of cañons, separated by the remnants of a once broad plateau.

Twenty-six miles south of the Platte Cañon, the Front Range sends forth toward the east that flat and very broad summit "known as the Arkansas Divide." From this very low divide, which strangers to the country would hardly notice, the water flows in numerous creeks northward into the Platte, and southward into the Arkansas River.

The summit of the Divide, nearest to the Front Mountain, over which the Denver and Rio Grande Railroad as well as the wagon-road passes, is only of 7,208 feet elevation. Near that summit the Front Mountain slopes are naturally not by far so high as farther to the south.

Not quite so badly eroded is the western slope of this portion of the Front Range, though the streams come down in narrow gulches into the Manitou Valley with occasional rugged spots in them; but the general features on the western slope show more moderation as far as rugged forms are concerned.

The average height of this portion of the Front Range is about 9,200 feet. Its width across from the base near the foot-hills or eastern slope to the one on the west side is about 9 to 10 miles.

The nature of the ground on the top makes its exploration difficult, for notwithstanding its general uniform top, the numerous small groups of exposed rocks, very fitly to be compared with roosters' crests, together with dense growth of pine timber, offer great obstacles to its explorations.

In the northern part of the Front Range, viz, north of the Summit or Arkansas Divide, the creeks descending from the range do not flow in a rectangular manner to their main drainage-channel, Plum Creek; but they come, "unlike the creeks on the southern part beyond the Arkansas Divide," obliquely, or flow in a northeast course, which necessarily gives to the spurs a northeast trend. The gulches and cañons in which this latter drainage emerges out of the mountains are rough, and sometimes even extremely so, yet altogether do not compare in that respect with those entering Monument Creek on the south side of the Arkansas Divide.

EVANS RIDGE—RANGE OF SECOND ORDER.

On the crest of the mountains, the distance from Argentine Pass to Mount Evans is 10 miles; within that distance there are six peaks of formidable height, varying from 13,600 to 14,200 feet elevation. Still farther to the east of Mount Evans the ridge lessens considerably in elevation. Two miles to the southeast from the main peak there is another point, named Rosalie, with an altitude of 14,000 feet, but from here the ridge declines until, 17 miles to the eastward, it has descended to about 10,000 feet.

From these mountains numerous spurs extend in the direction of the North Fork of South Platte River, and some of them coming directly south from the Evans group retain for some miles a character equally imposing with the main range. The drainage in that part is very complicated, flowing in deep and dusky-looking defiles.

Originating on the southern slopes of the Evans Mountains are two creeks, Elk and Deer Creek, the first having two main branches. The valleys of both these streams are not in every part pressed by the mountains into narrow cañons "except while in the high mountains," but they contain many open spots with good pasturage. Between the two branches of Elk Creek, and again between the latter and Deer Creek, there are spurs with a mean height of 10,000 feet, and a relative height of 1,600 feet above the streams.

The southern slope of the Evans group is by far the most rugged one. For several miles we see hardly anything else but steep granite walls, peaks, and rapidly descending timberless slopes, characteristic only of a wild mountain country of the first order.

Approximate geographical positions and elevations in the South Park District and adjoining regions.

Names of located points.	Longitude.	Latitude.	Elevation in feet.
	° ′ ″	° ′ ″	
Pike's Peak, Front Range	105 2 26	38 50 26	14,147
Mount Rosa, Front Range	104 56 45	38 45 15	....
Cheyenne Mountain, Front Range	104 52 30	38 44 5	9,848
Cameron's Cone, Front Range	104 58 30	38 50 0	11,460
Rhyolite Peak, Front Range	105 9 34	38 47 0	10,400
Mount Pisgah, Front Range	105 13 0	38 45 15	9,343
Blodget's Peak, Front Range	104 45 15	38 57 45	9,500
Stormy Peak, Front Range	104 59 45	39 11 45	9,200
Platte Mountain, Front Range	105 6 0	39 15 0	9,343
Thunder Butte, Front Range	105 11 58	39 10 30	9,500
Scraggy Butte, Front Range	105 12 0	39 21 0	8,600
Western Kanosha Twin Cone, Kanosha Range	105 42 0	39 25 45	12,350
Eastern Kanosha Twin Cone, Kanosha Range	105 40 45	39 24 25	12,340
Lost Park Mountain, Kanosha Range	105 26 15	39 18 15	11,800
Freeman's Peak, Kanosha Range	105 21 45	39 16 32	11,600
Virginia Mountain, Kanosha Range	105 18 0	39 18 30	10,600
Upper Tarryall Peak, Tarryall Range	105 36 27	39 18 45	11,650
Lower Tarryall Peak, Tarryall Range	105 26 30	39 9 20	11,200
Bison Peak, Tarryall Range	105 29 50	39 14 15	12,327
Farnam's Peak, Puma Hills	105 33 15	39 10 0	11,400
Pass Mountain, Puma Hills	105 31 20	39 3 26	11,200
Signal Butte, head of West Creek	105 13 18	39 3 20	8,800
Topaz Butte, near Florissant	105 17 15	38 59 40	9,100
Ptarmigan Peak, Park Range	106 10 5	39 9 0	13,200
Buffalo Peak, Park Range	106 7 15	38 59 30	13,541
Marmot Peak, Park Range	106 6 30	38 56 30	11,600
Sheep Mountain, Park Range	106 6 46	39 11 35	12,250
Thirty-nine Mile Mountain, head of Oil Creek	105 34 35	38 49 40	11,000
Chalcedony Butte	105 41 0	38 47 50	10,400
Cub Mountain, Evans Ridge	105 23 10	39 32 10	10,623
Platte Pulpit, Front Range	105 8 0	39 26 30	8,000
TOWNS AND KNOWN PLACES.			
Fair Play, South Park	105 59 45	39 13 30	10,048
Alma, South Park	106 3 40	39 17 15	10,453
Hamilton, South Park	105 45 30	39 20 30	9,743
Salt-works, South Park	105 56 20	38 57 25	8,826
Hartsell's post-office, South Park	105 47 28	39 1 30	8,700
Florissant post-office, South Park	105 17 20	38 57 0	8,000
Colorado Springs, Denver and Rio Grande Railroad depot	104 49 7	38 50 0	5,986
Colorado City	104 52 0	38 51 0	(?) 5,986
Manitou Springs	104 55 0	....	6,357
Monument City	104 52 15	39 5 40	6,354
Sedalia	104 58 0	39 26 0	....
PASSES.			
Kanosha Pass	105 45 30	39 25 0	10,150
Weston's Pass, Park Range	106 9 30	39 7 30	11,676
Trout Creek Pass	105 58 30	39 54 0	9,346
Pass near Thirty-nine Mile Mountain	105 37 0	39 49 30	9,550
Ute or South Park Pass	105 31 0	39 2 0	....
Rock Creek Pass	105 30 30	39 20 0	....
Webster's Pass, near Virginia Mountain	105 20 0	39 17 20	8,100
Summit, Arkansas Divide	104 54 30	39 7 30	7,208
RIVER JUNCTIONS.			
Mouth of Platte Cañon	105 6 0	39 29 30	5,564
South Fork of Platte and North Fork of Platte	105 10 6	39 24 40	6,110
Manitou Creek and South Platte River	105 14 0	39 14 15	6,620
Wigwam Creek and South Platte River	105 14 45	39 14 40	6,600
Lost Park Creek and South Platte River	105 16 20	39 12 30	....
Tarryall and South Platte River	105 20 0	39 5 0	7,326
Twin Creek and South Platte River	105 22 0	38 58 30	7,700
Rock Creek and Tarryall Creeks	105 42 0	39 17 30	9,100
Head of Upper Platte Cañon, exit of South Park	105 28 30	38 54 0	8,161
Jefferson and Tarryall Creeks	105 41 0	39 17 40	9,200
Main or Middle Platte Fork with Little Platte River	105 44 45	39 1 0	8,683
High Creek and Little Platte River	105 48 35	39 1 30	8,725
Fountain qui Bouille with Monument Creek	104 50 0	38 49 30	....
East and West Plum Creeks	104 58 30	39 25 45	....
Buffalo and North Fork of Platte River	105 15 45	39 18 0	6,500

CHAPTER IV.

SOUTH PARK DRAINAGE.—MAIN OR MIDDLE FORK OF THE SOUTH PLATTE RIVER.

The source of the Middle or Main Fork of the South Platte River has its origin in a large amphitheater, directly below the northern slope of Mount Lincoln.

Between the latter mountain and a huge spur to the north, lies a formidable mountain amphitheater, where, from snow-banks and little lakes, the first waters are gathered, which flow for 3 miles eastward to a point where the Breckenridge and Fair Play road descends from Hoosier Pass into the Upper Platte River Valley.

The surroundings here give to the Main or Middle Fork the character of an open valley, which prevails for 5 miles in a southern course.

In this valley are the mining towns Dudley and Alma. Immediately below Alma, Buckskin Creek, which heads between the spurs and slopes of Mount Buckskin and Mount Bross, joins the Platte. Only one mile south of this point Musquito Creek comes in, and one and a half miles still southward Sacramento Creek joins as a tributary. Both of the latter streams rise in the Park Range from 6 to 7 miles to the westward.

From Alma the stream turns in an angle of 40° to the southeast, and flows in a broad and grassy valley. Six miles southeast of Alma the Main or Middle Fork of the Platte River passes the well-known mining town of Fair Play, which is situated at the foot of the Upper Platte River Valley. Only a few miles below Fair Play, two small creeks, Beaver and Crooked Creeks, come from the southern slope of Silverheels Mountain. Beaver Creek heads on the west side of the latter mountain and flows for several miles parallel with the Upper Platte River, separated only by a mountain spur from Silverheels Mountain, until it reaches the Platte River.

Immediately below Fair Play the characteristics of a valley cease, the country opens to the south into an undulating country, while in an eastern direction the South Park Basin is invested with trachytic ridges, which originate, or at least assume their hilly character, at the base of Silverheels Mountain, and continue in several parallel ridges through the eastern portion of the South Park.

The Platte River presses close to the western flank of the most western one of these ridges, and continues so until 12 miles below Fair Play, where Trout Creek comes between two volcanic ridges from Silverheels Mountain, and enters the Platte River.

From the confluence of Trout Creek the river still continues southeast to a point known as Hartsell's ranch, where the Little Platte River enters. From this point the main stream bears hereafter the name of South Platte River. Before continuing to describe the main stream, we will have to sketch the main characteristics of the Little Platte River and its tributaries.

The main stream of the Little Platte comes from near Weston's Pass, on the eastern slope of the Park Range. A small lake near the head of the pass may be considered the principal feeder of that stream in its infancy as well as highest altitude. For 4 miles the Little Platte runs in a southeastern direction between two huge mountain spurs. Within that distance it has its steepest descent; after that it turns abruptly east and flows for four miles to a point where several morainal ridges, descending from the Park Range, terminate. Here the Little Platte receives a tributary from the south, namely, from the northern slopes of Buffalo Mountain, and still another one, arriving from a northern direction, which drains the slopes and spurs of a portion of the Park Range lying between Sheep Mountain and Weston Pass. Down to this point its fall has been 2,000 feet within 10 miles, or 200 feet per mile. Either of these tributaries carries nearly as much water as the main stream of the Little Platte. From the point of junction of these two streams with the Little Platte it still continues in an eastern direction for 3½ miles, with a slight bending to the southward, from where it enters the open country or basin of the South Park. After having entered the level portion of the Park district, it finally makes an abrupt bend to the south, and in a sluggish flow continues for 4½ miles, and when approaching to within 3½ miles of the salt-works it turns gradually to the east, receiving on its way, during 3½ miles, one more creek carrying a moderate body of water from the most eastern spur of Buffalo Mountain. This latter creek closes the series of flowing streams in this vicinity. All other creek-beds are perfectly dry, and scarcity of water is a predominant feature in th eimmediate neighborhood.

Three miles northeast of the salt-works another tributary comes from among the wide-spreading spurs of Buffalo Peak and joins the Little Platte after it has flowed for several miles through salty plains. This latter creek has a length of 12 miles, and owing to the many lateral branches which combine with the stream near its sources, its volume of water is quite respectable. The total fall of this creek from its source to the junction with the Little Platte is about 1,800 feet.

Two miles below the intersection of the last creek, the dry and parched bed of Agate Creek comes in, and 3½ miles still further eastward High Creek joins the Little Platte.

Agate Creek comes from a southern direction and from among the northern spurs of Black Mountain, which lies on the southern limit of the district described in these notes; its fall is about 800 feet within a length of 22 miles. For the most part during the year it contains no running water, for it sinks shortly after leaving its sources.

The district which Agate Creek drains is one of the most arid in the whole South Park. Numerous alkaline deposits over the whole of its drained area render the water useless—whenever we find such in small pools.

Grass is also sparse in this location, and forest vegetation is absent. From Aga e Creek the country rises westward for 6 miles in very gradual slopes to a low subridge running directly south from Trout Creek Pass. Close to that subridge numerous little groups of hills and remnants of terraces invest the country like barren islands in a dry ocean basin. Along the slope of the subridge we find here and there good pasturage and some springs, but the latter scarcely make their exit from the wooded portion of the ridge when their existence also ceases.

Three and a half miles down from the junction of Agate Creek the Little Platte River receives another tributary, named High Creek, which has its source on some of the highest parts of the Park Range and north of the Sheep Mountain. Its course is for 16 miles nearly parallel to and only from 2 to 2½ miles apart from middle or main Platte

River. Among the minor streams of the South Park, it must be counted among the most prominent ones, for although it flows for 15 miles in a dry and desert-like country, it still issues into the Little Platte with a considerable body of water.

High Creek is joined by another stream, Four Mile Creek, when still about 8 miles from its junction with Little Platte. The total length of High Creek is about 20 miles; its total fall is 1,600 feet, or 80 feet per mile.

At the junction of High Creek with Little Platte River, several terraces and remnants of buttes crowd close to the river-bank, and 3 miles below this point the Little Platte forms its junction with the previously-described middle or main South Platte.

The total length of main Little Platte is 32 miles; its mean fall per mile is 81 feet, and the total fall 2,600 feet.

The two united branches have made now a formidable stream, which for 17 miles meanders in a southeast direction through the southern portion of the South Park, where the South Platte, entering its first cañon, takes suddenly a northeast course, and continues so for 9 miles, inclosed with 600 feet high granite walls, until it frees itself from its rocky inclosure to assume a valley form again. Here it receives the waters of a lateral stream, Twin Creek.

Twin Creek originates by means of numerous branches on that plateau north of the Pike's Peak group called Hayden Park. At a point named Florissant or Castello's ranche, the main waters of Twin Creek unite with two other streams, one, a nameless one, coming from the south, and the other Topaz Creek, coming from the direction of Topaz Butte, or from the north. Down to Florissant the three creeks flow through an undulating plateau country. The depression through which they pass may be more compared with soft descending dales, sometimes ravines, and in other places narrows—not cañons.

From Florissant or Castello's downward, in direction of the Platte River, the valley form prevails, and retains the same character down to its junction with the South Fork of Platte River, which lies about 4 miles west of Castello's ranch. About 2½ miles before its issue into the Platte River another tributary, Fish Creek, which originates between the volcanic buttes several miles to the southwest, comes to join Twin Creek.

Fish Creek flows, for the greatest part of the way during its course of 11 miles, in a softly-descending hilly country, with a good many grassy ravines and dales. Its descent within its course is about 1,000 feet in total, or about 90 feet per mile.

For several miles down from its junction with Twin Creek, the South Fork of the Platte River bears the character of a narrow valley, but before it effects its intersection with the Tarryall Creek, which is 8 miles from the above place, the stream is pressed closer by the hills from both sides. During its course down to that point, there is not any stream of note entering on the east side, and, with the exception of one creek which brings the water from the Puma Hills (a ridge of mountains 6 miles to the west) from near the Ute Pass, a low pass, over which the Colorado Springs and Fair Play road crosses, there is no other one on the west side worthy of special mention. This last creek comes into the Platte where the road crosses the Platte River, near a well-known place named Link's ranch.

There are several springs on the eastern slopes of the Puma Hills, which form the eastern barriers of the South Park, but the arid nature of the country prohibits their continuation. They dry up before reaching the main channel of the Platte River.

From the confluence of South Platte Fork and Tarryall Creek, the river's course is, for a distance of 13 miles, cañon-like; not absolutely so, for in many places it is bordered by moderately-steep hills or spurs. Sometimes the steep slopes prevail in particular only on one side. While the general nature along this stream is cañon, it occurs in several places where that character prevails in an absolute meaning. One of these places is between the intersection of the two wild mountain-streams, Lost Park and Wigwam Creeks. For 12 miles the South Platte cannot be described as running in a cañon, or else we would have to apply that term to every defile, narrow or wide, in the whole Rocky Mountains. In many places that character exists only in a limited sense, and, within 12 miles, the river enters but three times, and only for a short distance, into such narrow places where we have to desist from following the stream. I have seen several attempts of ranching on the middle portion of the river "near Wigwam Creek," but these were abandoned, perhaps on account of the very rugged approaches on all sides, which make wagon-road communication with the settlements outside the mountains very difficult.

The general course of the South Platte River for 25 miles down to its junction with the North Fork of the South Platte is north 26° east. Nine miles below the entrance of Tarryall Creek, the South Fork of the Platte receives Lost Park Creek as a tributary. Three miles below that Wigwam Creek enters, and but three-fourths of a mile east of it a large creek, Manitou Creek, which is coming from the southeast, joins.

MANITOU CREEK.

Manitou Creek, together with the two branches of West Creek, drains quite an extensive district, amounting nearly to 200 square miles. This district comprises that area which lies west of the Front Range, commencing on the divide of the latter, from near that pass* which lies near the headwaters of Fontaine qui Bouille, and from there north along that divide to 39° 15′, or to a point east on a line from where Manitou Creek enters the South Fork of the Platte River.

The western line of this drainage-district would be somewhat irregularly shaped, as it extends about from a point north of Topaz Butte (near Florissant) in a curved line, first in northeastern and then northwestern direction, and also down to its junction with the Platte River. The southern limit lies on that plateau, 8 miles north of Pike's Peak, on which the Colorado Spring and South Park road crosses from the headwaters of the Fontaine qui Bouille into the South Platte River Valley.

The largest area which Manitou Creek, combined with West Creek, drains lies principally west of the Front Range, and also of its own valley. It consists of a high, gently-rolling plateau country, which descends softly inclined toward north and into the Platte River Valley.

The sources of Manitou Creek lie about 8 miles directly north of Pike's Peak, and are composed of many branches which come partially from the western slope of the Front Range, but principally of those that come in long and sometimes rough and narrow gulches from that softly-descending plateau-like area called Hayden Park.

* This pass is also called Ute Pass. This name has been used extensively, first, for the pass on the Williams Range leading from the Blue River into Williams Valley; second, for a pass leading over the Puma Hills into the South Park, and, third, for the one above mentioned.

Manitou Creek can pride itself on a fine valley, which begins but 5 miles from its headwaters and extends for 12 miles north, lying directly along the western base of the Front Range. A low spur, coming from the Hayden Park Plateau, divides Manitou Creek from West Creek. The distance between the East Branch of West Creek and Manitou Creek is often but 2 miles. Both creeks join in a cañon 3 miles before they enter combined the Platte River.

The western branch of West Creek comes from about 2 miles northeast of Topaz Butte, and strikes the East Fork in an oblique direction. It also possesses pretty valley features in some parts, and is well supplied with water. Its length is not far from 9 miles, while the eastern branch, including the distance below the junction with the western fork, is nearly 17 miles.

Before the united West Creek enters Manitou Creek, it passes for 5 miles along the eastern base of a commanding-looking butte, Thunder Butte—quite a landmark in this region—which rises abruptly to a height of 2,400 feet above the level of the creek. The height of this butte above sea-level is 9,430 feet, and it rises 3,000 feet above Platte River, estimated from near the entrance of Manitou Creek. The shape of Thunder Butte is elongated, with a northwest trend, and shows very steep and rugged spurs on the east side. While its crest may be nearly 3 miles long, the highest point of it lies to the south.

Manitou Creek* has a length of 27 miles, a total fall of 2,000 feet, and an average fall of 118 feet per mile. The valley is named Manitou Park; in its center stands a fine hotel, from which a road leads over the Front Range in the direction of Sadalia, and another one to Colorado Springs.

CHARACTERISTICS OF THE SURROUNDINGS OF WIGWAM CREEK, MANITOU CREEK, AND SOUTH FORK OF PLATTE RIVER.

The surroundings about the junction of Wigwam Creek, Manitou Creek, and South Fork of South Platte River are not so devoid of interesting features as to forbid allusion to them.

We have in the preceding paragraph, concerning the drainage of Manitou Creek, given already an outline sketch of Thunder Butte, a long-crested, imposing-looking butte, with a point rising some 3,000 feet above Platte River.

Of nearly equal scenic interest is the country to the northwest as well as to the east. Seven miles to the northwest is the imposing Kanosha Range, with Freeman's Peak as the last high point crowning it, and only 4 miles opposite and across Webster's Pass stands another conspicuous landmark, Virginia Mountain, with a longitudinal crest of several miles, steep and rugged, with long spurs falling off, terrace-shaped toward the south and to the margins of Wigwam Creek.

The crown parts of Virginia Mountain fall off suddenly about 2,000 feet, after which the mountain masses descend in long, sloping, broad spurs toward the Platte Cañon, and between the spurs follow deep carved gulches and cañons, which to penetrate and explore would seem hazardous for the average man and the inexperienced. Seven miles directly to the east of the confluence of Platte River and Manitou Creek stands another interesting monument of mountain structure,

* Manitou, I was informed, was the name first given to this creek. An English party taking possession of its valley, and following largely the propagation of trout, named it Trout Creek. As we have just about 1,000 Trout Creeks in the Rocky Mountains, I have allowed Manitou to stand.

Platte Peak, and vulgarly called "Devil's Head" by the mountaineers and inhabitants of the plain.

Platte Peak has a center position on that part of the Front Range which runs longitudinally from north of Pike's Peak, commencing north of Fountain qui Bouille Creek and running to the Platte Cañon near the exit of the river. The top of Platte Peak or Devil's Head consists of a long pulpit-shaped granite structure lying east and west. The granite turrets of which it is shaped stand erect, and but few can be climbed. Some of the single blocks are so odd in their forms that one of them, fronting the plains, resembles indeed a huge head, so distorted, however, that mountaineers saw fitness in comparing it with an imaginary being which has generally been supposed to exist only in the hottest of places. That huge granite pulpit of the Platte Mountain falls off several hundred feet suddenly, and the masses in all directions soon assume that flat, bulky shape descending only by degrees to where the deepest drainage-channel lies. Flat as that mountain mass may appear, and so gradual as its slopes may present themselves, the drainage has nevertheless cut deep fissures and gashes into the granite in some places from the very top, which widen as they approach the valley into gorges and cañon.

SOUTH FORK OF SOUTH PLATTE RIVER—Continued.

There is only one creek of note coming into the South Fork of the Platte River about 10 miles below the confluence of Wigwam and Platte Rivers. This nameless creek comes directly first in two branches from the Platte Mountain pulpit, which gives it a length of 8 miles. It strikes the Platte obliquely, coming in from a northeast direction.

Just before that creek joins the Platte the latter has passed on its left or west side another butte, a fantastic scraggy-shaped granite structure, with exceedingly steep faces toward the river. This butte, nearly 2 miles long, has by mountaineers and settlers been named Scraggy Butte, from its sharp serrated crest, whereon the straight rocks stand like upturned icicles. From this butte the river becomes wedged in considerably between steep sloping mountains, and two miles below it the South Fork of the South Platte is joined by the North Fork* of the South Platte River, which coming from the west has its sources in those high mountain portions lying on the main Colorado Range near Whale Peak, and in fact from all the mountain-slopes, from Kanosha Pass around to Evans Peak, and still many miles to the east of it.

The North Fork of the South Platte is the last conspicuous tributary which the main South Platte receives while in the mountains. It is from this confluence to the Foot Hills but a short distance in a straight line. The river within that space makes two more large bends, larger and more definite bends, than it made elsewhere within so short a distance. But its winding course is justified, for huge granite spurs hem its way to the very threshold of the plains, but its success is, in spite of obstacles, finally complete; men cannot follow its margins, but the South Fork of the Platte itself enters triumphantly the plains to greet a splendid valley.

TARRYALL CREEK.

Tarryall Creek is the largest tributary of the South Platte River as long as the latter is in the South Park region. The main stream has

*This North Fork of the Platte River must not be confounded with the Big North Fork of the Platte River, coming out of the North Park and joining the South Fork of the Platte at North Platte in the plains.

its sources immediately below and south of Hamilton Pass, and is strengthened by numerous little streams coming down the eastern slopes of the Silverheels group, and also from that one lying opposite the southern extension from Hamilton Mountain.

At the foot of Silverheel Mountain Tarryall Creek is considerably broken by placer and hydraulic mining, by which the creek-bed is for long stretches completely destroyed and its water turned into practical use. A small mining village, Hamilton, lies at the mouth of that mountain amphitheater, in which the Tarryall originates, and through which the road winds, going over the Hamilton Pass into the Blue River Valley.

Passing the latter village, it flows for 11 miles in what constitutes the flattest part of the upper portion of South Park. The creek has made here for its channel a furrow of 25 feet deep in the gravelly bottom of the park. Eleven miles below Hamilton it receives Jefferson Creek, united with Michigan Creek, as a tributary, with an amount of water equal to the main Tarryall Creek. These two creeks have their main sources near Mount Guyot, and east among the slopes and spurs on the main range facing the South Park. They flow for 18 miles, partially in mountains and for the greater part in an open park area, before they unite with the Tarryall Creek; and we may add that, after they have left the mountainous portion of country, they flow for at least 8 to 9 miles in the best pastured part in the park, crossing the main Denver and Fair Play road 2 miles north of their junction.

Where Jefferson Creek enters Tarryall Creek the latter has just passed through a cañon several miles long, which has been caused by the stream breaking through a broad terrace of volcanic overflows, which immediately, a little over a mile of this point, rises into a regular cluster of hills about 800 feet above Tarryall Creek, which continue as a low ridge in the direction of the southeast corner of the South Park.

Only a few miles below the junction of Jefferson Creek with the Tarryall, Rock Creek joins, coming from the mountains to the northeast; in particular where Tarryall and Kanosha Ranges are connected by means of a saddle. Some of the tributaries of Rock Creek drain the most northwestern slopes of the Kanosha Mountains. The whole length of Rock Creek not being over 8 miles, the abundance of water it contains is therefore astonishing. Other valuable attributes consist in the splendid pasturage along its margins and those of its many little tributaries.

The subsequent portion of Tarryall Creek is more or less an open valley, which continues for about 7 miles, when it enters between the northern portion of the Puma Hills and the Tarryall Range into a narrow valley. Numerous ranches along the creek give evidence of its good farming qualities, such as we possess, at least, here in this country of considerable altitude.

To the west of Tarryall Creek, while in this open valley, the cluster of volcanic hills referred to above front the stream with abrupt, steep faces, and bear here somewhat a dignified appearance, while their western slopes show a very gradual descent and exhibit hardly any exposures. To the east of this open valley part the long-stretched, timberless slopes of flat spurs come down from the Tarryall Range and border the stream occasionally with low bluffs. Only little water comes down from the Tarryall Mountains in this section. The streams are lost in gravel and sand before reaching the Tarryall bottom, while from the trachyte hills on the west side there is hardly any additional water furnished to that stream, for, except two or three running streams, the molds and drainage depressions in the hills show even no evidence of water-flow during any part of the season, as I have found no furrow or drainage-bed where water had once flowed, only moist, grassy places, with some pools of accumulated water, here and there.

When Tarryall Creek arrives at the point 7 miles below the junction of Rock and Tarryall Creeks, it is closely pressed by mountains on both sides for a distance of about 7 miles, but not so much that the road leading along this creek would be obliged to leave the valley and follow along the mountain spurs. We find no ranches within 4 miles of this cañon valley; but after that it opens, and remains so for 2 miles, so as to give room for the location of several ranches. Near the end of the 2 miles the mountains recede on the west side to a distance of 8 miles, thus making the country more generally open, but not level, for numerous small hills of granite, several hundred feet high, crowd near the creek and give it a cañon-like margin, while on the east the creek is bordered by the very bases of huge granite slopes from the Tarryall Range.

The Tarryall has, all the distance from Rock Creek, about 22 miles, a southeast course, after which it suddenly turns to the east. After meandering for 4 miles in a rugged cañon, it enters the South Platte River. The whole length of Tarryall Creek, from its source near Hamilton Pass, is 48 miles, with a total fall of 4,200 feet, and an average fall of 137 feet per mile. The scenery along the more southern part of the Tarryall Range is truly grand and gorgeous. Huge reddish granite masses, and in the most rugged shape, are here visible, rising abruptly to a mean height of 2,200 feet above the valley, so as to baffle in most places any human attempt to scale them. Only in the center of the valley have we been able to find a place where, with some effort, we were able to make the ascent with animals.

LOST PARK.

Between Tarryall Range on the west and Kanosha Range on the north and northeast, there lies another high mountain valley, apparently characteristic only of that portion of the country. This valley, separated from Creig Creek only by the width of the Kanosha Range, lies but four miles south of, and but 2,000 feet lower than, Creig's high mountain valley. Its mean elevation above sea-level is 9,200 feet. Inclosed on all sides by high and rugged mountains, and having as yet only two very steep, rocky, and imperfect approaches, namely, Rock Creek and Wigwam Creek trails, hunters and prospectors have named that mountain valley "Lost Park," perhaps from its seclusion. To the formidable creek that meanders through that valley, the name of "Lost Park Creek" has been attached for want of a better one. Where Tarryall and Kanosha are linked together by means of a low saddle, the Lost Park (main) Creek takes its rise. Only half a mile farther to the north another creek, Indian Creek, originates, draining the western slopes of Kanosha Range. Only three-fourths of a mile apart from each other, and separated only by a low ridge, the two creeks flow, with a moderate descent, along side by side to unite 5 miles below, where the full characteristics of a valley or park manifest themselves. Indications of a valley character exist, however, already on the main stream nearly all the way up to Rock Creek saddle. This creek receives also some lateral streams from the gently-sloping willow-flats on the northeast slope of Upper Tarryall Range. Before the two streams which have their sources near and about Rock Creek saddle unite, the western creek or main stream receives a large body of water from a creek coming from the west of station 39, or Bison Peak. The borders of this stream have, for about 2½ to 3 miles, the resemblance of a park by itself. It is in some places nearly one-third of a mile in width, in the lower part at least, and is intersected on its way to the (main) Lost Park by several mountain streams, bringing abundance of water from wide-spread willow-flats from among the northern portions of Tarryall Range. On this stream as well as on the above-mentioned willow-flats bison still roam, and Indians come here every year to hunt them. From the junction of this stream with Lost Park Creek, and 3 miles down the stream, the resemblance of a well-developed valley (or park) is hardly questionable. With scarcely 200 feet fall within a distance of 3 miles, its general surface appears flat. Along the creek, the mountain-spurs are much flattened, and, in consequence, a very soft rise exists immediately in rear of both river-banks. Here and there gravel benches make their appearance. The valley is from one-third to one-half mile broad, with abundance of high, wild grass near the creek, and excellent bunch-grass on the sides. The creek has cut a 10 to 12 feet deep channel. Numerous little mountain rivulets, with no wellde-fined beds, have produced many wet and miry places near the margin of the creek.

To estimate from the huge mountain masses that surround this park, and the considerable deposits of snow therein during winter, we reasonably conclude that great and powerful masses of water flow through this valley in spring-time.

From general appearance, and from the existence of some very regular gravel benches, as well as from the fact that the river-banks were disproportionately higher at the lower end of the park than in the center or elsewhere on the stream, I was led to the conclusion that this park, in remote times, was a large mountain lake, which, according to approximative calculation, contained about 9 miles of lake surface, including the inlets, which now are side-valleys.

At the lower extremities of the park, and 1 mile below a point where a small stream comes down alongside of Wigwam trail, the features about Lost Park Creek change from a quiet, almost idyllic mountain valley into a chaotic-looking cañon. The stream becomes at once pressed by steep mountain spurs into a narrow channel, and for 8 or 10 miles its borders are dark and desolate-looking walls which recede on the west side about 2½ miles from the creek, and rise to a height of 3,000 feet. On the east, the crests of the mountains are still nearer, and tower about 2,200 feet relative height above the bed of the creek. Inside the cañon, the Lost Park Creek represents only a turbulent, ever-foaming and ever-plunging stream, in constant battle with the rocks fallen into its channel from the precipitous mountain-sides; this continues until it emerges out of the chaotic region, a vast wilderness of rocks, again into a more moderate, open, and free country, which commences about 4 miles west of its confluence with Platte River.

The total length of Lost Park Creek is 25 miles; its total fall from Rock Creek Pass to its junction with South Platte River is 3,400 feet and its average fall per mile 136 feet.

WIGWAM CREEK.

Wigwam Creek rises between the rugged granite ridge east of Lost Park Cañon and the exceedingly rugged portion of Kanosha Range, or on the southern slopes of Freeman's Peak. This stream carries almost from its very source a powerful volume of water. There is one small willow park, of about 40 acres area, near the head of the stream. Excepting this small patch of comparatively level surface, there is not one-quarter of a mile on the whole creek's length that could not be termed absolute cañon. A rough trail, obstructed by down timber and rocks, leads along this creek into Lost Park, and can only be traveled on foot or on mules, and even then with difficulty.

One mile above its junction with the South Platte River, Wigwam Creek receives Webster's Creek as a tributary, which leads on the south side of Webster's Pass or the pass which leads between Freeman's Peak and Virginia Mountain over into the main Buffalo Creek country.

The upper or mountainous part of the country through which Wigwam Creek flows is heavily timbered. After it leaves the abrupt mountain part, timber becomes somewhat scarce. While the *Abies* species exists principally in the upper part, the *Pinus sylvestris* predominates in the lower region altogether.

Total length of Wigwam Creek is 10 miles; total fall, 2,600 feet average fall per mile, 260 feet.

CREIG CREEK AND THE SUMMIT VALLEY.

The Summit Valley, with Creig Creek originating at its head, exhibits such remarkable orographic features that it must be considered a curiosity not frequently seen in the Rocky Mountains. It is a regular, well-developed valley (Hochthal*) of about nearly seven miles in length and from 1,000 to 2,000 feet in width, well grassed and watered with a beautiful stream. It extends between the two mountain crests of Kanosha Range and North Platte River Mountains, at a mean height of 11,400 feet above sea-level. Both of the ridges rise about 800 feet in average above that mountain valley, while their peaks rise to a relative height of 1,200 feet above it. The course of the valley is directly southeast, like the two ranges, and the descent is only 1,200 feet within 7 miles. A quantity of large springs and numerous ponds at the head of the valley make the stream powerful at its infancy. After 7 miles of moderately gentle flow the stream is pressed between the steep sides of the two ridges, and for 3 miles it is bustling and tumbling in rapid descent down to an elevation of 8,400 feet, which shows the rapid fall of that stream of 3,000 feet within the short distance of 3 miles.

During this rapid trip through the mountain narrows the stream assumes an eastern course, and after passing through a small but impenetrable cañon of 1½ miles in length it turns directly to the northward for a few miles, where it enters the north branch of the South Platte River at a mean elevation of 7,400 feet.

The peaks on either side of the Mountain Valley of Creig Creek are neither bold nor huge in formation. They rise from 200 to 400 feet above the general saddle-height of the two ranges and are in most cases simple granite exposures, the contiguous strata having given away more readily to erosion.

The slopes on the east of the valley are moderately steep, with sparse timber on them, while the side fronting the North Fork of the South Platte is very rugged and precipitous. The spurs are sharp granite edges, with smaller peaks and rocky pulpits on them. The range on the west side of Creig's Mountain Valley is the higher and principal range,

* The name "Summit Valley" is not entirely equivalent to the German "Hochthal." These valleys of considerable absolute elevation are but rarely met with in the Rocky Mountains, while their occurrence is very frequent in the Alps.

while the eastern mountains swing around alongside of Creig Creek, and the last spur of it comes to a terminus at the very junction of Creig Creek with the North Fork of the Platte River. The western range continues on to Freeman's and Virginia Peak, near the headwaters of Buffalo.

The tributaries of Creig Creek are insignificant and have their rise along the mountain-slopes close by the stream. If we except a small narrow strip of park with plenty of willows and some good grass, containing perhaps an area of 30 acres below the most abrupt part through which the stream has to pass, and again some small open creek bends near its junction with the North Platte Fork, Creig Creek is, in its totality, a wild, rugged, and impassable stream.

NORTH FORK OF THE SOUTH PLATTE RIVER AND ITS VALLEY FEATURES.

The North Fork of the South Platte River has in regard to valley features just a trifle more than the mere appearance of them. We use the term valley principally in this case to make at least a cert in distinction between this stream and others that come down from the eastern slope into the Platte, for they are mostly all cañon streams as long as they remain in the mountains.

This valley seldom widens more than one-fourth of a mile, and it is closed very frequently by the steep hillsides so as to admit simply a passage for the stream. In such places the road is meandering, frequently several hundred feet higher than the river along the mountain spurs, until the bottom of the valley permits again an approach to the stream.

The valley of the North Fork of the South Platte commences near the reduction-works of Hallstown, where several mountain streams issue their water into one channel. The main stream comes from Whale Mine Gulch. Other important tributaries are Gibbons Creek, Bullion Creek, and Hand-Cart Creek, in junction with other small streams that rush down to the right and the left from the mountains. From here down to a point 5 miles below, where a small creek comes from Kanosha Pass, the features of a valley are more definitely expressed than elsewhere on the whole stream; only, before we get quite down to the junction of Kanosha Pass Creek, the valley closes again into a narrow defile for a short distance, but down to here the valley has had everywhere else a uniform width from one-fourth to one-third of a mile, and it contains frequently some good patches of pasturage.

A quarter of a mile below the junction of Kanosha Pass Creek the valley becomes very narrow, and continues to be so for 3 miles to a point where Geneva Creek comes from the north as a powerful mountain stream. It originates among the spurs and mountains near and about Mount Evans and has a fine cataract or fall $4\frac{1}{2}$ miles above this point. From here the valley closes and opens within a distance of 7 miles very frequently. The road seldom approaches the river very closely, the unevenness of ground and rugged nature of its margins preventing it. Yet extremely narrow as the valley is here, we find some attempts made at settlements, owing to the good grass along the hillsides, which enables the settlers to raise some cattle.

At a point called Slaght's, 7 miles east from junction of Geneva Gulch, the valley again opens for a short distance of one mile, and we see for the first time some fields and some level bottom pasture. Below this spot the river again is hemmed in by the mountains and remain so until

4 miles farther to the east we approach Bailey's Ranch, from which place the Fair Play road leaves the valley to assume a northeastern course toward Turkey Creek, Morrison, and Denver.

From Bailey's Ranch the North Fork of the Platte River bears in the direction of Buffalo Creek a distance of 12 or 13 miles. The character here is that of a narrow valley; of course not absolutely so, for there are still several places within that space where some mountain spurs or low ridges, "which occur particularly on the south side between Creig and Buffalo Creek," press the river into a narrow channel; but for the most part there is more area of open river bottom than on the remainder of the North Platte Fork.

A small number of settlers have occupied, in particular in the vicinity of Buffalo Creek junction, the whole valley for several miles upward. The grass among the willows near the river is abundant, and the moderately sloping hillsides show plenty of fine and rich bunch grass.

Below this junction of Buffalo Creek with the North Fork of South Platte River the stream enters a rugged cañon district and remains in it even after its junction with the main or South Platte Fork.

BUFFALO CREEK.

Buffalo Creek heads at the most eastern end of Kanosha Range, between the spurs of Lost Park Peak, Freeman's Peak, as well as Virginia Mountain. The largest portion of water comes from among the slopes of Kanosha Range, while the principal stream-bed comes directly from a pass, "Webster's Pass," which has an altitude of about 8,200 feet. For 2 miles below the summit the Pass Fork of Buffalo Creek meanders through a grassy basin about one mile in length, which bears evidence of having been a lake. Two buttes, peculiar monuments of erosion, stand within $1\frac{1}{2}$ miles of each other, and to the right and left of that basin. The western one is remarkable for its extreme sharpness and abrupt rise; the highest points seem but needles. The relative height of that granite butte is about 2,000 feet above the little lake basin. Two miles east of this butte, the two principal streams unite to constitute main Buffalo Creek, which flows hereafter directly in a course northeast, toward the North Fork of the South Platte River.

Although the country through which Buffalo Creek flows consists mainly of rolling and flattened spurs from Virginia Mountain on the east side, and a low granite ridge on the west, the creek has nevertheless a rough and tumbling passage over rocky ground before it unites with the North Platte Fork.

The length of Buffalo Creek is $11\frac{1}{2}$ miles from its uppermost source. The total fall of the stream is about 3,000 feet, and the fall from the base of the mountains down to the Platte Valley of the North Fork is about 1,000 feet, or 110 feet per mile.

Hydrographic table of the South Park, or South Platte River drainage, with approximate fall from the sources.

Name of stream.	Locality of source.	Length of stream, in miles.	Average fall per mile, in feet.	Total fall, in feet.	Empties into—
North Fork of South Platte River	Main range, east slope of Whale Peak	47	102	4, 800	South Fork of Platte River.
Geneva Creek	Main range, South Argentine Pass	12	......	....	North Fork South Platte River.
Deer Creek	Four miles south of Mount Evans	17	......	....	Do.
Elk Creek	Two miles south of Mount Evans	22	......	....	Do.
Creig Creek	Kanosha Range	17	247	4, 200	Do.
Buffalo Creek	Platte River range, near Virginia Mountain	12	200	3, 000	Do.
Main of Middle Fork of South Platte River	Mount Lincoln	*107	54	5, 800	
Little Platte River	Weston's Pass	32	81	2, 600	Main Fork of South Platte River.
Four-Mile Creek	Horseshoe Mountain, Park Range	18	100	1, 800	High Creek.
High Creek	Sheep Mountain, Park Range	20	80	1, 600	Main Fork South Platte River.
Agate Creek	Four miles north of Black Mountain	22	66	800	Do.
Trout Creek	South of Silverheels Mountain	17	117	2, 000	Do.
Tarryall Creek	Hamilton Pass	48	61	4, 200	Do.
Michigan Creek	Main range, near Mount Gnyot	16	......	....	Tarryall Creek.
Jefferson Creek	Mount Guyot	12	......	....	Michigan Creek.
Twin Creek	Hayden Park	14	87	1, 200	South Platte River.
Douglass Creek	Five miles north of Topaz Butte	10	......	....	Do.
Lost Park Creek	Between Kanosha and Tarryall ranges	25	136	3, 400	Do.
Wigwam Creek	Southern slopes Kanosha range	10	260	2, 600	Do.
Maine West Creek	Hayden Park	17	118	2, 000	Manitou Creek.
Monitou, or Bergen's Creek	......do	27	88	2, 400	South Platte River.
Custer Creek	Two miles northwest of Riley's Butte	10	......	....	North Fork South Platte.
Last Resort Creek	Two miles north of Riley's Butte	7	......	....	Do.

* To the plain.

CHAPTER V.

DRAINAGE AND PRINCIPAL CHARACTERISTICS OF THE EASTERN ROCKY MOUNTAIN SLOPE.

BEAR CREEK.

Bear Creek is the first large water which comes from the eastern slope of Evans Ridge, and north of the Platte Cañon. It drains quite a respectable mountain area, comprising about 2,000 square miles. The main source of Bear Creek comes directly from the eastern slope of Mount Evans, while another big branch, Roeder Creek ?, originates east of Mount Rosalie.

The southern mountain sides of the mountain called the "Chief," give rise to several streams, named Corral Creek, Metz Creek, and Vance Creek, and all the waters belonging to the Upper Bear drainage assemble in a splendid little park near Systie's ranch, whence a road leads out into Bergen's Park, and from there to the Foot Hills.

Bergen's Park consists of perhaps 9 square miles of gently-sloping area, and has proved to be one of the most available spots for settlers in the mountain west of the Foot Hills.

Four miles southeast of Bergen's post-office, and just at the Bear River bridge, Cub Creek enters. This branch heads near the last high peak, "Cub Mountain" (10,623 feet high), on the eastern end of that ridge which (Mount Evans) stretches toward the plains, between the South Platte River and Bear River drainage.

From near that point where Cub Creek enters, Bear River buries itself in a cañon from which it only emerges seven miles to the east, near Morrison Village, at the Foot Hills.

From here it breaks through the hogbacks, and is joined two miles below by Turkey Creek, draining the extreme outrunners of the Evans Ridge.

Along Turkey Creek, "though a cañon", leads the Denver and Fair Play wagon-road.

Bear River drainage system belongs to one of the most rugged portions of the eastern slope, Clear Creek excepted. Clear Creek drainage zone contains an area of about 330 square miles, and originates in several large streams coming from among the eastern slopes of the main range, and out of that district which is inclosed by the main range, in making the big bend from James Peak to Mount Evans.

There are four large streams running from that mountain inclosure; three of them unite near Georgetown, and the fourth one joins $4\frac{1}{2}$ miles below this city. Between each of these, heavy mountain spurs press forward in magnitude hardly less grand than the main range itself. From Mount Evans a colossal ridge is detached which leads off in an eastern direction, and occupies the space between Bear and Chicago Creeks and Clear Creek, rising and falling alternately, and terminates at the Foot Hills. The highest altitude attained by this ridge after leaving Mount Evans is 11,833 feet (Chief Mountain).

Nowhere else on the whole of the eastern Front Range are great mountain masses so abundant as in the country pertaining to the Clear Creek drainage system. The spurs naturally follow along the creeks, and, in consequence, have also a tendency to concentrate near the different junctions of the tributaries and the main Clear Creek channel.

Where huge mountains crowd so close to the drainage as is the case of the Clear Creek district, there is no room left for the development of a valley. This fact is manifested here, for Clear Creek is in a cañon from beginning to end, and there are only two small spots which might be excepted, and they are insignificant enough. In one of them is situated Idaho Village, and the other is a small strip $2\frac{1}{2}$ miles in length upward from Mill City. The same features appear on all the tributaries. Every stream that comes to join the main stream is inclosed by a cañon. Notwithstanding the excessively mountainous character of this region, which defies all attempts at agricultural pursuits, the Clear Creek district supports quite a large population which is employed in the industries of mining. There we find some of the largest and most thriving towns in Colorado, namely: Central City, Georgetown, Blackhawk, Idaho, besides several smaller villages and scattered settlements, like Empire and Mill Cities, Downieville, Silverplume, and settlements all along South Fork of Clear Creek.

The only attempts at farming I have observed is in the upper parts of Fall River, where a few enterprising, and, no doubt, hard-working men have availed themselves of isolated patches of moderately sloping ground to raise some potatoes and oats, the only products that can be raised in these mountains.

There are two roads leading into this mountain district, uniting at Idaho, one coming over and between heavy mountains from the Bear Creek country by the way of Bergen's, and the other over Floyd Hill from Central City. From Idaho the road continues on to Georgetown, while a branch road leads via Empire City into the Middle Park, crossing Berthoud Pass at an approximate elevation of 11,313 feet. Roads branch off from Georgetown in two directions; one leads up to South Fork of Clear Creek as far as mines extend, and the other presents a tolerably clear track along that branch of Clear Creek which takes its rise in that huge amphitheater beneath Gray's Peak. At the very headwaters of this branch we are surrounded by many objects of profound interest. Besides that interest which we take, perhaps, in the lofty peak standing immediately before us, there are other objects that claim our attention.

High up on the precipitous walls of the McClellan Range, "which, crescent-shaped, encircles that amphitheater on the east," are mines, appearing like swallow-nests on a cliffy mountain-side. This is the Stevens mine, at an elevation of 11,943 feet above sea-level, which, the signal-station of Pike's Peak excepted, is perhaps the highest place of human habitation in Colorado. The inhabitants of this rocky homestead ascend to it by means of ropes. Mount Kelso is opposite, but the mine thereon does not quite reach the height of the Stevens mine.

Another road leads up a tributary of South Fork of Clear Creek to and over the Argentine Pass into the valleys of Snake and Blue Rivers.

North of the Clear Creek district, the country lying east of the Rocky Mountain crest assumes totally different orographic features. We only find the characteristics of mountains of first order expressed in the great spurs detached to the eastward, which are occasionally from 2 to 6 miles long, but none of them possessing the bold features of the great spurs we see along the Gores Range, or along the western slope extending from 10 miles north of Arapaho Peaks northward to nearly 40° 30′ latitude. With two exceptions, the spurs toward east assume, after their separation from the main range, either a very moderately rounded form, or in most cases that depressed bulky and broad character which we generally observe in mountains destined to be soon absorbed by a lower country.

We might regard the crest of the main range as about 18 miles distant from the foot-hills. Two-thirds of this intervening space are occupied by mountains of subordinate order and totally different in character to what we are used to observe along the rest of the eastern slope for hundreds of miles. In the most northern parts of the Rocky Mountains, between parallels 46° and 48°, I had occasion to observe here and there clusters and mountain groups lying near and along the foot of the main chain, but they are irregular. Streams flow in most every direction, and the mountains, hills, and ridges often run parallel to the main range. In this case, however, it appears as if the approach to the main chain had been once a solid huge granite plateau about 3,000 feet high, "with only such unevenness of features as any not very undulating surface would produce." Through this the streams originating along the slopes have cut a remarkably straight easterly course to the plain. Mr. Archibald R. Marvin, assistant geologist and leader of the party in 1873, to which I was attached as chief topographer, described the eastern slope of the Front Range in that region with particular ability. He remarks:

"This mountain zone can in no wise be regarded as made up in distinct ranges or a system of ridges, but as a unit in itself, having characteristics which hold very uniformly over nearly all parts. From beneath the precipitous crest, from all the gorges and amphitheaters at its base, flow innumerable streams which, after emerging from these upper cañons into the smoother highlands, soon collect into a few principal water-courses. Flowing in a generally eastern course, these gradually sink their channels deeper and deeper into the rocks, the different main streams uniting their cañons here and there, and finally issue from their deep-cut gorges in the mountain front to flow out into the plains and into the Platte."

Again he says:

"The tendency of these cross-cutting streams is to throw this eastern mountain area into east and west ridges. These ridges are seldom sharp, but massive, and rather than striking one as a system of ridges, it impresses one as a system of deep-cut river channels."

He closes his remarks about this region in saying:

"The majority of these ridges rise somewhat above 8,000 feet, while the plains along the eastern base of the mountains average not far from 5,600 or 6,000 feet. A few points along the face of the mountains rise higher than the country immediately in their rear, such as Boulder and Golden Peaks, and Bear Peak, which stand close to the mountain edge. But as a whole the mountain zone lying between the main divide and the plains certainly impresses one as being, with a few exceptions, a region of uniform or gently undulating general elevation, carved by the powers of erosion, perhaps partly glacial but mostly by streams, into a mountain area of which portions are exceedingly rugged."

Following from the exit of Clear Creek the foot-hills for five miles in a northward direction, we arrive at the mouth of

RALSTON CAÑON,

through which comes forth a creek of a third order of the eastern slope drainage, for its sources lie only 10 miles from the hogback to the west, while its tributaries consist of small rivulets not over 2 to 3 miles in length.

It is in this respect almost entirely unique, having with the other streams only in common the characteristics of being a cañon stream. The natüre of the country, however, in which Ralston Creek rises is somewhat different from the rest of that cañon district, occupying nearly the whole area between Clear Creek and North Saint Vrain. Its sources lie in a mountain basin, caused by very gradual descending slopes from a ridge which connects 11 miles to the west with James Peak. In the rear and to the east of this basin stands that cluster of hills known as the Ralston Buttes, a cluster which deserves that name to the full extent, for it consists of a large number of sharp peaks resting all on a common mountain. The peaks are not over 10,590 feet high, but of a commanding appearance when compared with nearly all the rest of its surroundings. A rough road leads over this hilly cluster from Black Hawk into the Coal Creek Valley.

On the south side of Ralston Creek, and just south of the buttes referred to, we find another ridge occupying the space between Ralston and Clear Creek drainage, with an irregular crest, showing alternately peaks and deep saddles. This ridge is perhaps 5 miles long, and its peculiar characteristics terminate when arriving at its easternmost and highest point, Golden Peak.

Ralston Cañon is as yet impassable. A path leads from the foot-hills, where a small settlement exists, for about 2 miles into the cañon, but then ceases. A few settlers have availed themselves of some small patches of ground on the ridges and above the cañon to cultivate some potatoes.

COAL CREEK.

Little can be said of this stream as a mountain stream; it rises on the eastern slopes of Ralston Buttes, and has but a short course. Like Ralston Creek, it can boast of a little mountain basin near its head, which is occupied by some settlers. Into this basin the road from Blackhawk descends to resume its meandering tour through the narrow cañon which follows this basin toward the foot-hills.

THE BOULDER CREEKS.

a. North Boulder Creek.—The Boulder Creek of the plain consists of three branches, but the middle branch unites with the North Fork while yet in the mountains, and the remaining two branches enter the plain at points about 5 miles from each other. The North Branch of the Boulder originates near the northern slopes of Arapaho Peak and north of it. This peak, one of the finest along a large tract of the main range, throws a big spur in an eastern direction which divides the waters of the Middle and North Boulder. The middle stream takes its sources mainly in numerous amphitheaters beneath the crest of the main range beneath Arapho Peak and Boulder Pass. Three principal head branches, which form the Middle Boulder, are, from their very beginning, inclosed in cañon, and the streams remain in it until near Netherlands, where, for the short distance of 1½ miles, the comparatively low ridges on both sides of the river recede a little, giving the latter the appearance of a modest-looking valley-bottom. Soon, however, the granite walls again approach the river, inclosing it down to and beyond its junction with the North Boulder. Both rivers are cañoned up at the point of their junction, and have been so for many miles back.

The river is so much wrapped up in precipitous mountains during nearly 18 miles that the road leading along the cañon is considered one of the great road-building achievements in Colorado. This road was, indeed, constructed with difficulty. It has to cross and recross incessantly to make its existence possible, and in many places whatever space the road needed had to be hewn out of the solid granite. Another tributary to the North Boulder is Four Mile Creek, which is 12 miles long, and rises in the mountain spurs descending from the main range, about 3 miles south of Ward City. This creek flows between two rugged ridges until 3 miles east of Sugar Loaf Mountains it arrives at the meridian of Gold Hill, from where it bends to the southeast, joining with North Boulder 1½ miles before the latter passes the hogbacks near Boulder City.

b. The South Boulder.—Almost parallel to the middle branch runs the South Boulder, a formidable stream, and in volumes of water perhaps equal to the united Middle and North Boulder. Among the rugged mountain sides of the main range between Boulder Pass and James Peak itself are the sources of this stream. Four miles beneath the strongly eroded mcuntain sides, north of James Peak, lies a lake in a magnificent valley, inclosed on all sides by huge mountains. This valley or mountain basin,* perhaps 1½ miles in length and half a mile in width, is the prettiest spot along the whole stream. After leaving it, the river enters a cañon, and is freed from it for a short space when arriving close to Rollinsville, whence a road leads to Netherlands and to the Middle Boulder Valley, as well as to Blackhawk, and another one to Boulder City, by the way of Bear Cañon. After leaving Rollinsville and that small patch of bottom, the South Boulder plunges again into a cañon, impenetrable as yet, in which it remains until its exit near the foot-hills, 5 miles to the south of Boulder City. North, Middle, and South Boulder streams drain together 15 miles of slope along the main or Colorado Range.

JIM CREEK.

This stream enters the plain 8 miles north of the point where North Boulder emerges from the mountains. It consists of two forks; the one being the main Jim Creek, and the second Left Hand Creek. They unite before entering the plain. For their whole length they are both inclosed in cañons, excepting where the mountain-walls of the main fork spread apart to leave room for the settlement of Jim Town, an inconsiderable mining village. This principal branch heads beneath the main crest, 7 miles west of Ward City, and 4 miles north of Arapaho Peak. The second branch (Left Hand Creek) originates in the mountains directly north of Ward City.

SAINT VRAIN'S CREEK.

This stream heads in two large branches, the North and South Saint Vrain's, just below the main crest of the main or Colorado Range. There is also a Middle Branch, which, although heading slightly farther up on the range than the South Branch, is a tributary to it, and loses its name at the junction. The South Saint Vrains does not gather its waters from the main crest, but on the slopes of that long spur stretching east from Mount Audubon. The middle and north branches together drain 22 miles of the eastern slope of the main divide. The southern slopes of Long's Peak, and the huge amphitheaters to the south and west of it, furnish a large proportion of the waters of the North Saint Vrain's.

*See crest of the main Rocky Mountains.

After the many fast-falling mountain streams have united below and on the southern face of Long's Peak, the stream flows along, cañoned up on the one side by the broad granite faces of Bald Mountain, and on the other by the long morainal spurs of the base of Long's Peak. Soon, however, the North Saint Vrain's is completely inclosed in one of those granite cañons so common in this country, and in it receives a tributary from the south, which originates on the southeastern sides of Bald Mountain. This stream, only one mile from its junction, penetrates the granitic mass which holds the North Saint Vrain's in its narrow path. The united streams continue for 2½ miles with straight cañon sides, when another cañoned tributary is received, coming from between Long's Peak and Lillie's Mountain. This completes the main volume of water which the North Saint Vrain's carries through a continuous cañon till near the "Hogbacks," among which it is joined by the South Branch, which has just completed its journey through one of the boldest districts in those parts near the foot-hills.

The whole course of the South Saint Vrain's is in cañon, partially rugged, but for the most part of only moderate steepness, the bordering country bearing the character of a granite plateau. The sources, as I have mentioned before, lie along the northern sides of the spurs which form the eastern extension of Mount Audubon.

LITTLE THOMPSON.

This stream enters the plains about 4½ miles northeast of North Boulder exit. Its sources lie in the middle portion of that cluster of hills lying 5¾ miles east of Long's Peak, of which Lillie's Mountain (11,433 feet) is the dominating point.

The principal stream is formed by three large branches, the chief and most western one coming from the east slope of Lillie's Mountain. Several miles eastward this main branch is joined by Muggins Creek, along which the road leads from Longmont into Estes Park. The third branch, being the north branch of the Little Thompson, comes directly from among that immensely rugged granite mass which occupies the whole area between the Big and Little Thompson Rivers.

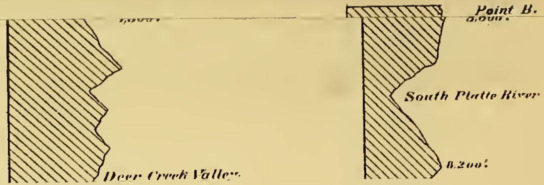
VICINITY OF ESTES PARK AND THE BIG THOMPSON RIVER.

Within the district treated in these notes we will scarcely be able to find a region so favorably distinguished as that presented by Estes Park. Not only has nature amply supplied this valley with features of rare beauty and surroundings of admirable grandeur, but it has thus distributed them that the eye of an artist may rest with perfect satisfaction on the complete picture presented. It may be said, perhaps, that the more minute details of the scenery are too decorative in their character, showing, as they do, the irregular picturesque groups of hills, buttes, products of erosion, and the finely-molded ridges in the very center of the park. Although this arrangement separates the otherwise broad expanse into a number of small areas, the total effect is pleasing in the extreme.

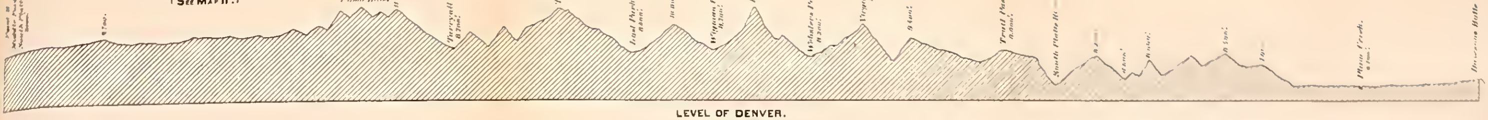
From the sides of the huge mountains which here inclose us flow down the streams concentrating in Estes Park. Fish Creek comes from the south and from the northern slopes of Lillie's Mountains; South Fork of Thompson, directly from the very cañon west and beneath of Long's Peak. Main Thompson rushes its waters down from the high main range 12 miles to the northwest. Fall River originates in a great amphitheater a few miles to the east of it, and the Black Cañon Creek brings turbulent waters through a black gorge from the lofty peaks to the north.

The Big Thompson, as its united headwaters are called, flows through the middle of Estes Park, which lies just 11 miles directly northeast of the very pinnacle of Long's Peak. The park does not consist of a compact park area, but lies in separate portions along each of the streams, the largest part of which is stretched along Fish Creek and along the entrance of Black Cañon Creek, and where the former joins the Thompson River. Soon after the junction of Fish Creek the river leaves the park to continue its journey for 9 miles through a rugged cañon, where it becomes augmented by another powerful stream, the North Fork, coming partly from along the slopes of Buckhorn Mountain and partly from the mountains to the west of it. Between the two branches, and for many miles before they join, rises a voluminous granite ridge, with its highest points 2,000 feet above the river-level. To the south of the Nine Mile Cañon the precipitous slopes of that level-topped granite ridge is upheaved, which, although eroded and bisected by many cañons, stretches on pretty much the same level for many miles to the south, and crosses even the Little Thompson 11 miles southward.

From the junction of the two branches the river still pursues its course for 4 miles in a cañon, passing on its way the Palisades, 2,200 feet above river-level. Between the latter the river is somewhat relieved from its rocky inclosure over a mile in distance, passing after that through the last and shortest cañon, and meandering from about 6 to 8 miles among the smallest of the Foot Hills group called the "Hog-backs," enters the plain very near the junction of Buckhorn and Big Thompson Rivers.

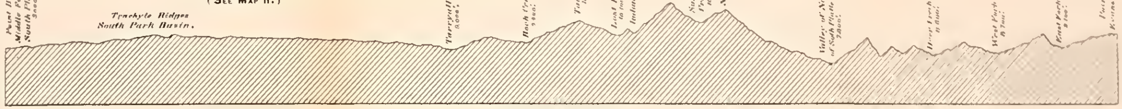

Point B.
South Platte River
8,200'
Deer Creek Valley

PROFILE.
FROM POINT B MIDDLE FORK OF SOUTH PLATTE RIVER
TO DAWSONS BUTTE ON THE PLAIN.
(SEE MAP II.)



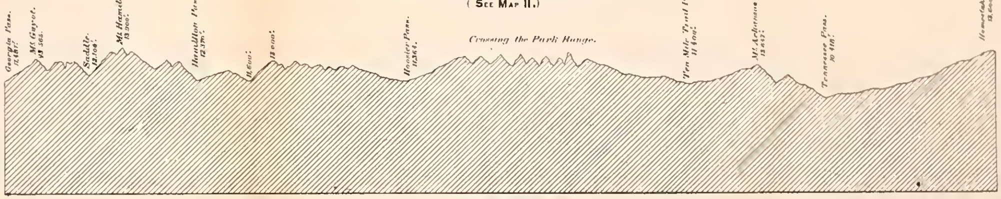
LEVEL OF DENVER.
5190 feet.

PROFILE.
FROM POINT B. MIDDLE FORK OF SOUTH PLATTE RIVER
TO POINT D. ON EVANS RANGE.
(SEE MAP II.)



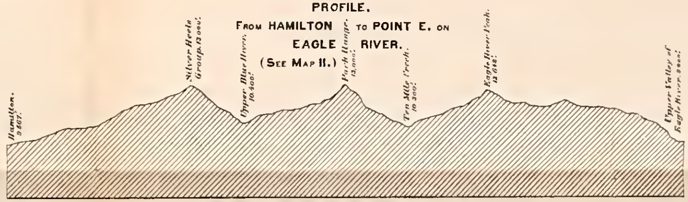
LEVEL OF DENVER.

PROFILE.
OF THE CREST ON THE CONTINENTAL DIVIDE.
FROM GEORGIA PASS TO HOMESTAKE PEAK.
(SEE MAP II.)

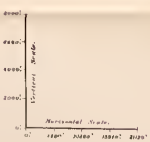


LEVEL OF DENVER.

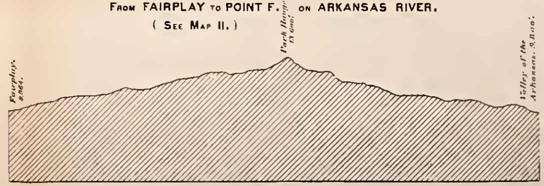
PROFILE.
FROM HAMILTON TO POINT E. ON
EAGLE RIVER.
(SEE MAP II.)



LEVEL OF DENVER.



PROFILE.
FROM FAIRPLAY TO POINT F. ON ARKANSAS RIVER.
(SEE MAP II.)



LEVEL OF DENVER.

Plate LX

AM. PHOTO-LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS)

Hydrographic table of drainage of the eastern slope from parallels 39° 8′ to 40° 30′.

Name of stream.	Locality of source.	Length of stream in mountains.	Length of stream in plains.	Total length of the separate streams.	Total of main stream.	Unites with—	Empties into—
		Miles.	*Miles.*	*Miles.*	*Miles.*		
Big Thompson	Main range, 2 miles northwest of Long's Peak	38	29	67	67	South Platte	Platte River.
Fall River, tributary to Big Thompson	Mountains northwest of Estes Park	11	....	....	....	Big Thompson	
North Fork of Big Thompson	Buckhorn Mountains, and west of them	15	....	....	....	do	
Dry Creek	Foot Hills east of the Palisades	11	2	....	13	do	
Little Thompson	East of Lillie's Mountains	14	23	....	42	do	
Saint Vrain { North	South and east slopes of Long's Peak	25	10	....	35	Jim Creek	Boulder.
Saint Vrain { Middle	Main range of mountains north of Arapaho	21	....	21	....	North Saint Vrain	
Saint Vrain { South	Main range, near Mount Audubon	12	....	12	....	Middle Saint Vrain	
Jim Creek	Main range, south of Mount Audubon	21	12	33	....	Saint Vrain	
Left Hand Creek	Bald Mountain, near Ward mine	14	....	14	....	Jim Creek	
Four Mile Creek	Southeast of Bald Mountain	12	....	12	....	North Boulder	
Boulder { North	North of Arapaho Peak	21	7	28	} 72	Saint Vrain	South Platte.
Boulder { Middle	South slopes of Arapaho Peak	16	....	16			
Boulder { South	North slopes of James Peak	28	15	43			
Coal Creek	East slopes of Ralston's Buttes	9	22	31	31	Boulder	Do.
Ralston Creek	Southwest of Ralston's Buttes	17	10	37	37	Clear Creek	Do.
South or Main Fork of Clear Creek	Main range between Mount Evans and Gray's Peak	39	40	79	79	Ralston Creek	Do.
Northwest Fork of Clear Creek	Main range in Big Bend	12	....	12	....	South Clear Creek	
Mill Creek	Main range south of James Peak	7	....	7	....	do	
Fall River	Slopes of James and Parry's Peak	9	....	9	....	do	
Chicago Creek	North slope of Evans Peak	13	....	13	....	do	
North Fork of Clear Creek, Black Hawk Branch	Mountains east of James Peak	17	....	17	....	do	
Bear Creek	East slope of Mount Evans	29	12	41	....	Turkey Creek	Do.
Turkey Creek	Slopes of Evans Ridge extension	15	3	18	....	Bear Creek	
Deer Creek	Slopes of Mount Lincoln	107	*65	†172	....	....	
West Plum Creek ‡	Front Range, near Butte	6	14	20	20	East Plum Creek	
East Plum Creek	Near summit Arkansas Divide	....	38	(§)	38	West Fork	Do.

* To junction with Big Thompson.
† From source to Big Thompson River.
‡ West Plum Creek receives a number of tributaries from the Front Range; but the contradictory statement about their identity received from persons living there prompts me to abstain from describing any, for I am convinced that, owing to the great diversity of opinion about their true names, mistakes would be unavoidable.
§ East Plum Creek being the longest, I consider it the main stream. The length is 28 miles to its junction with West Plum. From their junction their length is 10 miles.

NOTE.—The figures express not the distances in a straight line, but include also the principal bends during their course.

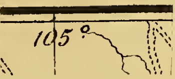
Approximate geographical positions and elevation of points on the eastern slope of the Rocky Mountains, from Platte Cañon to parallel 40° 30′.

Names of located points.	Longitude.	Latitude.	Elevation.
	° ′ ″	° ′ ″	*Feet.*
Denver, Kansas Pacific depot	104 59 23	39 45 0	5, 196
Boulder City	105 16 35	40 0 40	5, 536
Golden City	105 12 40	39 45 30	5, 687
Georgetown	105 42 10	39 42 30	8, 530
Central City	105 30 0	39 47 55	8, 300
Black Hawk	105 29 15	39 48 0	7, 975
Nevada	105 30 50	39 47 45	8, 800
Idaho Spring	105 30 45	39 44 50	7, 535
Caribou, Planters' Hotel	105 35 30	40 4 30	9, 905
Nederland, (formerly Middle Boulder)	105 30 10	39 57 30	8, 263
Gold Hill	105 23 30	40 4 0	8, 463
Morrison	105 11 25	39 39 25	....
Ward City	105 30 30	40 4 37	....
Rollinsville	105 29 45	39 54 50	8, 323
Junction House, Denver, and South Park Road	105 18 15	39 32 0	8, 153
Bergen's Post-office	105 21 30	39 41 15	7, 643
South Boulder Peak	105 17 42	39 57 16	8, 533
Squaw Mountain	105 29 30	39 40 36	11, 733
Golden Peak	105 20 52	39 49 0	9, 650
Ralston Buttes	105 25 30	39 53 0	10, 590
Bergen's Peak	105 23 30	39 40 0	9, 773
Mount Morrison	105 12 55	39 40 12	7, 903
Lillie's Mount, near Estes	105 30 12	40 17 0	11, 433
Sugar-Loaf	105 24 55	40 1 32	8, 933
Eagle Peak	105 20 45	40 48 8	8, 440
Northern Palisade, on Big Thompson River	105 18 0	40 26 30	8, 250
The Big Hogback, near Little Thompson River	105 16 5	40 19 45	7, 923
Prospect Hill, Estes Park	105 30 45	40 21 40	8, 893
Junction of Big Thompson River and Buckhorn Creek	105 8 45	40 25 10	5, 400
Junction of North and South Saint Vrains	105 15 50	40 13 0	....
Junction of Saint Vrains and Left Hand Creek	105 5 35	40 9 15	....
Junction of Bear and Turkey Rivers	105 9 0	39 39 0	....
Junction of South and Middle Boulder	105 12 40	40 2 0	....
Fish Creek and Big Thompson, (Estes Park)	105 30 45	40 21 40	8, 893

View of Longs Peak, Lillie's Mountain, and a Portion of the Main Range From a Peak in Estes Park.

Plate LXI

OUTLINE MAP OF THE
MIDDLE PARK REGION and the EASTERN ROCKY MOUNTAIN SLOPE
Showing Drainage, Roads, Trails, Peaks & Passes
to accompany the Geographical Report of
G. R. BECHLER


105°

U S GEOLOGICAL & GEOGRAPHICAL SURVEY OF THE TERRITORIES. F V HAYDEN IN CHARGE.

PART III.

ZOÖLOGY.

HISTORY OF THE AMERICAN BISON,

BISON AMERICANUS.

BY J. A. ALLEN.

EDITORIAL PREFACE.

OFFICE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES,
Washington, *April* 30, 1877.

The great interest which attaches to the history of the American Bison renders the publication of the present article desirable, as the edition of the original memoir was too small to supply the very general demand for a work of such magnitude and importance as Mr. Allen's "The American Bisons, Living and Extinct."

By the kind permission of Prof. N. S. Shaler, Director of the Kentucky Geological Survey, the work is republished in the present connection, with the modifications noted beyond.

It being scarcely practicable to reproduce the memoir in full, it has been deemed advisable to restrict the scope of this reprint to the portion treating of the living species, as being of the most general interest. Such subtraction of the portion relating to the extinct species, and omission of the illustrations, brings the body of the memoir within the reasonable limits of the present volume.

The editorship of the memoir in its new form having devolved upon me, it becomes expedient to state the modifications which I have introduced upon consultation with the author, and with his full concurrence.

The memoir as originally published has the following titles:

Memoirs of the Geological Survey of Kentucky. | *N. S. Shaler, Director.* | *Vol. I. Part II.* | — | *The American Bisons,* | *living and extinct.* | *By J. A. Allen.* | *With twelve plates and map.* | — | *University press, Cambridge:* | *Welch, Bigelow, & Co.* | 1876.

Memoirs of the Museum of Comparative Zoölogy, | *at Harvard College, Cambridge, Mass.* | *Vol. IV. No.* 10. | — | *The American Bisons,* | *living and extinct.* | *By J. A. Allen.* | *Published by permission of N. S. Shaler, Director of the Kentucky* | *Geological Survey.* | *With twelve plates and a map.* | *University press, Cambridge:* | *Welch, Bigelow, &* *Co.* | 1876.

4*to. pp. i–ix*, 1–246, 1 *col'd map*, 12 *pll.*, 13 *ll explanatory*, 2 *wood cuts in text.*

These two publications were simultaneous, and only differ in the titles. The following are the contents of the memoir:—

Title. p. i.
Preliminary Note (N. S. Shaler). p. iii.
Introduction. pp. v–ix.

PART I.

1.—Distinctive Characteristics and Affinities of the Bisons. pp. 1–3.
2.—General historical Account of the Remains of Extinct Bisons hitherto found in North America. pp. 3–7.
3.—Description of the Extinct Species. pp. 7–31.

4.—Geographical Distribution and Geological Position of the Remains of the Extinct Bisons of North America. pp. 32–35.
5.—Relation of the Existing Species of Bisons to the Extinct Species. pp. 35, 36.
6.—Description of the Existing Species. pp. 36–70.

PART II.

1.—Geographical Distribution, past and present, of *Bison americanus*. pp. 71–191.
2.—Products of the Buffalo. pp. 191–201.
3.—The Chase. pp. 202–215.
4.—Domestication of the Buffalo. pp. 215–221.
Appendix I. pp. 223–231.
Appendix II. (N. S. Shaler). pp. 232–236.
Index. pp. 237–246.
Map and twelve plates, each with unpaged explanatory leaf.

The changes made in the present republication are substantially as follows:—

1. The omission of the illustrations, explanatory pages, and textual references.
2. The omission of the portion relating to the extinct species, the present reprint being confined to the one existing species, beginning at p. 36 of the original.
3. The incorporation of the appendices in the body of the text.
4. The addition of much new matter by the author himself.
5. Various minor modifications, with the slight alteration, chiefly verbal, of context incident thereto.
6. Alteration of the title to suit the republication, and substitution of editorial preface for the preliminary matter of the original.

No editorial abridgment or digest of any part of the memoir has been deemed advisable, the portions of the memoir here reproduced being printed exactly according to the copy furnished by the author, who has, as already said, added much new matter and made some little changes, *passim*, in the context. A few editorial notes, chiefly explanatory of modifications of the text are introduced, always in brackets.

In its present form, and with the wide circulation now given, it is believed that the memoir will satisfy the desire long felt by the public to possess a complete and thoroughly reliable history of the most conspicuous and most important quadruped of America, prepared with the greatest care and pains, after protracted and patient research, by one of the most eminent therologists of the country.

ELLIOTT COUES,
Secretary of the Survey.

PART I.

DESCRIPTIVE AND BIOGRAPHICAL.

BISON AMERICANUS (GMELIN) SMITH.

American Bison or Buffalo.

Bos americanus GMELIN, Syst. Nat., I, 204, 1788.—DESMAREST, Nouv. Dict. Hist. Nat., III, 531, 1816; Mammalogie, 496, pl. xliv, 1820.—HARLAN, Fauna Amer., 268, 1825.—GODMAN, Amer. Nat. Hist., III, 4, 1826.—DESMOULIN, Dict. Class. Hist. Nat., II, 365, 1822.—RICHARDSON, Fauna Bor. Amer., I, 279, 1829.—FISCHER, Synop. Mam., 495, 653, 1829.—COOPER, Month. Am. Journ. Geol. & Nat. Hist., 1831, 44, 174, 207 (remains at Big-bone Lick, Ky.); Amer. Journ. Sci., XX, 371, 1831; Edinb. New Phil. Journ., XI, 353, 1831.—DOUGHTY, Cab. Nat. Hist., II. 169, pl. xiv, 1832.—SABINE, Franklin's Journey, 668, 1833.—WAGNER, Schreber's Säugt., V, 472, 1855.—GIEBEL, Säugt., 271, 1855.—BAIRD, Mam. N. Amer., 682, 1857; U. S. & Mex. Bound. Survey, Pt. II, 52, 1859.—NEWBERRY, Pacif. R. R. Expl. & Surveys, VI, iv, 72, 1857.—SUCKLEY & GIBBS, Ibid., XII, ii, 138, 1860.—XANTUS, Zool. Garten, I, 109.—ALLEN, Proc. Bost. Soc. Nat. Hist., XIII, 186, 1869; XVII, 39, 1874.

Bison americanus CATESBY, Nat. Hist. Carolina, II, App., 20, xxviii, 1743.—BRISSON, Reg. Anim., Quad., 1756.— SMITH, Griffith's Cuv., V, 374, 1827.—DE KAY, Nat. Hist. New York Zool., Pt. I, 110, 1842.—SUNDEVALL, Kong. Sv. Vet. Akad. Handl. för 1844, 203, 1846.—GRAY, Knowsley's Menag., 49, 1850; Cat. Mam. Brit. Mus., Pt. III, 39, 1852; Hand-List of Edentate, Thick-Skinned & Ruminant Mam., 85, 1873.—GERRARD, Cat. Bones of Mam. Brit. Mus., 230, 1862.—TURNER, Proc. Zoöl. Soc. London, XVIII, 177, 1850.—AUDUBON & BACHMAN, Quad. N. Amer., II, 32, pls. lvi, lvii, 1851.—BAIRD, Rep. U. S. Pat. Off., Agricult., 1851, 124 (plate), 1852.—LEIDY, Proc. Acad. Nat. Sci. Phila., 1854, 200, 210; Extinct Mam. Faun. N. Amer., 371, 1869.—ALLEN, Bull. Essex Institute, VI, 46, 54, 59, 63, 1874.—RÜTIMEYER, Verhandl. Naturf. Gesells. in Berlin, IV, iii, 1865; Versuch einer natürlichen Geschichte des Rindes, II, 58.

Bos bison var. β LINNÉ, Syst. Nat., I, 99, 1766.—KALM, Travels in N. Amer. (Forster's Transl.), I, 297.

Bos bison SCHINTZ, Synop. Mam., 482, 1845 (in part only).

"*Bos urus* var. BODD., Elen. Anim., 1784."

Bos bonasus BRANDT, Zoogeographische und Palæontologische Beiträge, 105, 1867 (in part only).—LILLJEBORG, Fauna öfvers Sveriges och Norges Ryggrad., I, 877, 1874 (in part only).

Taurus mexicanus HERNANDEZ, Mexico, 587.

Taurus quivirensis NIEREMB., Hist. Nat., 181, 182.

Le Bison [*d'Amérique*], BUFFON, Hist. Nat., XI, 284, Suppl. III, pl. v.—F. CUVIER & GEOFFROY, Hist. Nat. des Mam., I, livr. xii, 1819; II, livr. xxxii; III, livr. xliv.—G. CUVIER, Reg. Anim., I, 170, 1817; Oss. Foss., 3d Ed., IV, 117, 1825.

American Bison, AGASSIZ, Proc. Bost. Soc. Nat. Hist., XI, 316, 1867.

Buffalo, COOPER, Month. Am. Journ. Geol., 1831, 174, 207 (remains at Big-bone Lick).—KNIGHT, Amer. Journ. Sci., XXVII, 166, 1835 (remains at Big-bone Lick).—LYELL. Proc. Geol. Soc. London, IV, 36, 1843 (remains at Big-bone Lick).

Description.—An adult measures about nine feet (two and three fourths metres) from the muzzle to the insertion of the tail, and thirteen and a half feet (about four and one sixth metres) to the end of the tail, including the hairs, which extend about fifteen inches beyond the vertebræ. The female measures about six and a half feet (about two metres) from the muzzle to the insertion of the tail, and about seven feet (two and one sixth metres) to the end of the tail, including the hairs, which extend about ten inches beyond the vertebræ. The height of the male at the highest part of the hump is about five and a half to six feet (about two metres); of the female at the same point about five feet (about one and a half metres). The height of the male at the hips is about four and two-thirds feet (nearly one and a half metres); of the female at the same point about four and a half feet (about one and a third metres). Audubon states the weight of old males to be nearly two thousand pounds, that of the full-grown fat females to be about twelve hundred pounds.

The horns of the males are short, very thick at the base, and rapidly taper to a sharp point, which in old individuals becomes worn off on the lower side, and the end is often shortened by the same process and occasionally much splintered. Their direction is outward and upward, finally curving inward. The horns of the females are much smaller at the base but nearly as long as in the males, but they taper very gradually, and are hence much slenderer, and are rather more incurved at the tips, where they are rarely abraded as in the males. The hoofs are short and broad, those of the fore feet abruptly rounded at the end; those of the hind feet are much narrower and more pointed. The muffle is broad and naked, having much the same form as in the domestic ox. The short tail has the long hairs restricted to a tuft at the end.

In winter the head, neck, legs, tail, and whole under parts, are blackish-brown; the upper surface of the body lighter. The color above becomes gradually lighter towards spring; the new short hair in autumn is soft dark umber or liver-brown. In very old individuals the long woolly hair over the shoulders bleaches to a light yellowish-brown. Young animals are generally wholly dark brown, darkest about the head, on the lower surface of the body, and on the limbs. The young calf is at first nearly uniform light chestnut-brown, or yellowish-brown, with scattered darker hairs on the belly, where are also occasionally small patches of white. Toward autumn the light yellowish color is replaced by the darker brown that characterizes the older animals. After the first few months the younger animals are darker than they are later in life, at middle age the coat, especially over the shoulders, becoming lighter and presenting a bleached or faded appearance, which increases with age. The horns, hoofs, and muffle are black, the hoofs being sometimes edged or striped with whitish. There are no important sexual differences in color.

The woolly hair over the shoulders is much longer and more shaggy than elsewhere on the body; it increases in length on the neck above, gradually losing its woolly character, and between the horns attains a length of ten to fourteen inches, nearly concealing the ears and the bases of the horns, and often partly covers the eyes. The long hair advances also on the face, where it decreases in length and becomes more woolly again, extending far forward in a pointed area nearly to the nose. The chin and throat are also covered with long hair, which under the chin forms an immense beard, eight or ten inches to a foot or more in length. Thick masses of long hair also arise from the inner and posterior surfaces of the upper part of the fore legs, where the hair often attains a length of six or eight inches. A strip of long hair also extends along the crest of the back nearly to the tail. The tail is covered with only short soft hair till near the tip, from which arises a tuft of coarse long hair twelve to eighteen inches in length. The hinder and lower portions of the body and legs are covered with short soft woolly hair. This is moulted early in spring, after which for a few weeks the hinder portions of the animal are quite or nearly naked. The shoulders retain permanently the long shaggy covering, which with the long hair of the neck and head gives them, especially during the moulting season, a singularly formidable aspect.

The female, as already stated, is much smaller than the male, with a less elevated hump, much smaller, slenderer, and more curved horns, less heavily developed beard, less shaggy head, etc., but presents no essential differences in color.

Albinism and Melanism.—Pied individuals are occasionally met with, but they are of rare occurrence.* I have seen but a single specimen, the head of which, finely mounted, is now in the Museum of Comparative Zoölogy. I obtained it of hunters at Fort Hays, Kansas, near which place it was taken in 1870, where it was regarded as a great curiosity. In this specimen, a female, the whole face, from between the horns to the muzzle, is pure white, but in other respects does not differ from ordinary examples. White individuals are still more rare, but are not unknown. A former agent of the American Fur Company, who had had unusually favorable opportunities of judging, informed me that they probably occur in the proportion of not more than one in millions, he having seen but five in an experience of twenty years, although he had met with hundreds of pied ones. Black ones are rather more frequent, but can only be regarded as very rare. The fur of these is usually much softer and finer than that of ordinary individuals, and black robes, from this fact and their great rarity, bring a very large price. They seem to be more frequent at the northward than elsewhere.

Varieties.—There are two commonly recognized varieties of the buffalo, known respectively as the *wood buffalo* and the *mountain buffalo*. The wood buffalo is described by Hind† as larger than the common bison of the plains, with very short soft pelage and soft short uncurled mane, thus more resembling in these points the Lithuanian bison or aurochs. It is said to be very scarce, and to be found only north of the Saskatchewan and along the flanks of the Rocky Mountains, and to never venture into the plains. A supposed variety of the bison, referred to by some of the northern voyagers as occurring north of Great Slave Lake, and known only from vague rumors current among the natives, is in all probability the musk ox (*Ovibos moschatus*).

The mountain bison, so often referred to by hunters and mountaineers as a variety or perhaps a distinct species, seems to agree in all essential particulars with the so-called wood bison of the region farther north. The same characters of larger size, darker, shorter, and softer pelage, are usually attributed to it, but one meets with such different, exaggerated, and contradictory accounts of its distinctive features from different observers, that it is almost impossible to believe in its existence, except in the imaginations of the hunter and adventurer. I have found that those actually conversant with it, and whose opinions in general matters are most entitled to respect, regard it as but slightly or not at all different from the bison of the plains. Others who know it only from hearsay, and whose notions of it are consequently vague, generally magnify its supposed differences, till some do not hesitate to declare their belief in it as a specifically distinct animal from the common bison of the plains.† Dr. Cooper, speaking of the bisons found formerly in

* See Long's Expedition to the Rocky Mts., Vol. I, p. 471.

† Hind (H. Y.), Nar. of Canadian Red River Explor. Exped., etc., Vol. II, pp. 106, 107, 1860.

† See Bulletin Essex Institute, Vol. VI, p. 55, 1874.

the mountain valleys about the sources of the Snake River, says he "saw no difference in the skulls, indicating a different species, or 'mountain buffalo' of hunters."* The bisons formerly living in the parks and valleys of the central portion of the Rocky Mountain chain doubtless did often grow to a larger size than those of the plains, with rather larger horns, and, being less subjected to the bleaching effects of the elements in their partially wooded retreats, would naturally have a darker and perhaps softer pelage. The weathered bison skulls I met with in 1871 in the upper part of South Park and in the vicinity of the tree-limit in the Snowy Range of Colorado were certainly larger, in the average, by actual measurement, than those of the Kansas plains. The small bands now lingering here and there in the mountains, and now currently known as the mountain buffalo, may be in part the remnants of a former larger mountain form, but certainly a part of them are actually recent migrants from the plains. In 1871 I was able to trace the migration of a small band up the valley of the South Platte and across South Park to the vicinity of the so-called Buffalo Spring, situated considerably to the southward of Fairplay. Specimens of the "mountain bison" sent in a fresh state from Colorado to the Smithsonian Institution during the present winter (December, 1875) certainly presented no appreciable differences from winter specimens from the plains. The mountain race of the bison was apparently a little larger than the buffalo of the plains, and doubtless was nearly identical with the race known farther northward as the "wood buffalo." Their more sheltered and in some other respects somewhat different habitat would tend to develop just the differences claimed to distinguish the mountain and northern woodland race.

Castrated buffaloes are said to be occasionally met with where the buffaloes are abundant, being castrated when quite young by hunters. They are reported to attain an immense size, being so much larger than the others as to be conspicuous from their large size.

Relationship to the Aurochs.—The American bison is a little smaller than the aurochs (*Bison bonasus*), with a much larger chest, a smaller and weaker pelvis, a shorter and smaller tail, more shaggy head, and heavier beard. The more important differences, as shown by a comparison of the skeletons, consists in the chest (see subjoined measurements, Table I) in *Bison americanus* being absolutely larger than in *Bison bonasus*, while the pelvis is very small and weak. The *B. americanus* is hence greatly developed anteriorly, or in the thoracic portion of the body, with the pelvic portion disproportionately reduced, while in *B. bonasus* just the reverse of this obtains—a small compressed thorax and a strong heavy pelvis. This gives the aurochs the appearance of standing higher on its legs. The dorsal outline is about equally declined posteriorly in each species, *not* relatively much more declined in *B. americanus*, as generally stated. Neither does the aurochs possess relatively longer hind limbs, as compared with the fore limbs, than *B. americanus*, the proportion being essentially the same in the two, whether the total height of the animal be assumed as the basis of comparison, or whether the comparison be based on the bones of the limbs alone.

Comparing, for example, a fine perfect skeleton of a very large old male of each species, beautifully and correctly mounted,† the height of

*Amer. Nat., Vol. II, p. 538, 1868.

† These skeletons are Nos. 91 (*Bison americanus*) and 165 (*Bison bonasus*) of the osteological collection of the Museum of Comparative Zoölogy, both of which were prepared and mounted in the same manner by the same persons, under the supervision of Prof. H. A. Ward, of Rochester, and represent two pieces of his best osteological work, which is justly celebrated for its neatness and accuracy.

the American bison at the highest dorsal spine is found to be sixty-six inches; at the anterior end of the sacrum, fifty-two inches; which makes the proportion between the two measurements as 80 to 100. The height of the aurochs at the highest dorsal spine is seventy-three inches; at the anterior end of the sacrum, sixty inches; making the proportion between the two measurements as 82 to 100. This difference is not greater than often occurs between two individuals of the same species. A comparison of the anterior and posterior limbs gives a similar result. Thus the proportionate length of the fore limb (excluding the scapula) to the hind limb, in the American bison, is the some as that in the aurochs, namely, as 91 to 100.

While the skeleton of the aurochs is, generally speaking, heavier and more massive than that of the American bison, and considerably larger in all its measurements, the ribs are actually much shorter and straighter, giving a *much smaller thoracic cavity.* The length of the first rib in *B. americanus*, for example, is 452 mm.; in *B. bonasus*, 375 mm.; of the third rib in *B. americanus*, 548; in *B. bonasus*, 492; of the sixth rib in *B. americanus*, 711; in *B. bonasus*, 697; of the ninth rib in *B. americanus*, 910; in *B. bonasus*, 869; of the twelfth rib in *B. americanus*, 783; in *B. bonasus*, 750; of the fourteenth rib (osseous portions only), in *B. americanus*, 437; in *B. bonasus*, 418. The pelvis, on the other hand, is fully one-fourth larger in all its dimensions, and the bones that enter into its composition are far more massive in the aurochs than in the American bison. The smaller size of the posterior part of the vertebral column in the American bison is also further seen in its diminutive tail as compared with that of the aurochs. Among other noticeable skeletal differences are the relatively greater length of the dorsal series of the vertebræ, and shorter sternum of the American bison.

While the above-given comparisons are based on a single skeleton of each species, the subjoined measurements (see Table I) shows that these conclusions are borne out by further material.

As already noticed (p. 2[*]), the American bison is *not* distinguished from the aurochs by the possession of fifteen pairs of ribs and only four lumbar vertebræ, as was formerly supposed, and as has been so often stated, the two species having normally the same number of lumbar vertebræ and the same number of pairs of ribs. Professor Rütimeyer† refers to the greater length of the anterior dorsal spines in *Bison americanus*, but this difference is evidently not constant, as is shown by the measurements given in Table I. He also regards the differences in the relative length of the different segments of the extremities to each other and to the whole height of the animal as affording differences worthy of note. He gives a table illustrative of these differences, which I subjoin. He says: "Nahm ich die Lärge von Metacarpus und Carpus zusammen als Einheit, so verhielten sich dazu die andern Segmente der Extremitäten folgendermassen:

	Bison americanus.		B. europæus.	
"Carpus—Metacarpus	1.	3.387 (1.)	1.	3.697 (1.)
Radius (Aussenseite)	1.102		1.254	
Humerus mit Trochanter	1.285		1.443	
Scapula vorderer Rand	1.795		1.843	
Metacarpus mit Naviculare	1.151	3.999 (1.180)	1.098	4.489 (1.214)."
Tibia aussen	1.379		1.588	
Femur mit Trochanter	1.469		1.803	

Taking the same method of comparison with five specimens of *B. americanus* and two specimens of *B. bonasus* (=*europæus*) as a basis, gives

[* Of the original edition.—Ed.]

† Versuch einer natürlichen Geschichte des Rindes, etc., Part II, p. 68.

proportions not differing essentially from Rütimeyer's, though the figures range ten to fifteen per cent. larger, being probably based on larger specimens.

Carpus and Metacarpus	1.	3.680 (1.)	1.	3.901 (1.)
Radius	1.260		1.327	
Humerus (with Trochanter)	1.420		1.574	
Scapula	1.940		1.836	
Metacarpus	1.400	4.800 (1.130)	1.364	4.834 (1.155)
Tibia	1.680		1.727	
Femur (with Trochanter)	1.720		1.743	

The differences between the two species in these proportions are very slight, scarcely greater in fact than occur between different individuals of *Bison americanus*.

Dr. J. E. Gray placed the aurochs and American bison in different sections of the genus *Bison*, the first of which, containing the aurochs, is characterized as having the "tarsi elongate, fore and hind quarters subequal," and the other, containing the American bison, as having the "tarsi short, hinder quarters very low." In the description of the aurochs he says again, "fore and hind legs subequal; tarsi elongate," contrasting it with "tarsus short, hinder quarters very low," in his diagnosis of *Bison americanus*. The difference in height between the fore and hind quarters of the aurochs and American bison is, as already shown, more apparent than real, owing to the greater size of the pelvic region in the aurochs. The difference in the relative length of the tarsus is also much less than one might infer from Dr. Gray's diagnosis.

In *Bison americanus* the proportional length of the metatarsal bone to the length of the femur and tibia taken together is (in five specimens) as 29–31 to 100; in *Bison bonasus* (two specimens), as 28 to 100, showing an actual slightly greater length of the metatarsal segment in *Bison americanus*. The length of the carpus and metacarpus in *B. americanus* (same specimens) to the length of tarsus and metatarsus is as 74 to 100; in *Bison bonasus*, as 73 to 100. The length of the upper portion of the fore limb (humerus and radius) to the upper portions of the hind limb (femur and tibia) in *B. americanus* (same specimens as before) is as 75–83 to 100; in *B. bonasus*, as 80–84 to 100. These proportions coincide with those obtained from comparing the entire fore and hind limbs with each other, as well as the relative height of the animal at the shoulder and hip (as previously given); and show a slightly greater average relative length of the hind limb in *B. bonasus* as compared with *B. americanus*. The differences, however, are really much less than different individuals of either species present when compared with each other.

TABLE I.[*]—*Measurements of Skeletons of Bison americanus and Bison bonasus.*

	Bison americanus.						Bison bonasus.		
	1	2	3	4	5	6	7	8	9
	♂	♂	♂	♂	♀	♀	♂	♂	♂
Whole length of skeleton (including skull)	3338	2980	2916	2920	3120	2789	3375	3416	.....
Length of skull	527	530	565	510	500	422	580	565	569
Length of cervical vertebræ	527	470	430	480	520	457	590	538	?433
Length of dorsal vertebræ	1150	950	900	880	1000	868	940	985	.....
Length of lumbar vertebræ	407	340	330	380	370	357	390	400	.....
Length of sacral	254	190	210	250	245	228	315	293	.....
Length of caudal	476	500	480	420	485	457	560	635	.....
Length of first rib	452	350	380	.....	.....	287	345	375	.....
Length of first rib, osseous portion, along external curvature	414	300	330	300	320	274	305	335	.....

[* Table IX of the original.—ED.]

TABLE I.—*Measurements of Skeletons of Bison americanus and Bison bonasus*—Continued.

	Bison americanus.						Bison bonasus.		
	1	2	3	4	5	6	7	8	9
	♂	♂	♂	♂	♀	♀	♂	♂	♂
Length of first rib, cartilaginous portion	38	50	50	....	....	31	40	39	....
Length of third rib	548	....	510	....	....	450	479	492	....
Length of third rib, osseous portion	439	385	420	390	430	361	386	418	....
Length of third rib, cartilaginous portion	115	....	90	....	....	88	93	100	....
Length of sixth rib	711	....	700	....	....	632	640	699	....
Length of sixth rib, osseous portion	557	550	560	550	580	503	525	559	....
Length of sixth rib, cartilaginous portion	154	....	140	....	....	122	115	140	....
Length of ninth rib	910	....	920	....	....	780	785	869	....
Length of ninth rib, osseous portion	670	630	680	635	680	584	600	660	....
Length of ninth rib, cartilaginous portion	240	....	240	....	....	198	185	210	....
Length of twelfth rib	783	....	820	....	....	745	730	750	....
Length of twelfth rib, osseous portion	540	580	590	575	610	532	540	530	....
Length of twelfth rib, cartilaginous portion	243	....	230	....	....	215	190	220	....
Length of fourteenth rib	693	....	710	....	....	593	585	....	....
Length of fourteenth rib, osseous portion	437	490	520	450	460	396	420	418	....
Length of fourteenth rib, cartilaginous portion	254	....	190	....	....	197	165	....	....
Length of sternum	469	490	480	490	475	463	510	533	....
Length of spine of sixth cervical	114	110	150	90	103	76	180	120	90
Length of spine of seventh cervical	305	260	370	330	347	244	395	287	266
Length of spine of first dorsal	468	470	475	445	453	330	395	470	423
Length of spine of second dorsal	477	485	465	430	440	342	420	496	440
Length of spine of third dorsal	445	435	430	400	406	317	393	470	435
Length of spine of fourth dorsal	400	420	390	360	370	305	370	437	410
Length of spine of fifth dorsal	348	390	350	320	335	287	330	397	371
Length of spine of sixth dorsal	350	355	315	290	300	248	300	363	343
Length of spine of seventh dorsal	315	310	290	260	265	244	275	325	300
Length of spine of eighth dorsal	284	285	260	235	250	223	240	293	290
Length of spine of ninth dorsal	242	245	225	210	213	197	210	267	247
Length of spine of tenth dorsal	210	210	200	180	185	170	170	217	228
Length of spine of eleventh dorsal	173	185	165	155	160	153	155	185	190
Length of spine of twelfth dorsal	146	155	140	130	135	128	145	146	154
Length of spine of thirteenth dorsal	120	120	120	110	118	116	125	134	....
Length of spine of fourteenth dorsal	108	100	110	100	106	101	90	127	127
Distance between ends of pleurapophyses of first lumbar	227	310	280	230	230	268	258	279	297
Distance between ends of pleurapophyses of second lumbar	310	335	305	300	314	276	296	325	348
Distance between ends of pleurapophyses of third lumbar	356	365	330	333	345	293	345	363	375
Distance between ends of pleurapophyses of fourth lumbar	360	365	340	350	373	315	367	387	381
Distance between ends of pleurapophyses of fifth lumbar	309	295	300	326	350	315	335	343	297
Transverse diameter of proximal end of first sacral	240	....	....	240	245	250	250	245	216
Length of innominate bone	515	560	500	510	550	449	590	647	571
Greatest (external) width of pelvis anteriorly	470	490	450	475	497	438	484	560	....
Distance between most lateral parts of posterior end of pubic bones	283	284	....	260	273	250	305	315	....
Length of ilium	283	290	290	265	290	258	320	338	320
Length of ischio-pubic bones	270	270	250	250	275	234	290	311	288
Length of thyroid foramen	115	....	....	115	116	110	115	118	114
Breadth of thyroid foramen	63	....	....	70	73	70	74	76	65
Breadth of scapula	483	470	460	480	500	427	500	508	478
Breadth of scapula at proximal end	287	270	235	270	284	217	285	310	....
Length of humerus	330	365	365	350	383	325	395	433	..
Antero-posterior diameter of the proximal end	158	....	....	142	145	128	150	158	....
Transverse diameter of the proximal end	128	....	....	117	130	113	120	134	....
Greatest breadth of its distal end	110	....	....	88	96	82	90	168	105
Least circumference of its shaft	185	177	183	170	196	141	162	174	190
Length of radius	313	315	320	310	320	295	365	364	340
Transverse diameter of proximal end	100	....	....	95	93	84	95	105	....
Transverse diameter of distal end	94	....	....	88	88	71	96	90	....
Length of ulna	437	415	420	410	418	381	435	520	457
Length of its olecranon	148	130	120	133	140	114	165	270	....
Least breadth antero-posteriorly	74	....	....	65	65	65	68	73	....
Length of carpus	53	50	55	50	62	36	60	51	....
Length of canon bone	197	205	200	200	204	190	220	218	195
Width of proximal end	78	....	....	72	75	63	81	88	78
Width of distal end	80	....	....	76	83	62	71	76	74
Length of inner metatarsal	44	....	....	40	48	36	43	70	62
Length of first phalanx (fore limb)	68	60	55	57	64	61	74	74	....
Width of first phalanx, proximal end	43	....	....	39	43	28	57	43	....
Width of first phalanx, distal end	40	....	....	36	41	27	37	42	....
Length of second phalanx	40	40	40	35	38	40	43	44	....
Width of second phalanx, proximal end	44	....	....	35	40	32	38	42	....
Width of second phalanx, distal end	41	....	....	31	37	31	34	35	....
Length of unguinal phalanx, inner side	63	60	60	53	62	55	52	74	....
Length of femur	431	425	430	420	400	367	496	470	478

TABLE I.—*Measurements of Skeletons of Bison americanus and Bison bonasus*—Continued.

	Bison americanus.						Bison bonasus.		
	1	2	3	4	5	6	7	8	9
	♂	♂	♂	♂	♀	♀	♂	♂	♂
Greatest diameter of proximal end	160	.....	.....	145	140	134	145	150	...
Greatest diameter of distal end	120	.....	.....	110	112	110	116	125	...
Least circumference of shaft	158	150	160	142	145	132	165	177	...
Least diameter of shaft	46	.....	.....	43	44	40	44	49	48
Length of tibia	427	395	380	380	390	364	465	476	478
Transverse diameter of proximal end	127	.....	.....	118	110	108	122	130	125
Transverse diameter of distal end	78	.....	.....	74	73	70	74	83	....
Its least circumference	148	.....	.....	140	144	128	160	159	....
Length of tarsals in situ (inside)	101	90	.....	90	105	69	107	108	....
Length of calcaneum (outside)	155	.....	.....	145	160	145	173	181	163
Least circumference of its shaft	120	.....	.....	110	118	97	113	127	128
Length of metatarsal	250	243	.....	248	245	153	264	267	249
Transverse (lateral) diameter of proximal end	65	.....	.....	55	58	51	68	68	....
Transverse antero-posterior diameter of proximal end	55	.....	.....	50	57	47	59	58	....
Transverse (lateral) diameter of distal end	70	.....	.....	65	70	62	70	68	65
Transverse antero-posterior diameter of distal end	36	.....	.....	36	39	31	33	38	....
Least (lateral) diameter of its shaft	35	.....	.....	34	35	30	43	44	40
Length of first phalanx (hind limb)	75	73	65	60	66	40	73	82	76
Width transversely of proximal end	38	.....	.....	34	35	28	34	38	38
Width of distal end	37	.....	.....	33	35	27	33	37	37
Length of 2d phalanx	44	40	45	37	41	39	46	50	51
Width of proximal end	38	.....	.....	33	35	32	35	38	37
Width of distal end	32	.....	.....	27	32	30	30	28	34
Length of unguinal phalanx, inner side	63	80	65	55	66	57	62	70	55

EXPLANATION OF TABLE I.

1. *Bison americanus.* Male, mounted skeleton (No. 91, Mus. Comp. Zoölogy), from near Fort Hays, Kansas.
2. *Bison americanus.* Very old male, unmounted skeleton, the bones mostly ligamentously attached (Mus. Comp. Zoölogy), from near Fort Hays, Kansas.
3. *Bison americanus.* Very old male, unmounted skeleton, the bones mostly ligamentously attached (Mus. Comp. Zoölogy), from near Fort Hays, Kansas.
4. *Bison americanus.* Male, disarticulated skeleton (No. 10, Mus. Comp. Zoölogy), from near Fort Hays, Kansas.
5. *Bison americanus.* Female, disarticulated skeleton (No. 11, Mus. Comp. Zoölogy), from near Fort Hays, Kansas.
6. *Bison americanus.* Female, mounted skeleton (No. 92, Mus. Comp. Zoölogy), from near Fort Hays, Kansas.
7. *Bison bonasus.* Old male, mounted skeleton (No. 165, Mus. Comp. Zoölogy), from the Menagerie of Schœnbrunn, received from the Vienna Museum.
8. *Bison bonasus.* Young male, mounted skeleton (No. 11,514, National Museum, Washington), from the Vienna Museum.
9. *Bison bonasus.* Male (measurements from Richardson's Zoölogy of the Voyage of the Herald).

[Measurements in millimetres.—ED.]

The skull of *Bison bonasus* is rather longer perhaps than that of *Bison americanus*, but the average difference in length is very slight. It would be often, in fact, almost impossible to decide absolutely as to whether a skull from an unknown locality belonged to one rather than to the other of the two species, especially those of young individuals or females. Neither the teeth nor the relative size and form of any portion of the skull afford any absolutely distinctive characters. The chief difference consists in the rather more massive character of the skull in *Bison bonasus*. The close resemblance in all essential features between the skulls of the two species is sufficiently indicated in the subjoined table of measurements of a considerable number of skulls of each species.

The greater prominence and thickness of the orbital cylinder in the aurochs has been cited by Rütimeyer as a distinctive feature of the aurochs, but in a comparison of skulls of corresponding ages the difference is not apparent, the slightly greater size and thickness corresponding merely with the generally more massive character of the osseous system of the aurochs. The difference in the nasal bones referred to also by the same author is intangible, being equalled in different individuals of *Bison americanus*.

TABLE II.[*]—*Measurements of twenty-two Skulls of Bison americanus and of five Skulls of Bison bonasus.*

	Bison americanus.																						Bison bonasus.				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	♀	♀	♀	♀	♀	♀	♀	♂	♂	♂	♂
Anterior border of premaxillæ to occipital crest	550	514	530	550	550	525	505	558	534	510	500	555	550	500	500	600	442	420	450	490	480	422	458	565	570	525	580
Anterior border of premaxillæ to anterior edge of orbits	280	290	290	275	273	273	250	270	270	267	265	275	270	250	250	323	240	220	240	253	255	260	230	290	305	....	305
Anterior end of nasal bones to occipital crest	458	463	440	460	452	430	420	460	440	425	415	440	437	420	....	445	368	350	370	390	378	410	393	484	427	....	440
Fronto-nasal suture to occipital crest	247	267	....	263	240	232	230	270	230	227	214	240	215	230	230	255	200	190	193	210	208	216	208	285	257	250	265
Anterior end of nasal bones to base of horn-cores	362	355	...	370	375	350	350	360	355	340	350	355	360	343	....	365	310	300	315	345	340	348	332	394	....	....	375
Breadth of forehead at narrowest point†	270	273	....	270	285	254	270	277	267	252	240	280	272	265	252	299	200	205	208	210	213	220	206	276	245	231	267
Distance between extreme outer edge of orbits	310	305	310	323	345	298	295	333	320	280	290	330	332	335	323	338	250	230	236	267	260	240	230	310	328	310	312
Distance between bases of horn-cores	266	267	280	280	300	268	284	296	272	260	255	280	286	263	271	283	205	210	214	214	213	220	205	278	282	230	270
Width of skull at the auricular openings	240	267	250	272	270	238	220	273	253	227	238	277	267	260	260	280	174	186	190	226	214	203	193	254	258	240	245
Length of horn-cores measured along upper side	204	197	200	200	215	203	220	196	185	157	146	180	210	176	175	....	145	135	195	132	133	133	153	190	230	....	270
Length of a line connecting base and tip	190	163	....	195	200	178	175	176	173	130	132	162	178	161	170	....	125	120	134	125	130	127	127	177	....	....	240
Circumference of base of horn-core	254	254	....	255	260	200	214	240	235	195	200	217	233	255	240	300	138	135	158	163	165	155	178	240	242	....	260
Distance from mesial plane of skull to tip of horn-core	330	298	....	328	350	314	317	327	298	253	267	300	330	300	290	....	220	205	230	235	233	248	216	320	....	....	310
Distance between extreme tips of horn-cores	620	584	....	640	680	575	575	615	590	484	515	565	620	585	560	....	418	362	425	468	450	490	395	647	622	...	560
Length of nasals	204	194	195	194	210	205	192	187	197	187	200	195	193	185	....	200	170	163	168	185	172	195	185	220	174	200	183
Greatest breadth of one nasal	60	55	....	57	65	55	53	58	53	57	52	62	55	57	....	65	44	46	46	52	46	49	38	52	52	....	45
Breadth of palatines opposite second true molar	108	110	....	100	103	104	97	112	104	80	93	102	96	106	98	113	89	88	90	88	92	102	88	105	102	....	96
Greatest height of skull	158	150	....	154	162	160	152	162	170	147	144	165	168	156	148	117	140	130	137	156	142	146	133	168	....	....	167
Length of molar series of maxilla	140	154	....	140	147	150	152	140	134	148	140	150	135	138	145	143	150	130	152	138	136	146	140	148	142	....	152
Length of lower jaw from tip to angle	420	406	400	...	410	400	320	400	400	390	397	410	413	....	....	416	365	352	360	382	380	385	369	433	385	....	408
Height of lower jaw from tip to angle	217	215	200	....	210	215	195	200	208	197	200	215	200	....	....	225	180	170	190	195	495	207	165	230	....	....	203
Length of molar series of lower jaw	155	165	....	....	156	156	160	153	147	160	153	153	148	....	....	146	158	....	....	147	145	155	153	158	157	....	157

[* Table X of the original.—ED.]

† Between orbits and base of horn-cores.

EXPLANATION OF TABLE II.

1. *Bison americanus.* A very old male from Kansas (M. C. Z., No. 95).
2. *Bison americanus.* Male, ten to twelve years old, from Kansas (M. C. Z., No. 91).
3. *Bison americanus.* Very old male, from Kansas.
4. *Bison americanus.* Very old male, from Kansas (M. C. Z., No. 93).
5. *Bison americanus.* Male, about fifteen years old, from Kansas (M. C. Z., No. 10).
6. *Bison americanus.* Male, about six years old, from Kansas (M. C. Z., No. 11).
7. *Bison americanus.* Male, about four years old, from Kansas (M. C. Z., No. 94).
8. *Bison americanus.* Male, about ten years old, from Kansas (M. C. Z., No. 97).
9. *Bison americanus.* Male, about twelve years old, from Kansas (M. C. Z., No. 99).
10. *Bison americanus.* Male, four or five years old, from Kansas (M. C. Z., No. 100).
11. *Bison americanus.* Male, about six years old, from Kansas (M. C. Z., No. 102).
12. *Bison americanus.* Male, about twelve years old, from Kansas (M. C. Z., No. 1770).
13. *Bison americanus.* Male, about twelve years old, from Kansas (M. C. Z., No. 1771).
14. *Bison americanus.* Male, about twelve years old, from Kansas (M. C. Z., No. 1215).
15. *Bison americanus.* Male, about fifteen years old, from Kansas (M. C. Z., No. 1216).
16. *Bison americanus.* Male, ten or twelve years old, from Kansas (National Mus., No. 12233).
17. *Bison americanus.* Female, four or five years old, from Kansas (M. C. Z., No. 1937).
18. *Bison americanus.* Female, about three years old, from Kansas (M. C. Z., No. 1768).
19. *Bison americanus.* Female, about three years old, from Kansas (M. C. Z., No. 96).
20. *Bison americanus.* Female, about nine years old, from Kansas (M. C. Z., No. 101).
21. *Bison americanus.* Female, about six years old, from Kansas (M. C. Z., No. 105).
22. *Bison americanus.* Female, about six years old, from Kansas (M. C. Z , No. 92).
23. *Bison bonasus.* Female, about five or six years old (M. C. Z., No. 1790).
24. *Bison bonasus.* Old male, from Menagerie of Schœwbrunn (M. C. Z., No. 165).
25. *Bison bonasus.* Male. Measurements, as given by Richardson, in Zoöl. Voy. of theHerald, p. 122.
26. *Bison bonasus.* Old male, from Schœnbrunn. Measurements as given by Cuvier (Ossem. Foss., 3d ed., Tome IV, p. 121).
27. *Bison bonasus.* Male, about six years old, from the Vienna Museum (National Mus., No. 11514).

Individual variation.—The American bison presents a considerable range of what may be termed individual variation. This has already been noticed in respect to the metacarpal bones, where it was shown that not always the thickest and stoutest examples are the longest. Thus a metacarpal of a male 192 mm. in length exceeds in all other dimensions another specimen having a length of 213 mm. A similar difference is traceable throughout the skeleton (see Table I), so that we have individuals that present in all parts of their structure a slender or attenuated form, and others that are relatively thick and stout, the tallest and longest specimens being sometimes exceeded in stoutness, comparing bone with bone, by those of considerably less stature. There are again individuals that differ from the average in general bulk, without presenting any other unusual differences. Variations in the relative length of the different bones of the limbs, of the ribs, the dorsal spines, etc., are of frequent occurrence. As such variations are now so well known to characterize vertebrates in general,—each species having a considerable normal range of osteological variation,—they may be passed over without further remark.

Among more unusual variations are the occasional development of an extra rib, or an extra pair of ribs, which may articulate either with the last cervical or the first lumbar vertebra. A famous instance of the latter was presented by a specimen described by Cuvier (the first skeleton of the American bison that came under the eye of an osteologist), which had fifteen pairs of ribs, and only four, instead of five, lumbar vertebræ [original edition]. The mistake to which this abnormal specimen gave rise in respect to the number of dorsal and lumbar vertebræ and the number of pairs of ribs possessed by the American bison as compared with the aurochs, has already been noticed,—a mistake that still survives in some of our leading text-books of comparative anatomy. In the Museum of Comparative Zoölogy is a male from Kansas possessing a supplemental pair of ribs which articulate with the last cervical vertebra, instead of with the first lumbar, as in the case of Cuvier's specimen.

Variations in the form of the skull are often strikingly apparent, affecting not so much, however, the relative size of the different parts, or the proportion of width to length, as the frontal outline or profile, and the curvature and relative direction of the horns. In respect to the profile, the frontal region varies in different specimens of the same sex and of corresponding ages in the forehead being either flat, or even slightly concave, or very convex. The horns are usually so much depressed that when the skull is placed on a flat surface with the dorsal aspect downward the points will not touch the surface on which the skull rests,—in other words, do not rise to the plane of the forehead; in other specimens they sometimes rise so high as to prevent the skull from touching the flat surface by a space of one or two inches. The horn-cores are also sometimes directed backward far beyond the plane of the occiput, though usually not reaching it. Such differences as these are so considerable that they are sometimes, in allied groups, regarded as indicative of specific differences.

The variation in length in a series of a dozen aged male skulls ranges from 500 to 600 mm., but the usual range of variation is between 500 and 550 mm. The extremes in breadth are 240 and 280 mm., ranging usually between 240 and 275 mm. The lower jaw varies in length in the same series from 400 to 420 mm.; the nasals from 194 to 204 mm.; the horn-cores from 180 to 215 mm. The length of the alveolar space of the upper molars varies from 138 to 154 mm.; of the lower, from 148 to 165 mm. The variation in the length of the alveolar space in the females overlaps that of the males, the length of the lower molar series ranging from 145 to 158 mm., and that of the upper molar series from 136 to 152 mm. It thus appears that in respect to the size of the teeth the sexual difference is not very great,—far less than that between other parts of the skull and skeleton.

The individual variation in respect to the horns themselves, in size and direction of curvature, is well worthy of special notice. Of two males of nearly corresponding ages, one has horn-cores measuring 220 mm. in length, the other only 146 mm. The variation in the circumference at the base ranges from 235 to 300 mm. In respect to curvature, the horns are sometimes gently curved the whole length, and sometimes abruptly bent upward at the end of the basal third. They also vary greatly in size in individuals of corresponding ages. The difference in these respects between different individuals of *Bison americanus* is hence much greater than the average difference between *B. americanus* and *B. bonasus*.

Synonymy and Nomenclature.—The first systematic name applied to the American bison under the binomial system of nomenclature was *Bos americanus*, given it by Gmelin in 1788, the specific name being evidently adopted from Catesby, who in 1743 called it *Bison americanus*, as did also Brisson two years later. By this specific name, coupled with the generic appellation of either *Bos* or *Bison*, it has since been almost universally known, a few very conservative naturalists having always regarded it as either merely a variety of the aurochs or as absolutely identical with it. It hence forms almost the only exception among North American mammals of a species that has never had a prominent synonym. Hernandez refers to it under the name of *Taurus mexicanus*, but Hernandez wrote long prior to the establishment of the binomial system of nomenclature, as did also Nieremburg, who called it *Taurus quivirensis*, so that these names have never been regarded as having a claim to priority.

To the Spanish colonists the American bison was commonly known under the name of *Cibola*, but some Spanish writers speak of it under the name *Bisonte*, while De Laët and others called it *Armenta*. *Bœuf sauvage* was the name given it by Du Pratz, though often also called *Buffle*, *Vache sauvage*, and sometimes *Bison d'Amérique*, by the early

French colonists, while the Canadian *voyageurs* are said to term it simply *le bœuf*. Kalm spoke of the American bisons as *Wilde Ochsen und Kühe*, while the early English explorers also often referred to this animal under the same English equivalent, and also used for it the names *Buffle* and *Bœuf sauvage*. These two last-mentioned names were also applied, by both the early French and the early English explorers, to the moose (*Alces malchis*) and the elk (*Cervus canadensis*). Charlevoix called the bison the *Bœuf du Canada*. Marquette called it the *Pisikious*, adopting the name then current among the Illinois Indians, while Hennepin called it *Taureau sauvage*. Lawson and Bricknell used the name *Buffelo*, which name, modified to *Buffalo*, was employed by Catesby and was early adopted by the English colonists. According to Richardson it is called *Peecheek* by the Algonquins, *Adgiddah* by the Chepewyans, and *Moostoosh* by the Crees.

In the United States this animal has generally borne the name of *buffalo*, though discriminating writers persist that the name is erroneous, and that it should be called the *American bison*. The latter is undoubtedly its correct English cognomen, but probably among the people generally the name *buffalo* will never be supplanted. The term *American buffalo* is doubtless defensible for those who prefer it, and even *buffalo* is no more a misnomer than scores of the names of our common mammals and birds. The name *Robin* as applied to *Turdus migratorius*, is even more objectionable than that of *buffalo* as applied to the American bison. The name *buffalo* is of course strictly applicable only to the genus *Bubalus*, embracing the true African and Indian buffaloes.

Figures of the American Bison.—The first figure of the bison ever published is doubtless that given by Thevet in 1558,* three years after the publication of Vaca's "Journal," in which occurs the earliest description of the American bison. This is an extremely rude figure, having but little resemblance to the bison. In 1633 De Laët† published another equally faulty. Nieremburg§ in 1635, and Hernandez‡ in 1651, published others, which so much resemble Thevet's that they seem to be merely enlarged, slightly modified copies of it. Hernandez's figure, however, has been repeatedly referred to as the first published figure of the American bison. Towards the end of the seventeenth century a somewhat similar figure was published by Hennepin.§ During the eighteenth century others were added by Du Pratz, Lawson (in his "History of Carolina‖), Catesby,¶ Buffon,** and others, Catesby's and Buffon's being very fair representations of the animal intended, and are the first that attain a tolerable degree of accuracy.

The first good figures are those given by F. Cuvier and Geoffroy,†† consisting of a series of three, drawn from specimens living in the Menagerie at Paris. The first is that of a young male in summer pelage, the second that of a young female, and the third that of a calf a few weeks old. These are all very fine, especially in respect to color, in which they excel all others, those of Catlin and Audubon being of too dark a tint.

Catlin, in his "North American Indians" (Vol. I), devotes a series of fourteen spirited plates to the illustration of the American bison. The male is represented in plate vii of this work; the female in plate viii;

* Les Singularitz de la France Antarctique, p. 145. † Amer., p. 303. ‡ Hist. Nat., p. 181. § Mex., p. 587. ‖ Discovery of a Vast Country, etc., p. 90. ¶ Fig. 115. ** Nat. Hist. of Carolina, etc., pl. xx. †† Hist. Nat., Suppl., III, pl. v. ‡‡ Hist. Nat. des Mam., Tome I, livr. xii (young male); Tome II, livr. xxxii (young female); Tome III, livr. xlix (calf a few weeks old).

in plate ix is depicted a collision of a bull and a horse during a chase, and in plate x a wounded bull is represented. In plate cv is figured a herd in the rutting season; in plate cvi a herd at rest, with an old bull wallowing in the foreground; plates cvii to cxii form a series illustrating the hunting of the buffalo by the Indians; plates cxiii and cxiv represent buffaloes attacked by wolves.

Besides Audubon's* well-known figures, among those worthy of special notice are those in Schoolcraft's great work on the Indians,† in which in plate viii is given a comparative view of the buffalo and domestic cow; in plate ix, a view of a buffalo chase; in plate x, buffalo hunting in winter; in plate xi, a view of a large herd of buffaloes; in plate xii, another view of a large herd with an old bull in the foreground; plate xiii, buffalo skinning.

The earlier figures are of course noteworthy only as being the first attempts at delineating the American bison. Those by Catlin, on the other hand, truthfully and vividly depict scenes which, though formerly characteristic of our plains, will soon be known only in history, and are well worthy of consultation by any one interested in the subjects he there delineates. Audubon's illustrations are faithful likenesses, and the scenes and figures given in Schoolcraft's work may also be examined with profit; the most accurate figures, however, are those given by Cuvier and Geoffroy.

Fossil Remains.—The remains of the American bison in a fossil or semifossil condition have been found sparingly over a wide area, but no instance is at present known of their discovery beyond the known limits of its range at the time of the earliest explorations of the continent. In the National Museum at Washington are semifossil remains from Colorado, collected by Major Powell, and from Kansas, collected by Dr. Hayden. I found a fossil tooth of this species in Central Iowa, and have received from Mr. Orestes H. St. John a fossil astragalus from the banks of the Big Blue River in Kansas. Professor Wyman has reported its remains from the mounds of the Lead Region in Wisconsin and Iowa; Dr. Leidy has figured a tooth from the Lead crevices of Jo Daviess County, Illinois, and also from the Ashley River, South Carolina.‡ Professor Baird has reported the existence of its fossil remains in the caverns of Central Pennsylvania. The alleged occurrence of its remains at Gardiner, Maine, proves, however, to be probably erroneous, as will be shown further on.§

Its bones have also been found in large quantities about the Salt Licks of the Ohio Valley, especially at Big-bone Lick, Kentucky. The accumulations at the last-named locality date back to remote times, since in the lower strata of these bone-deposits are found the bones of *Mastodon americanus*, *Megalonyx*, *Elephas*, an extinct species of *Equus*, and an extinct species of *Ovibos*, but, according to Professor Shaler, the bones of *Bison americanus* occur only in the more superficial strata, which are composed almost solely of the remains of this animal. These remains differ in no appreciable respect, in form or in size, from those of the recent bison of the Plains.|| The only

* Quad. North America, Vol. II, pls. lvi, lvii.

† Hist. Prosp. & Cond. Indian Tribes of North America, Vol. IV, pls. viii–xiii.

‡ In both instances doubtfully referred by Dr. Leidy to *Bison latifrons*.

§ See the chapter on the Geographical Distribution of the American Bison.

|| A skull from Big-bone Lick (No. 2047, M. C. Z.) presents the greatest convexity of the forehead of any I have met with, but does not differ in other respects from ordinary examples. On the other hand, other Big-bone Lick skulls exhibit the usual degree of flatness. No. 2050 has unusually large horn-cores, but is not in other respects distinguishable from average recent examples.

difference of note consists in the very different manner of the wearing of the molar teeth. In the recent bison of the Plains, the crowns of the teeth present a nearly even surface, every part of the tooth being worn to nearly the same level. In the remains from Big-bone Lick, however, the crown surface wears into a series of deep transverse serrations, the ridges of which often rise a fourth of an inch above the intervening hollows. The difference between the two in this respect is strikingly great, and evidently relates to the different character of the food obtainable in the two districts. The bison of the Plains necessarily feeds wholly upon short, fine grasses, which rarely attain a height of more than a few inches, and are consequently at times more or less sprinkled with sand and dust. The Ohio Valley, on the contrary, is a region of rank herbage, and tall, succulent grasses. The Plains bison must take with its food more or less gritty material,* which tends not only to wear the teeth down evenly, but far more rapidly than was the case in the Ohio Valley, the teeth in the Plains bisons generally being very much worn, even in middle-aged animals, while in very old animals the teeth are often worn down to the fangs. Even the temporary set become wholly worn out before they give place to the permanent series. Nothing of this kind has been observed in specimens from Big-bone Lick, even in the oldest individuals.

[†] "*On the Age of the Bison in the Ohio Valley.—By N. S. Shaler.*—In the original Memoir of Mr. Allen, allusion is made to certain researches carried on by me in Big Bone Lick in Kentucky, which have some reference to the question of the age of the Buffalo in the Ohio Valley. These investigations, begun in 1868 and continued in 1869, have only been sufficient to point the way to further studies which it is in the plan of the Kentucky Geological Survey to prosecute, but which it may not be in its power to undertake for some time to come. I therefore give a short sketch of the evidence collected at Big Bone Lick with a view to showing the limits of the observations that have been made there.

"The springs at Big Bone Lick, as at all the other licks of Kentucky, are sources of saline waters derived from the older Palæozoic rocks. These saline materials, as has been suggested by Dr. Sterry Hunt, have their origin in the imprisoned waters of the ancient seas, or in the salts derived therefrom, which have been locked in the depths of the strata below the reach of the leaching action of the surface water. Whenever the rocks lie above the line of the drainage, these salts have been leached away. As we go below the surface they increase in quantity until we reach the level, where these waters remain saturated with the materials which existed in the old sea-waters. The displacement of these old imprisoned waters is brought about by the sinking down of water on the highlands through the vertical interstices of the soil and rock, and the consequent tendency of the water below the surface to restore the hydrostatic balance. This action is particularly likely to occur when the rocks above the drainage are limestones or shales; while a bed of rock at some distance below the drainage is of sandstone and permeable to water. This is the case at Big Bone Lick, where at about two hundred feet below the surface we have the calciferous sandstone with a structure open enough to admit the free passage of water in a horizontal direction. That some such process is at work is shown by the fact that

* In the teeth of specimens from the Plains I have found sharp, angular particles of quartz wedged into the cavities of the teeth.

[† The matter here interpolated in quotation-marks constitutes App. II of the original.—Ed.]

the water will rise ten feet or more above the surface of the soil if enclosed in a pipe. The fact that the reservoir of these waters is below the general surface causes them to appear in the bottom of the valleys, and the considerable abstraction of matter from the underlying beds probably amounts to some hundred cubic feet per annum in the case of Big Bone Lick, causes a depression at the point of escape, and brings about pretty generally the formation ofa swamp in a depressed and constantly lowering basin, through which the spring water seeps away, and where a large part of it is usually evaporated. This swamp forms a natural trap for all the higher mammalia in it. When excavations are made near the existing outlets of the springs, we find the remains of the large mammals brought by man, the horse, cow, pig, and sheep.

"In the frequent change of outlet of these springs, it comes to pass that at many points near the surface of the thirty or forty acres that lie in the little basin where Big Bone Lick is found, there are old spring vents, about which bones are found, that no longer give forth saline waters. It is a fact bearing on the history of the buffalo, that their remains about Big Bone Lick are, when found, away from the purest springs and never at any depth beneath the surface. In the recent springs they are very abundant, but not much more ancient in their appearance than the domesticated animals. The evidence obtained at this point leads to the conclusion that the first appearance of this species into the country was singularly recent, and also shows that their coming was like an irruption in its suddenness. These buffalo bones are wonderfully abundant in some of the shallow swampy places of this neighborhood. I have seen them massed to the depth of two feet or more, as close as the stones of a pavement, and so beaten down by the succeeding herds as to make it difficult to lift them from their bed.

"As will be seen from the accompanying diagram, [here omitted,] there seems to have been some degradation of the surface of this swamp after the deposition of many of the mastodon remains, and before the coming of the buffalo. This lowering of level was apparently consequent on the down cutting of the bed of the small creek that drains the valley. The old elevated beds had probably washed a good deal when the buffalo came, but it was principally by its wallowing and stamping that the bones of the mastodon, elephants, &c., were exposed to the air. At no point in this old ground did I find a trace of the buffalo, though in some of it the bones identified by Mr. Allen as belonging to *Ovibos* were found. There, too, were found the bones of the moose and caribou. I am inclined to believe from these investigations that the *Bison americanus* did not appear at Big Bone Lick until a very recent time.

"All the observations made by the Kentucky Survey in the caverns of the State, and the neighboring district of Tennessee, have led to the discovery of no bison remains in these subterranean receptacles, where the bones of the beaver, deer, wolf, bear, and many other mammals have been discovered. The observations of the officers of the survey, to be published hereafter, will show that our caves have been used as the homes of the living and the receptacles of the dead by more than one of the earlier tribes of this region, but they seem never to have brought the bones of this animal to the caves.

"Some years ago I ventured to call attention to the general absence of the remains of this animal in all the mounds of the historic and prehistoric races, and to the fact that on their pipes and pottery, though they figure every other indigenous mammal and some of the birds of this region, seeking their models even in the manitee of Florida, I have never been able to find any trace of buffalo bones in any of the mounds which so often contain bones of other animals, nor have I been able to ascertain that they have ever been found in such places. At an ancient camping-ground on the Ohio River, about twelve miles above Cincinnati, where the remains are covered by alluvial soil of apparently some antiquity, and where the pottery (hereafter to be figured in the Memoirs of the Survey) is rather more ancient in character than that made by our modern Indians, I found bones of deer, elk, bear, fox, &c., but none of buffalo. At a number of other old camps on the Ohio River there is the same conspicuous absence of the remains of this animal. These evidences, negative and incomplete as they are, make it at least probable that the buffalo was unknown to the people who built the mounds and preceded the tribes which were found here by the whites in the seventeenth century. The same arguments warrant us in supposing that the *Bison latifrons*, with its contemporaries, the musk ox, the elephant, and the mastodon, had vanished before the advent of this race, or at least before the time of which we have evidence in the fossils already found.

"I have long been of the opinion, without claiming originality therein, that the tribes which built the mounds and shapely measured forts of this region were driven to the southward by an invasion of other tribes coming from the northward and northwestward. In the Memoirs now in preparation concerning the ancient peoples of this region, it will be claimed, on what seems to Mr. Lucian Carr, ethnologist of the Survey, and to myself, sufficient evidence that these mound-building peoples were essentially related to the Natchez group of Indians, and were driven southward by the ruder tribes of the somewhat related tribes which occupied the northern parts of the Mississippi Valley when we first knew it. All this seems to me to have a possible significance in the problem of the coming of the buffalo. When we remember that the Indians north of the Ohio were much in the habit of burning the forests, and so making open plains or prairies, and that, as Mr. Allen has well pointed out, the buffalo cannot penetrate far into the denser forests, it may be that it was this destruction of forests that laid the way open to their entrance. The so-called Barrens of Kentucky, the southward extension of the Wabash prairies, give us evidence on this point. As soon as the Indians were driven away, these Kentucky prairies sprang up in timber and are now densely wooded. The same is in part true of other prairies of the Ohio Valley. I am inclined to think that the forcing back of the timber line from the Mississippi is principally due to the burning of the forests by the aborigines in their eastward working, aided by the continued decrease of the rain-fall, which I believe to have been a concomitant of the disappearance of the glacial period.* The question of the origin of the buffalo and its relation to the earliest tribes of people in this district is made still more complicated by the fact that there is no doubt that there was an earlier and closely related species of buffalo in this district, probably coeval with the mammoth and mastodon, and possibly with the caribou and elk, which had doubtless disappeared before the coming of any race of men that has as yet been identified in this country.

"The succession of events in this region, as far as the species of bison are concerned, seems to have been somewhat as follows, viz.:—

"1st. The existence of the *Bison latifrons* in company with the mammoth and its contemporaries,—the mastodon, musk ox (*Bootherium cavi-*

* Notes on the cause and geological value of variations in rain-fall; Proceedings of the Boston Society of Natural History, vol. xviii, p. 176, *et seq.*

frons, Leidy), etc. This species, like its contemporaries, by its size gave evidence of the even climate and abundant vegetation of the time just following, and probably in part during the glacial period.

"2d. The disappearance of this fauna, followed by the coming of a race (mound-builders) that retained no distinct traditions, and have left no art records of the presence of any of the large animals of the preceding time.

"3d. The disappearance of this race from the region north of the Tennessee, probably leaving representatives in the Natchez group of Indians, followed by the occupation of the country by a race that greatly extended the limits of the treeless plains to the eastward, and so permitted the coming of the modern bison into this region.

"I have long been disposed to look upon the succeeding glacial periods as the most effective causes of the changes that led to the determination of new specific characters among animals, and I am strongly disposed to think that in the *B. americanus* we have the descendant of the *B. latifrons*, modified by existence in the new conditions of soil and climate to which it was driven by the great changes closing the last ice age.

"When the exploration of Big Bone Lick is completed, it will doubtless show that there was an interval of some thousands of years between those two species." [End of App. II of the original.—ED.]

Geographical Distribution.—Since the geographical distribution of the American bison, past and present, is treated at length in a subsequent chapter devoted especially to the subject, a few words only on this point will suffice in the present connection. The habitat of the bison formerly extended from Great Slave Lake on the north, in latitude about 62°, to the northeastern provinces of Mexico, as far south as latitude 25°. Its range in British North America extended from the Rocky Mountains on the west to the wooded highlands about six hundred miles west of Hudson's Bay, or about to a line running southeastward from the Great Slave Lake to the Lake of the Woods. Its range in the United States formerly embraced a considerable area west of the Rocky Mountains, its recent remains having been found in Oregon as far west as the Blue Mountains, and further south it occupied the Great Salt Lake Basin, extending westward even to the Sierra Nevada Mountains, while less than fifty years since it existed over the headwaters of the Green and Grand Rivers, and other sources of the Colorado. East of the Rocky Mountains its range extended southward far beyond the Rio Grande, and eastward throughout the region drained by the Ohio River and its tributaries. Its northern limit east of the Mississippi was the Great Lakes, along which it extended eastward to near the eastern end of Lake Erie. It appears not to have occurred south of the Tennessee River, and only to a limited extent east of the Alleghanies, chiefly in the upper districts of North and South Carolina.

Its present range embraces two distinct and comparatively small areas. The southern is chiefly limited to Western Kansas, a part of the Indian Territory, and Northwestern Texas,—in all together embracing a region about equal in size to the present State of Kansas. The northern district extends from the sources of the principal southern tributaries of the Yellowstone northward into the British Possessions, embracing an area not much greater than the present Territory of Montana. Over these regions, however, it is rapidily disappearing, and at its present rate of decrease will certainly become wholly extinct during the next quarter of a century.

Habits.—The American bison is, as is well known, pre-eminently a gregarious animal. At times herds have been met with of immense size, numbering thousands, and even millions, of individuals. The accounts given by thoroughly veracious travellers respecting their size sound almost like exaggerations. Herds were formerly often met with extending for many miles in every direction, so that the expression "so numerous as to blacken the plains as far as the eye can reach" has become a hackneyed description of their abundance. Some writers speak of travelling for days together without ever being out of sight of buffaloes, while it is stated that emigrant trains were formerly sometimes detained for hours by the passage of dense herds across their routes. In the early history of the Kansas Pacific Railway it repeatedly happened that trains were stopped by the same cause. Such statements as these seem like exaggerations, but no facts are perhaps better attested. I must myself confess to slight misgivings in respect to their thorough truthfulness until I had, in 1871, an opportunity of seeing the moving multitudes of these animals covering the landscape on the plains of Kansas, when I was convinced of the possibility of the seemingly most extravagant reports being true. Only when demoralized and broken up by constant persecution from hunters do the herds become scattered. At other times only the old bulls, lean and partly disabled from age, leave the herds and wander as stragglers.

The organization and composition of the herds, though wholly simple and natural, has been the subject of much romancing on the part of a few fanciful writers. Generally the cows with their calves are found toward the middle and on the front of the herds, the cows being at all times more watchful than the bulls, and also more active. The cows are hence the first to detect danger, and generally take the initiative in the movements of the herd. The younger animals of both sexes mingle with the cows, as do also to a greater or less extent the younger and middle-aged bulls. The older bulls are generally found nearer the outside of the herd, while last of all the old patriachs of the flock bring up the rear. Some of the latter are often found far out on the outskirts, miles away from the main herd, occurring singly or in small parties of three or four to a dozen individuals. These are usually the superannuated members of the community, which lag behind from listlessness or sheer weakness. This simple grouping of the different individuals of the herds has given rise to exaggerated accounts of the sagacity of the buffalo, and much fine writing has at times been expended in describing the supposed regularity and almost military precision of their movements. The sluggish, partly disabled old males constitute the lordly sentinels of such tales, who are supposed to watch with fatherly care over the welfare of the flock, and to give early warning of the approach of danger. On the contrary, these supposed alert protectors are the most easily approached of any members of the flock, the experienced hunter finding no trouble in creeping past within a few yards of them in endeavoring to reach the more desirable game beyond them.* They are slower, too, to recognize danger when it is observed. The timidity and watchfulness of the cows, accustomed as they are to the care of their offspring, lead them to take the initiative in the movements of the herd, and this, as already stated, keeps them near the front, especially when the herd is moving. The popular belief that the bulls keep the cows and the young in the middle of the herd, and form themselves, as it were, into a protecting phalanx, has some apparent basis, but the theory that the old bulls, the least watchful of all the members of the herd, are sentinels posted on the outskirts to give notice of any ap-

* See the chapter beyond devoted to an account of the different methods of hunting the buffalo.

proaching enemy, is wholly a myth, as is also the supposition that the herds consist of small harems.

The rutting season begins in July, but is not at its height till the following month. Rarely is more than a single calf produced at a birth. The period of pregnancy being about nine months, the calves are born from the beginning of March till the end of June, and follow the mother for nearly a year. Generally, also, the yearlings and two and three year olds are found associated with the cows and younger bulls. During no part of the year do the sexes form separate herds, but are found mingled together nearly in the manner already described.* It has been asserted, however, that the bulls select their partners and keep near them till the cows are about to calve, when for a time they leave them.† During the rutting season the bulls often wage fierce battles, but they are believed never to result fatally. The actions of the combatants are not much unlike those of domestic cattle under similar circumstances, they pawing the ground and bellowing, blustering loudly before engaging in actual combat. Their short horns are not apparently very dangerous weapons, and the stunning effect of the heavy shocks that must follow the violent collision of these monsters when fighting is doubtless partly broken by the immense thickness of hair with which their foreheads are protected. At this season the bulls become lean, but regain their flesh again in autumn, when they are usually in the best condition. The cows, on the other hand, as well as the yearlings and two-year-olds, are generally fattest in June.

In respect to the degree of maternal affection possessed by the buffalo cow there seems to be a wide range of opinion among observers. Some

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*Since the above was written I have met with the following remarks from the pen of Col. R. I. Dodge: "When the calves are young they are kept always in the centre of each small herd, the cows with them, while the bulls dispose themselves on the outside. When feeding, the herd is more or less scattered, but on the approach of danger it closes and rounds into a tolerably compact circular mass.

"The small herds, which compose the great herd, have each generally more bulls than cows, seeming all on the very best terms with each other. The old bulls do undoubtedly leave the herd and wander off as advance or rear guards and flankers, but I am disposed to believe this due to a misanthropic abnegation of society on the part of these old fellows, to whom female companionship no longer possesses its charm, rather than to their being driven out by the younger bulls, as is generally believed. This habitual separation of the large herd into numerous smaller herds seems to be an instinctive act, probably for more perfect mutual protection. It has been thought, said, and written by many persons, that each small herd is a sort of community, the harems and retainers of some specially powerful bull, who keeps proper order and subjection among them. Nothing is further from the truth. The association is not only purely instinctive, voluntary, free from domination of power, of sexual appetite, or individual preferences, but is most undoubtedly entirely accidental as to individual components. I have, when unobserved, carefully watched herds while feeding. I have seen two or more small herds merge into one, or one larger herd separate into two, or more. This is done quietly, gradually, and, as it were, accidentally, in the act of feeding, each buffalo seeming only intent on getting his full share of the best grass. I have already said that the cow sand calves are always in the centre, the bulls on the outside. When feeding herds approach each other and merge into one, the only perceptible change—and this is so gradual as scarcely to be noticeable—is that the bulls on the sides of contact work themselves out toward the new circumference, which is to inclose the whole; and when a larger herd breaks, by the same gradual process, into smaller ones, the bulls instinctively place themselves on the outside of each. When pursued the herds rush together in one compact, plunging mass. As soon as the pursuit is over, and the buffaloes are sufficiently recovered from their flight to begin feeding, those on the outside of the mass gradually detach themselves, breaking into smaller herds, until the whole large herd is in its normal condition. If each dominant bull had on such occasions to run through the herd to look up his lost wives, children, and dependents, his life would not only be a very unhappy, but also a very busy one."—*Chicago Inter-Ocean* (newspaper) of August 5, 1875.

†See Audubon and Bachman's Quad. N. America, Vol. II, p. 37.

deny that the mother has any affection for its offspring, stating that when frightened the buffalo cow will abandon her calf without the slightest hesitation. On the other hand, others report her as being not only constantly vigilant in the care of her young, but bold in its defense. Colonel Dodge, indeed, states that the duty of protecting the calves devolves wholly upon the bulls. He says: "I have seen evidences of this many times, but the most remarkable instance I have ever heard of was related to me by an army surgeon, who was an eyewitness. He was one evening returning to camp, after a day's hunt, when his attention was attracted by the curious action of a little knot of six or eight buffaloes. Approaching sufficiently near to see clearly, he discovered that this little knot were all bulls, standing in a close circle with their heads outward, while in a concentric circle at some twelve or fifteen paces distant sat licking their chops in impatient expectancy, at least a dozen large gray wolves, excepting man, the most dangerous enemy of the buffalo. The Doctor determined to watch the performance. After a few moments the knot broke up, still keeping in a compact mass, and started on a trot for the main herd, some half a mile off. To his very great astonishment the Doctor now saw that the central and controlling figure of this mass was a poor little calf, so newly born as scarcely to be able to walk. After going fifty or a hundred yards the calf lay down. The bulls disposed themselves in a circle as before, and the wolves, who had trotted along on each flank of their retreating supper, and licked their chops again. This was repeated again and again, and although the Doctor did not see the *finale* (it being late, and the camp distant), he had no doubt that the noble fathers did their whole duty by their offspring, and carried it safely to the herd."*

Audubon states, on the contrary, that the cow does not at such times desert its young, but tries to defend it,† which statement is confirmed by many plainsmen and hunters who are thoroughly conversant with the habits of the buffalo.

The moulting of the buffaloes begins quite early in the season, their skins being in prime condition for robes during only about three months of the year. They are in their best estate for this purpose in December, though they are in fair condition in November and January, and are indeed pretty fully haired in the months preceding and following these. The long hair on the legs, neck, and head is not annually shed, but the soft short wooly covering of the body is usually renewed each year. The short soft hair begins to loosen in February, and during the following months gradually falls, so that by May or June the body of the animal, especially the posterior part, becomes quite naked, and remains so for several weeks. Gradually the dark-colored new hair begins to appear, covering the animal's body with a fine soft velvety coat. During the period of moulting the animal presents a very ragged and uncouth appearance, the woolly hair hanging here and there in matted loosened masses with intervening naked spaces. During this period the animals search for trees, bushes, rocks, or banks of earth against which they may rub to free themselves from the loosened hair, often also rolling on the ground for the same purpose. The hair on the hump, which is thicker and longer than that on the other parts of the body, is last shed, and in very old animals is not always annually renewed. The moulting of the pelage takes place later in the old and lean animals than in the others, and nearly a month later in the cows than in the bulls, so that in June, while the greater part are smooth and dark, a

* *Chicago Inter-Ocean*, August 5, 1875.

† Quad. N. Am., Vol. II, p. 37.

few are conspicuous among the others from still retaining their old and faded coats of the previous year.

The buffalo is quite nomadic in its habits, the same individuals roaming, in the course of the year, over vast areas of country. Their wanderings, however, are generally in search of food or water, or result from the persecutions of human foes. The fires that annually sweep over immense tracks of the grassy plains, sometimes destroying the herbaceous vegetation over thousands of square miles in continuous area, often force the buffaloes, besides inspiring them with terror, to make long journeys in search of food. Occasionally the ravages of the grasshoppers cause similar migrations, these pests leaving large sections of country as bare of vegetation as it is when swept by a prairie fire. The habit of the buffaloes, too, of keeping together in immense herds renders a slow but constant movement necessary in order to find food, that of a single locality soon becoming exhausted. They are also accustomed to make frequent shorter journeys to obtain water. The streams throughout the range of the buffalo run mainly in an east and west direction, and the buffaloes, in passing constantly from the broad grassy divides to the streams, soon form well-worn trails, which, running at right angles to the general course of the streams, have a nearly north and south trend. These paths have been regarded as indicating a very general north and south annual migration of these animals. It is, indeed, a wide-spread belief among the hunters and plainsmen that the buffaloes formerly performed regularly very extended migrations, going south in autumn and north in spring. I have even been assured by former agents of the American Fur Company that before the great overland emigration to California (about 1849 and later) divided the buffaloes into two bands, the buffaloes that were found in summer on the plains of the Saskatchewan and Red River of the North spent the winter in Texas, and *vice versa*. The early Jesuit explorers reported a similar annual migration among the buffaloes east of the Mississippi River, and scores of travelers have since repeated the same statement in respect to those of the Plains. That there are local migrations of an annual character seems in fact to be well substantiated, especially at the southward, where the buffaloes are reported to have formerly, in great measure, abandoned the plains of Texas in summer for those further north, revisiting them again in winter. Before their range was intersected by railroads, or by the great trans-continental emigrant route by way of the South Pass, the movements of the herds were, doubtless, much more regular than at present. North of the United States, as late as 1858, according to Hind,* they still performed very extended migrations, as this author reports the Red River bands as leaving the plains of the Red River in spring, moving first westward to the Grand Coteau de Missouri, then northward and eastward to the Little Souris River, and thence southward again to the Red River plains.

As already stated, a slight movement northward in summer and southward in winter is well attested as formerly occurring in Texas; the hunters report the same thing as having taken place on the plains of Kansas; further north the buffaloes still visit the valley of the Yellowstone in summer from their winter quarters to the southward; along the 49th parallel they also pass north in summer and south in winter; there is abundant evidence also of a similar north and south migration on the Saskatchewan plains. Yet it is very improbable that the buffaloes of the Saskatchewan plains ever wintered on the plains of Texas;

* Canadian Exploring Expeditions, etc., Vol. II, p. 108.

and absolutely certain that for twenty-five years they have not passed as far south even as the valley of the Platte. Doubtless the same individuals never moved more than a few hundred miles in a north and south direction, the annual migration being doubtless merely a moderate swaying northward and southward of the whole mass with the changes of the seasons. We certainly know that buffaloes have been accustomed to remain in winter as far north as their habitat extends. North of the Saskatchewan they are described as merely leaving the more exposed portions of the plains during the deepest snows and severest periods of cold to take shelter in the open woods that border the plains. We have, for instance, numerous attestations of their former abundance in winter at Carlton House, in latitude 53°, as well as at other of the Hudson's Bay Company's posts.

The local movements of the buffaloes are said to have been formerly very regular, and the hunters conversant with their habits knew very well at what points they were most likely to find them at the different seasons of the year. Of late, however, the buffaloes have become much more erratic, owing to the constant persecutions to which they have been for so long a time subjected. In Northern Kansas the old trails show that their movements were formerly in the usual north and south direction, the trails all having that course. Since the construction of the Kansas Pacific Railway, however, their habits have considerably changed, an east and west migration having recently prevailed to such an extent that a new set of trails, running at right angles to the earlier, have been deeply worn. Until recently the buffaloes ranged eastward in summer to Fort Harker, but retired westward in winter, few being found at this season east of Fort Hays. In summer and early autumn, hunting-parties, as late as 1872, made their headquarters at Hays City; later in the season at Ellis and Park's Fort; while in midwinter they had to move their camps as far west as Coyote, Grinnell, and Wallace, or to a distance of one hundred to one hundred and fifty miles west of their fall camps, in consequence of the westward winter migration of the buffaloes. Two reasons may be assigned for this change of habit: first, their reluctance to cross the railroad, and secondly, the greater mildness of the winters to the westward of Ellis as compared with the region east of this point. During the winter of 1871–'72 I found that for a period of several weeks, in December and January, the country east of Ellis was covered with ice and encrusted snow sufficiently deep to bury the grass below the reach of either the buffaloes or the domestic cattle. In the vicinity of Ellis the amount of snow and ice began rapidly to diminish, while a little further westward the ground was almost wholly bare. I was informed, furthermore, that this was the usual distribution of the snow in this region whenever any fell there. Although occasionally the snow does not accumulate in sufficient quantity to render grazing difficult over any of the country west of Fossil Creek, the buffaloes regularly abandon this region in winter for the country further west, where snow is of more exceptional occurrence.

The wanderings of the buffaloes often render it necessary for them to cross large streams, which they seem to do with reckless fearlessness and at almost any season of the year, though frequently at the cost of the lives of many of the old and feeble as well as of the young. Lewis and Clarke speak of their crossing the Upper Missouri in such numbers as to delay their boat, the river being filled with them as thick as they could swim for the distance of a mile.* Other Western travellers men-

* Lewis and Clarke's Exped., Vol. II, p. 395.

tion similar scenes.* Bad landing-places, such as bluffy banks or miry shores, often prove fatal to the half-exhausted creature after reaching the shore.† In winter they boldly cross the rivers on the ice; toward spring, however, after the ice has become weakened by melting, and even occasionally at other times, in consequence of their crowding too thickly together, the ice breaks beneath their weight and great numbers are drowned. In spring they often cross amid the floating ice, at which times they are sometimes set upon by the Indians, to whom they then fall an easy prey. According to Audubon, small herds occasionally find themselves adrift on masses of floating ice, where the majority perish from cold and lack of food rather than trust themselves to the icy, turbulent waters.‡

The behavior and movements of the buffalo are in general very much like those of domestic cattle, but their speed and endurance seem to be far greater. When well under way, and with a good start, it takes a fleet horse to overtake them, their speed being much greater than one would suppose from simply watching their movements from a distance, their gait being a rather clumsy, lumbering gallop. When pursued, or when urged on by thirst, rough ground and a tumble now and then seem to scarcely retard their progress, they plunging headlong down the steep sides of ravines and resuming their course up the opposite slope as if they had found the ravine no obstacle to their progress. When thirsty, in order to get at streams or springs, they will often leap down vertical banks where it would be impossible to urge a horse, and will even descend precipitous rocky bluffs by paths where a man could only climb down with difficulty, and where it would seem almost impossible for a beast of their size and structure to pass except at the cost of broken limbs or a broken neck. On the bluffs of the Musselshell River I found places where they had leaped down bare ledges three or four feet in height with nothing but ledges of rocks for a landing-place; sometimes, too, through passages between high rocks but little wider than the thickness of their own bodies, with also a continuous precipitous descent for many feet below. Nothing in their history ever surprised me more than this revelation of their expertness and fearlessness in climbing.§ Ordinarily, however, the buffalo shows commendable sagacity in respect to his choice of routes, usually choosing the easiest grades and the most direct courses, so that a buffalo trail can be depended upon as affording the most feasible road possible through the region it traverses.

When moving in large bands across the plains their course is often plainly marked by the column of dust they raise, even when the animals themselves are far beyond sight, the scene calling to mind the passage of a distant troop of cavalry at full speed, or a heavy train of army

* Catlin, North Am. Indians, Vol. II, p. 13; Fremont, Explorations, etc., p. 23.

† The following incident in point is related by Colonel Dodge: "Late in the summer of 1867 a herd of probably four thousand buffaloes attempted to cross the South Platte near Plum Creek. The river was rapidly subsiding, being nowhere over a foot or two in depth, and the channels in the bed were filled or filling with loose quicksand. The buffaloes in front were hopelessly stuck. Those immediately behind, urged on by the horns and pressure of those yet further in the rear, trampled over their struggling companions to be themselves engulfed in the devouring sand. This was continued until the bed of the river, nearly half a mile broad, was covered with dead or dying buffaloes. Only a comparative few actually crossed the river, and these were soon driven back by hunters. It was estimated that considerably more than half the herd, or over two thousand buffaloes, paid for this attempt with their lives."—*Chicago Inter-Ocean*, August 5, 1875.

‡ Audubon and Bachman, Quad. N. Am., Vol. II, p. 38.

§ On this point see further Dr. Coues's communication given in Part II.

wagons. The presence of a herd to the windward of the observer, even if a mile or two distant, can usually be detected by the peculiar odor that arises from it, especially during the rutting season. At this time, too, the roaring of the bulls can often be heard when the animals are miles away, and hidden, perchance, by intervening swells of the prairie, particularly at night, or when the air is still. Few things make a more vivid or lasting impression—and one that at the time is often far from agreeable—upon the mind of the traveler, encamped far out on the open prairie, than the roar and tramp of an approaching herd of buffaloes, especially at night-time. Nothing, again, is more pleasantly exhilarating, or gives one a stronger sense of being really amid nature's untamed wilds, than, when encamped on the outskirts of a quiescent herd, to be awakened on a fresh June morning by their distant bellowing, and to see them, as daylight advances, quietly grazing over a vast expanse of the green prairie.

As may be well imagined, not only the movements but the habits of the buffaloes, in their undisturbed daily lives, are in general not far different from those of grazing herds of domestic cattle. They indulge in similar gambols, and, when belligerent, in similar blustering demonstrations. When approached by man they will often assume an aspect so threatening that a novice at buffalo-hunting might easily be appalled by the fierce demonstrations indulged in by the boastful but cowardly old bulls. Bold at first, and apparently challenging attack, the old bulls, with the head lowered and the tail erect, will pace uneasily to and fro, threateningly pawing the earth, or face the approaching enemy with a sullen and most determined air only to take to their heels the very next moment. The bulls are at all times excessively fond of pawing the ground, and of throwing up the earth with their horns, thrusting them into banks when such are at hand, or into the bare level ground, which they accomplish by lowering themselves upon one knee. To such an extent do they pursue this pastime that the horns of the older bulls become very much worn and splintered, in occasional instances the horny covering of the more exposed part being worn very thin, and in rare instances entirely through to the bony core. Particularly bovine, also, is the satisfaction they take in rubbing themselves against whatever will oppose resistance, whether it be rocks, trees, bushes, or a clay-bluff; the telegraph-poles, however, erected along the railroads that cross their range, afforded them especial delight as scratching-posts, and soon became as well smoothed and covered with tufts of hair and grease from their unctuous hides as are the posts about a farmer's cattle-yard. What is very unlike anything in the habits of domestic cattle, however, is their propensity to roll themselves on the ground, which, notwithstanding their seemingly inconvenient form, they do with the greatest ease, rolling over as completely as a horse, and apparently with far less exertion. But their especial delight is to roll in the mud, or in "wallowing," as it is termed, from which exercise they arise looking more like an animated mass of mud than their former selves. The object of these peculiar ablutions is doubtless to cool their heated bodies and to free themselves from troublesome insects. When not finding a muddy pool ready at hand, an old bull proceeds to prepare one. Finding in the low parts of the prairies, says Catlin, who has described the process with considerable detail,* a little stagnant water amongst the grass, and the ground underneath soft and saturated with moisture, an old bull lowers himself upon one knee, plunges his horns into the ground, throwing up the earth and soon making an excavation

* North American Indians, Vol. I, p. 241.

into which the water trickles, forming for him in a short time a cool and comfortable bath, in which he wallows "like a hog in the mire." In this "delectable laver" he throws himself flat upon his side, and then, forcing himself violently around with his horns, his feet and his huge hump, ploughs up the ground still more, thus enlarging his pool till he at length becomes nearly immersed. Besmeared with a coating of the pasty mixture, he at length rises, changed into "a monster of mud and ugliness," with the black mud dripping from his shaggy mane and thick woolly coat. The mud soon drying upon his body forms a covering that insures him immunity for hours from the attacks of insects. Others follow in succession, having waited their turns to enjoy the luxury; each rolls and wallows in a similar way, adding a little to the dimensions of the hole, and carrying away a share of the adhesive mud. By this means an excavation is eventually made having a diameter of fifteen or twenty feet, and two feet in depth. These wallows thus become characteristic marks of a buffalo country, outlasting even the ordinary trails, while their effect upon the country is much more marked, rank vegetation growing about their borders and serving to indicate their positions when quite distant.

The buffaloes, however, do not always choose moist places in which to roil, and are quite content with wallowing in the dust when mud-and-water wallows are not conveniently at hand; wherever, in short, large herds have grazed, hollows formed by their indulgence in this propensity are of very frequent occurrence. These circular depressions, which are also usually called "wallows," are of smaller size than the water wallows, being eight to ten or twelve feet or more in diameter, and a few inches to upwards of a foot in depth. These also are not effaced by natural agencies for many years, and hence remain as lasting evidence of the former existence of populous herds of buffaloes at the localities where these old "wallows" are found. Owing to the impervious nature of the clayey soil that generally characterizes the Plains, these hollows temporarily retain the water that collects in them during falls of rain, affording grateful supplies of this important element to the various animals of the region, as well as often to man, these pools usually lasting for several days, or until slowly evaporated by the sun.

The American bison, like the other species of the bovine group, is characterized by a rather sluggish disposition, and is by no means remarkable for alertness or sagacity, being not only unwieldy in bulk, but also "the stupidest animal of the plains." As Colonel Dodge has remarked, "his enormous bulk, shaggy mane, vicious eye, and sullen demeanor give him an appearance of ferocity very foreign to his nature. Dangerous as he looks, he is, in truth, a very mild, inoffensive beast, timid and fearful, and rarely attacking but in the last hopeless effort of self-defence. The domestic cattle of Texas, miscalled 'tame,' are fifty times more dangerous to footmen than the fiercest buffalo. . . . . Endowed with the smallest possible amount of instinct, the little he has seems adapted rather for getting him into difficulties than out of them. If not alarmed at sight or smell of a foe, he will stand stupidly gazing at his companions in their death-throes, until the whole herd is shot down. He will walk unconsciously into a quicksand or quagmire already choked with struggling, dying victims. Having made up his mind to go a certain way, it is almost impossible to swerve him from his purpose. . . . . When travelling nothing in his front stops him, but an unusual object in his rear will send him to the about at the top of his speed."*

In illustration of this curious habit of the buffalo to rush into the most

*Chicago Inter-Ocean, August 5, 1875.

apparent danger, Colonel Dodge relates the following: "The winter of 1871–72 was unusually severe in Arkansas. The ponds and smaller streams to the north were all frozen solid, and the buffalo were forced to the rivers for water. The Atchison, Topeka and Santa Fé Railroad was then in process of construction, and nowhere could this peculiarity of the buffalo of which I am speaking be better studied than from its trains. If a herd was on the north side of the track, it would stand stupidly gazing and without symptom of alarm though the locomotive passed within a hundred yards. If on the south side of the track, even though at a distance of one or two miles from it, the passage of a train set the whole herd in the wildest commotion. At its full speed, and utterly regardless of consequences, it would make for the track, on its line of retreat. If the train happened not to be in its path it crossed the track, and stopped satisfied. If the train was in the way, each individual buffalo went at it with the desperation of despair, plunging against or between locomotive and cars, just as the blind madness chanced to take them. Numbers were killed, but numbers still pressed on to stop and stare as soon as the obstacle was passed. After having trains ditched twice in one week, conductors learned to have a very decided respect for the idiosyncrasies of the buffalo, and when there was a possibility of striking a herd 'on the rampage' for the north side of the track, the train was slowed up, and sometimes stopped entirely."*

The sluggish nature and in some respects intense stupidity of the buffalo hence tend greatly to place this animal wholly at the mercy of its enemies, chief among whom is man, whether civilized or in the savage state. An account of the various devices for their destruction practiced by man, and of the results that have followed the reckless, exterminating slaughter he has waged upon this inoffensive and helpless animal, being given in subsequent portions of this memoir, it is unnecessary to refer at length to these matters here. Let it suffice, then, in this connection, to say that their unwariness renders them an easy prey to the hunter, who, by keeping to the leeward of the herd, finds no difficulty in approaching these animals sufficiently near for their easy destruction, even when he is unmounted, while their pursuit on horseback has ever been one of the favorite pastimes of the sportsman. Fortunately for the buffaloes, they possess few other enemies, the wolves being their only other formidable foe. These have now become so reduced in numbers over most of the present range of the buffalo that they no longer form a very serious check upon its increase. Formerly they everywhere harassed the buffalo, destroying many of the young, and even worrying and finally killing and devouring the aged, the feeble, and the wounded. Thirty years since, the wolves, next to the Indians, were the great scourge of the buffaloes, and had no small degree of influence in effecting their decrease. The earlier explorers of the plains often speak of finding a solitary buffalo, disabled by accident or by age, surrounded by a pack of hungry wolves, who would tease and wound him day and night till he finally fell a prey to their ravenous appetites. Catlin and other writers have often referred to this matter at length, Catlin having also given a series of paintings of these encounters between the bison and his hungry tormentors.† Says Catlin, in his graphic account of one of these attacks, "During my travels in these regions [Upper Missouri country], I have several times come across such a gang of these animals surrounding an old or wounded bull, where it would seem, from appearances, that they had been for several days in attendance, and at intervals

* *Chicago Inter-Ocean*, August 5, 1875.

† North American Indians, Vol. I, p. 257, pls. cxiii, cxiv.

desperately engaged in the effort to take his life. But a short time since, as one of my hunting companions and myself were returning to our encampment with our horses loaded with meat, we discovered at a distance a huge bull, encircled with a gang of white wolves; we rode up as near as we could without driving them away, and, being within pistol-shot, we had a remarkably good view, where I sat for a few moments and made a sketch in my note-book (plate cxiv); after which we rode up and gave the signal for them to disperse, which they instantly did, withdrawing themselves to the distance of fifty or sixty rods, when we found, to our great surprise, that the animal had made desperate resistance, his eyes being entirely eaten out of his head, the gristle of his nose mostly gone, his tongue half eaten off, and the skin and flesh of his legs torn almost literally into strings. In this tattered and torn condition, the poor old veteran stood bracing up in the midst of his devourers, who had ceased hostilities for a few minutes to enjoy a sort of parley, recovering strength and preparing to resume the attack in a few moments again. In this group some were reclining to gain breath, whilst others were sneaking about and licking their chops in anxiety for a renewal of the attack; and others, less lucky, had been crushed to death by the feet or the horns of the bull. I rode nearer to the pitiable object as he stood bleeding and trembling before me, and said to him, 'Now is your time, old fellow, and you had better be off.' Though blind and nearly destroyed, there seemed evidently to be a recognition of a friend in me, as he straightened up, and, trembling with excitement, dashed off at full speed upon the prairie, in a straight line. We turned our horses and resumed our march, and when we had advanced a mile or more we looked back, and on our left, where we saw again the ill-fated animal surrounded by his tormentors, to whose insatiable voracity he unquestionably soon fell a victim."

The buffalo, when taken young, is easily tamed, and soon becomes thoroughly domesticated. With this fact so well known, it seems remarkable that this animal should not have long since been added to our list of domesticated and useful animals. The few experiments that have been made seem to have met with encouraging results, as will be shown in a later portion of the present memoir,* and to have failed simply through lack of interest and persistency. Through crossing them with domestic cattle they have even given promise of improved breeds, and an attempt to propagate them in confinement by an enterprising stock-raiser, either as pure stock or as a mixed race, would undoubtedly prove remunerative. In the vicinity of the present range of of the buffalo, tame individuals are frequently met with, which are reared and kept simply as pets or objects of curiosity, just as occasional specimens of the deer, elk, or pronghorn are kept. A young buffalo that was owned by the sutler at Fort Hays in 1871, then about two years old, proved to be a most eccentric and amusing beast. Through the attentions of visitors he acquired, among his other accomplishments, a great fondness for beer, of which he would sometimes partake to excess, when he would occasionally perform rather strange antics. He was usually inoffensive in his manners, though latterly his behavior to strangers was rather too familiar to be always agreeable, and gradually he became somewhat irritable in consequence of constant teasing. But on these occasions of inebriety he sometimes took it into his head to clear the so-called "officers' room" at the sutler's, to which he was often admitted, of its occupants. On one of these occasions he is reported

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* See the chapter on "The Domestication of the Buffalo."

to have mounted a billiard-table, from which he was not easily dislodged; at another time he is said to have ascended the stairs leading to the second story, and was with great difficulty induced to descend again. His excesses, lack of proper care, and unnatural diet at length seemed to seriously impair his health, as he soon grew thin, and did not long survive.

The herds of cattle that are driven from Texas to Wyoming and other Northern Territories are sometimes accompanied by one or two young tamed buffaloes. Two two-year old buffaloes thus reached Percy, Carbon County, Wyoming, in December, 1871, *en route* for Utah. One of them, however, was killed by some hunters near Percy, who claimed to have mistaken it for a wild animal,—a fate which not unfrequently befalls the tamed buffaloes of the frontier. The other was shipped westward by rail with the rest of the herd. These individuals mixed as freely with the domestic cattle as any other members of the herd, and were as easily managed, and had no greater fear of man than the others.

The very young buffalo calf, when separated from its mother, often evinces the utmost stupidity and lack of discernment; sometimes thrusting its nose into a tuft of herbage, it seems to imagine itself wholly hidden from view, and, in its fancied security, will stand and allow itself to be captured. A horse seems to possess for it a strange fascination, and it is very apt, when one is lost from the herd, to follow one whenever opportunity for it offers. In this way buffalo calves have frequently been known to follow a horse and its rider into the nearest military or trading-post, miles from the herd. Catlin speaks of several that he sent down the Missouri by steamers to friends in Saint Louis, which had unwittingly in this way made themselves prisoners.

It may here be added, however, that the stupidity of the buffalo, as well as its sagacity, has been by some writers greatly overstated. A herd of buffaloes certainly possesses, in an eminent degree, the sheep-like propensity of blindly following its leaders, whenever a large affrighted herd is fleeing from some real or fancied danger. It certainly seems a stupid thing for a whole herd to rush into destruction instead of turning aside and avoiding the danger. A little reflection, however, will show that in such instances as the rushing of a herd over a precipice or into a pound prepared especially to entrap them the act is not wholly one of stupidity, but comparable to that of a panic-stricken crowd of human beings rushing pell-mell from a public building when an alarm of fire is given, at the cost of limbs and lives, when more deliberate action would avoid such accidents. In the case of the buffalo, the individuals in the front ranks of a herd, rushing to the verge of a precipice or into a pound, discover the danger too late to be able to turn aside if they would, owing to the irresistible pressure of the mass behind, who are not in position to be aware of the danger toward which they are moving. Their crowding together on weak ice may result in disasters they can hardly be expected to foresee. Their crowding forward into quicksands is presumably the blind action of more or less excited herds; a rashness a single animal or a few together would avoid.

Many other details respecting the habits of the buffalo might be appropriately added to the present account, especially in relation to their behavior in captivity and when pursued or attacked by their human foes; but as most of these points will be noticed quite fully incidentally in subsequent portions of this memoir, it is perhaps unnecessary to refer to them further in the present connection.

PART II.

I—GEOGRAPHICAL DISTRIBUTION, PAST AND PRESENT, OF BISON AMERICANUS.

The fate of none of our larger mammals is more interesting than is that of the bison, since total extermination is eventually surer to none than to this former "monarch of the prairies." Since Europeans first came to this continent all the larger ruminants and carnivores have become greatly reduced in number throughout its vast extent, and many species have already become extinct over extensive areas where they were formerly the most characteristic animals. The moose and the caribou have a far less extended range, particularly to the southward, now than formerly; the common deer, once abundant throughout Eastern North America, is now confined to the least settled parts of the country, having totally disappeared over three-fourths of the region it formerly occupied; the elk, formerly existing over nearly the whole continent, now scarcely survives east of the Mississippi River, though less than half a century ago it ranged in large bands over the fertile prairies of Illinois, Wisconsin, Iowa, and Minnesota, and was of occasional occurrence in the mountainous parts of even the Atlantic States; the bear, the wolf, and the panther, formerly so numerous as to be, if not dangerous, at least a source of great annoyance to the early settlers, are now found, east of the Great Plains, only in the least settled and more broken wooded portions of the country. The bison, at once the largest and the most important animal to the aboriginal tribes of this continent, as it was also the most numerous over the immense region it frequented, still occurs in almost numberless bands, but it has become so circumscribed in its habitat, and is so constantly persecuted by professional hunters, that its total extermination seems to be fast approaching.

The precise limits of the range of the buffalo at the time when the first Europeans visited America is still a matter of uncertainty, yet reliable data are sufficiently abundant to establish the boundaries of its habitat at that time with tolerable exactness. These data exist in the form of incidental memoranda in the narratives of the early explorers rather than in formal statements bearing directly upon the subject, and though often unsatisfactorily vague in respect to dates and localities, they enable us to trace approximately the eastern and southern boundary of its habitat at a date as early at least as the beginning of the seventeenth century. It was, beyond doubt, almost exclusively an animal of the prairies and the woodless plains, ranging only to a limited extent into the forested districts east of the Mississippi River, and never occurring as a regular inhabitant of the denser woodlands. The opinion most prevalent in respect to its primitive range, as expressed by authors who have given most attention to the subject, is, that it for a long time inhabited the whole of that part of North America east of the Rocky Mountains between the parallels of 30° and 60°; some, however, make the Alleghanies the eastern limit of its eastward extension. To the westward some have considered its habitat as embracing a considerable part of that portion of the western slope of the Rocky Mountains contained within the United States. The purpose of the present article is not only to determine, as definitely as can now be done, its former extreme limit of distribution, but to give also a detailed history of its extermination over the area from which it has disappeared. Although hundreds of volumes and distinct papers relating to the early exploration and settlement of the country embraced within the former range of this animal have been consulted in the preparation of this paper, there probably still exist many important facts, incidentally recorded in little-known documents and in works in which such facts would hardly be expected to occur, which have been overlooked, and which will ultimately serve to indicate still more definitely the date of its extinction at particular localities, though little probably that will materially affect the general results herewith presented.

Probable extent of its former habitat.—The boundaries of the former habitat of the buffalo appear to have been about as follows: Beginning with the region east of the Mississippi River, its extension to the northward was limited by the Great Lakes, while the Alleghanies may be taken as its general eastern limit, its occurrence in the mountainous and more elevated parts of the Carolinas being due rather to the occasional wandering of small bands through the mountains from the immense herds that formerly inhabited the valleys of West Virginia and the adjacent parts of Kentucky and Tennessee, than to this region having been regularly embraced within its habitat. To the southward it seems never to have been met with south of the Tennessee River. It is well known to have ranged over Northern and Western Arkansas, and thence southward over the greater part of Texas and across the Rio Grande into Mexico. Westward it extended over Northern New Mexico and then westward and northward throughout the Great Salt Lake Basin, and probably to the Sierra Nevada Mountains in California and the Blue Mountains in Oregon. North of the United States, its western boundary seems to have been formed by the main chain of the Rocky Mountains, among the foot-hills of which it has been found as far north as the sources of the Mackenzie River. Its most northern limit appears to have been the northern shore of the Great Slave Lake in about latitude 62° to 64°. In the British Possessions its range to the eastward did not extend beyond the plains west of the Hudson's Bay highlands. Thence southward it occupied the valleys of the Saskatchewan and its tributaries to Lake Winnipeg and the valley of the Red River of the North. It ranged thence southward over the head-waters of the Mississippi, extending eastward nearly to the western shore of Lake Michigan, and thence still eastward over the prairies of Northern Indiana, and along the southern shore of Lake Erie into Western Pennsylvania, where, as already stated, the Alleghanies formed, in general, its eastern limit. It was hence wholly absent from the region immediately north of the Great Lakes, and consequently from every portion of the present Canadas; its existence on the Atlantic slope of the continent being also confined to the highlands of North and South Carolina. With this preliminary statement respecting the extent of its former habitat, we will pass now to the details of the subject, presenting not only the evidence on which this general statement rests, but also investigating the numerous supposed references to its occurrence outside of these boundaries.

The evidence bearing upon the general subject is, of course, resolvable into two kinds: first, that of a positive character, or direct statements touching the points at issue; secondly, inferential evidence, mainly of a negative character. The first explorers of the different parts of the continent, being largely dependent for sustenance upon the chase, have naturally recorded in the narratives of their explorations the wild animals they met with. In the case of an animal so important as the buffalo, it is presumable that they would usually state where it was first encountered, and that they would refer frequently to its presence or absence, as the case might be, at subsequent periods of their journeys. When no reference whatever is made to the buffalo in the narratives of different travelers who passed at different times over the same region, it has been assumed, in the total absence also of all other evidence to the contrary, that the buffalo did not, during that period at least, exist over the special area in question.

The use of the term *vaches sauvages* by many of the early French Jesuit writers, and that of *wild cows* by some of the early English explorers, and also the terms *buffe*, *buffle*, and *bœuf sauvage*, for the designation of the moose (*Alces malchis*) and the elk (*Cervus canadensis*) as well as the buffalo, has resulted in erroneous conclusions in respect to the former range of the buffalo. Difficulties have also often arisen in respect to the identification of localities from the fact that the names of rivers, lakes, etc., were often differently applied by different writers, and were frequently entirely different from those now employed to designate the same landmarks. Care, however, has been taken to trace out, in such cases, the modern equivalents of the older geographical names.

For convenience of treatment the former supposed habitat of the buffalo is divided into several districts, which are treated separately in what has seemed to be their most natural order.

THE EASTERN BOUNDARY OF THE FORMER HABITAT OF THE BUFFALO CONSIDERED, INCLUDING AN EXAMINATION OF THE ALLEGED EVIDENCE OF ITS OCCURRENCE IN NEW ENGLAND, THE CANADAS, THE MARITIME PARTS OF THE MIDDLE STATES, VIRGINIA, THE CAROLINAS, AND FLORIDA.

As already stated, many prominent authorities have regarded the range of the buffalo as formerly extending eastward to the Atlantic Coast, including the Middle States, and even portions of New England and the Canadas, while others seem to have had no doubt of its former existence from New York along the seaboard to Florida. Its former occurrence in the western parts of North and South Carolina, Georgia, Virginia, and Pennsylvania is established beyond question; but its presence elsewhere on the Atlantic slope is highly questionable. Dr. Richardson, writing in 1829, says: "At the period when Europeans began to form settlements in North America this animal [the American Bison] was occasionally met with on the Atlantic Coast," etc.* De Kay, writing in 1842, also leaves it to be inferred that the buffalo existed generally along the Atlantic slope south of New York. He says: "The bison, or American buffalo, has long since been extirpated from this State [New York]; and although it is not at present found east of the Mississippi, yet there is abundant testimony from various writers to show that this animal was formerly numerous along the Atlantic coast, from New York to Mexico."† Unfortunately, however, he gives no reference to any of this "abundant testimony." Captain R. B. Marcy, writing in 1853, says: "Formerly, buffaloes were found in countless herds over almost the entire northern

* Richardson, Faun. Bor. Americana, Vol. I, p. 279, 1829.
† Zoölogy of New York, Vol. I, p. 110, 1842.

continent of America, from the twenty-eighth to the fiftieth degree of north latitude, and from the shores of Lake Champlain to the Rocky Mountains,"* and also cites a number of supposed references to its occurrence in Newfoundland, New England, and Virginia. Professor Baird, as late as 1857, also states as follows: "The American buffalo was formerly found throughout the entire eastern portion of the United States to the Atlantic Ocean, and as far south as Florida."†

Region North of North Carolina.—Various writers during the last part of the sixteenth and the early part of the seventeenth centuries speak also of its occurrence in Canada, New England, Virginia, the Carolinas, and Florida; but some of these countries then embraced regions of indefinite extent to the westward, and thus often (as in the case of Canada and Florida, certainly) did in those early times include a portion of the range of the buffalo. But upon careful examination of the writings of these authors I have failed to find a single mention of the occurrence of this animal within the present limits of New York, New England, Canada, or Florida that will bear a critical examination. On the other hand, in a score or more distinct enumerations of the animals of Virgina and New England, made prior to 1650, not a single allusion is made to the buffalo as existing on the Atlantic slope, north of the Carolinas, although all the other larger mammals are mentioned, and here and there described with sufficient detail to render them unquestionably recognizable.‡

* Marcy's Exploration of the Red River, p. 103, 1853.

† Mammals of N. America, p. 684. See also Patent-Office Report, Agricultural, 1851–'52, p. 124, 1852.

‡ A few of these general notices, taken from a variety of sources, but largely from Hakluyt's and Purchas's collections of voyages, are appended as examples of their general character :—

James Cartier, or Jacques Carthier, in 1534, reported "great store of wilde beasts, as Faunes, Stags, Beares, Marternes, Hares and Foxes, with divers other sorte," on the St. Lawrence, but mentions no other large animals—nothing like the buffalo—in his several distinct enumerations of the "beasts."—HAKLUYT, *Voyages*, Vol. III, pp. 231–290.

Sir Francis Roberaul, in his account of his voyage up the St. Lawrence in 1542, says of the Indians: "They feed also of Stagges, wild Bores, Bugles, Porkespynes, and store of other wild beastes."—HAKLUYT, Vol. III, p. 290.

In Hariot's account of Virginia, written in 1587, he ennumerates among the beasts, "Deere," "Conies," "Saquenuckot, and Maquowoc, two kinds of small beasts, greater than Conies, which are very good meat," "Squirels" and "Beares," and adds: "I have the names of eight and twenty severall sorts of beasts, which I have heard of to be here and there dispersed in the countrey, especially in the maine: of which there are only twelve kinds that we have yet discovered, and of those that be good meat we know only them before mentioned."—HAKLUYT, Vol. III, p. 333.

In the Report of Gosnold's Voyage (1602) to Northern Virginia are enumerated "Deere in great store, very great and large: Beares, Luzernes, blacke Foxes, Beavers, Otters, Wilde-cats, very large and great, Dogs like Foxes, blacke and sharpe-nosed; Conies."—PURCHAS, *Pilgrims*, Vol. IV, p. 1653.

Martin Pring, in the account of his voyage (made in 1603), speaks of the "Beasts" of Northern Virginia, as follows: "We saw here also sundry sorts of Beasts, as Stags, Deere, Beares, Wolves, Foxes, Lusernes, and Dogges with sharpe noses." Again, he says: "The Beasts here are Stags, fallow Deere in abundance, Beares, Wolves, Foxes, Lusernes [Raccoons], and (some say) Tygres, Porcupines, and Dogges with sharpe and long noses, with many other sorts of wild beasts, whose Cases and Furres being hereafter purchased by exchange may yeeld no small gaine to us."—PURCHAS, Vol. IV, pp. 1654, 1656.

In James Rosier's account of a voyage made by Captain George Waymouth, in 1605, to Virginia, we find, in his enumeration of the products of the country, the following: "*Beassts.* Deere red and fallow, Beare, Wolfe, Beaver, Otter, Conie, Marterns, Sables, Hogs, Porkespines, Polcats, Cats, wild great, Dogs some like Foxes, some like our other beasts the Savages signe unto us with hornes and broad eares, which we take to be Olkes or Loshes." (PURCHAS, Vol. IV, p. 1667.) The locality here referred to more particularly was the mouth of the St. Lawrence River, Virginia at this time including the northern portion of the Atlantic coast as far as it had been explored.

Captain John Smith, in his Description of Virginia, published in 1606, says: "Of

Furthermore, no remains of the buffalo have as yet been found in the Indian shell-mounds of the Atlantic coast,* while the bones of elk, deer, caribou, bear, and other large mammals and birds occur with greater or less frequency at different localities.†

Professor Baird, however, refers to the occurrence of their bones "in the alluvial deposits of rivers, bogs, and caves," near Carlisle, in Pennsylvania.‡

Among the more important references to the supposed occurrence of the buffalo on the Atlantic slope, north of the Potomac, are the following. One often quoted is that contained in a letter from Mr. Anthonie Parkhurst to Richard Hakluyt, dated 1578, concerning the "true state and commodities of Newfoundland." Parkhurst writes: "Nowe againe, for Venison plentie, especially to the North about the grand baie, and in the South neere Cape Race and Plesance: there are many other kinds of beasts, as Luzarnes, and other mighty beastes like to camels in greatnesse, and their feete cloven, I did see them farre off not able to discerne them perfectly, but their steps shewed that their feete were cloven, and bigger than the feete of Camels, I suppose them to bee a kind of Buffes which I read to be in the countreyes adjacent, and very many in the firme lande."§ Though it is supposed by some that the musk ox may have been referred to in this allusion to a "kind of Buffes," there is apparently

Beasts, the chiefe are Deare, nothing differing from ours. In the Desarts, towards the heads of the Rivers, there are many, but amongst the Rivers, few. There is a beast they call *Aroughcun*, much like a Badger, but useth to live on trees as Squirrels doe. Their squirrels, some are neere as great as our smallest sort of wilde Rabbets, some blackish, or blacke and white, but the most are gray. A small beast they have, they call *Assapanick*, but wee call them flying Squirrels, because spreading their legs, and so stretching the largeness of their skinnes, that they have been seen to flie thirtie or fortie yards. An Opassam hath a head like a Swine, and a taile like a Rat, and is of the bignesse of a Cat. Under her belly she hath a bag, wherein she lodgeth, carrieth, and suckleth her young. Mussascus, is a beast of the forme and nature of our water Rats, but many of them smell exceeding strongly of Musk. Their Hares are no bigger than our Conies, and few of them to be found.

"Their Beares are very little in comparison of those of *Muscovia* and *Tartaria*. The Beaver is as big as any ordinarie great Dog, but his legs exceeding short. His fore feet like a Dogs, his hinder feet like a Swans. His taile somewhat like the forme of a Racket bare without haire, which to eate the Savages esteeme a great delicate. They have many Otters, which as the Beavers they take with snares, and esteeme the skins great ornaments, and of all those beasts they use to feede when they catch them.

"There is also a beast *Vetchunquoyes*, in the forme of a wilde Cat, their Foxes are like our silver haired Conies of a small proportion, and not smelling like those in *England*. Their Dogs of that Countrey are like their Wolves, and cannot barke but howle; and their Wolves not much bigger than our *English* Foxes. Martins, Powlecats, Weessels, and Minks we know they have, because we have seene many of their skins, though very seldome any of them alive. But one thing is strange, that wee could never perceive their vermine destroy our Hens, Egges, nor Chickens, nor doe any hurt, nor their Flyes nor Serpents any way pernitious, where in the South parts of *America* they are alwaies dangerous and often deadly."—PURCHAS, Vol. IV, pp. 1695, 1696.

In Hakluyt's "Description of Florida," compiled from the French authors, he says, under the head of "The Beastes of Florida:" "The Beastes best known in this Countrey are Stagges, Hindes, Goates, Deere, Leopards [Lynxes], Ounces, Lusernes, divers sorts of Wolves, wilde Dogs, Hares, Cunnies, and a certaine kinde of Beast that differeth little from the Lyon of Africa."—HAKLUYT, Vol. III, p. 369.

In a "True Declaration of the estate of the Colonie in Virginia," printed in 1610, we

* I have been assured of this fact by the late Professor J. Wyman, and by Mr. F. W. Putnam, and others who have made these prehistoric remains of the aborigines a special study.

† See Wyman's Account of some Kjœkenmœddings, or Shell-heaps, in Maine and Massachusetts.—*Amer. Naturalist*, Vol. I, pp. 561–584, 1868.

‡ Patent-Office Report, Agricultural, 1851–'52, p. 124.

§ Hakluyt, Voyages, etc., Vol. III, p. 173, London, 1600. (The Editi n of 1810 is the one quoted in this memoir.)

little reason to doubt that these "Buffes" were the moose, which the early voyagers found on the adjacent mainland in great numbers; yet Marcy* and others have supposed this to be a possible reference to the buffalo, probably from the occurrence of the word "Buffes."

Another similar reference to the occurrence of an animal like an ox in Newfoundland is contained in the report of Sir Humphrey Gilbert's voyage to this island in 1583. In an enumeration of the "commodities thereof" are mentioned "Beasts of sundry kindes, red deare, buffles or a beast, as it seemeth by the tract & foote very large, in maner of an oxe."† In the account of the "first voyage made to the coast of America" by Captains Philip Amadas and Arthur Barlowe, in 1584, it is said that they treated with the Indians for "Chamoys, Buffe and Deere skinnes";‡ and Thomas Hariot, in his "briefe and true report of the new found land of Virginia," written in 1587, mentions "Deer skinnes dressed after the manner of Chamces, or undressed," among the commodities of the country. § The same writer speaks later of the "beasts" of Virginia, and says, "I have the names of eight and twenty severall sorts, ... of which there are only twelve kinds that we have yet discovered, and of those that be good meat, we know only them before mentioned," among which there is no mention of any "Buffes," "Buffles," "wild Cattle," or anything that can be regarded as at all like the buffalo. ||

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read: "The Beasts of the Countrie, as Deere, red, and fallow, do answere in multitude (people for people considered) to our proportion of oxen, which appeareth by these experiences. First the people of the Countrie are apparelled in the skinnes of these beasts; Next, hard by the fort, two hundred in one heard have been usually observed. Further, our men have seen 4000. of these skins pyled up in one wardroabe of *Powhaton;* Lastly, infinite store have been presented to *Captaine Newport* upon sundry occurrents: such a plentie of Cattell, as all the Spaniards found not in the whole kingdome of *Mexico*, when all their presents were but hennes, and ginycocks, and the bread of Maize, and Cently. There are *Arocouns*, and *Apossouns*, in shape like to pigges, shrouded in hollow roots of trees; There are Hares and Conies, and other beasts proper to the Countrie in plentifull manner."—FORCE'S *Coll. Hist. Tracts*, Vol. III, No. 1, p. 13.

Captain John Smith, in his "Description of New England," printed in 1616, thus enumerates the "beasts": "Moos, a beast bigger than a Stagge; Deere, red, and Fallow; Bevers, Wolves, Foxes, both blacke and other; Aroughconds [raccoons], Wildcats, Beares, Otters, Martins, Fitches, Musquassus, and diverse sorts of vermine, whose names I know not."—FORCE'S *Coll. Hist. Tracts*, Vol. II, No. 1, p. 17.

William Strachey, in his "Historie of Travaile into Virginia Britannia," written before 1620, says: " . . . . the people [about the Chesapeake Bay] breed up tame turkies about their howses, and take apes in the mountaines," on the authority of an Indian named Machumps. Again he says: "Martins, pole-catts, weesells, and monkeys we knowe they have, because we have seene many of their skynns, though very seldom any of them alive."—*Hakluyt Society's Publications*, Vol. for 1849, pp. 26, 125.

"In New England's Plantation" (London, 1630), it is said: "For Beasts there are some Beares, and they say some Lyons also; for they have been seen at Cape *Anne*. Also here are severall sorts of Deere, some whereof bring three or four young ones at once, which is not ordinarie in *England*. Also Wolves, Foxes, Beavers, Otters, Martins, great wild Cats, and a great Beast called a Molke [moose] as bigge as an Oxe. I have seen the skins of all these Beasts since I came to this Plantation, excepting Lyons. Also here are great store of Squerrels, some greater, and some smaller and lesser; there are some of the lesser sort, they tell me, that by a certaine Skin will fly from Tree to Tree though they stand farre distant."—FORCE'S *Coll. Hist. Tracts*, Vol. I, No. 12, p. 8.

Thomas Morton, in his "New English Canaan," printed in 1632, devotes six pages to a description of the "beasts," giving very quaint and curious descriptions of all the more important, but makes no reference to any animal like the buffalo.

Father Andrew White, in describing Maryland in 1632, says, "But so great is the abundance of swine and deer that they are rather troublesome than advantageous.

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* Exploration of the Red River of Louisiana, p. 104, 1853.

† Hakluyt, Voyages, etc., Vol. III, p. 195.

‡ Ibid., p. 303. § Ibid., p. 327. || Hakluyt, Voyages, etc., p. 333.

In the narrative of the travels of David Ingram from the Gulf of Mexico to Cape Breton, in Nova Scotia, made in 1568–'69, are unquestionable references to the buffalo, which have been referred to as possible evidence of its existence on the Atlantic slope, but the whole narrative is full of exaggerations and fanciful descriptions of mythical things and scenes, while the localities are wholly vague. The account speaks, for instance, of "great plentye of Buffes . . . . w[ch] are Beastes as bigge as twoe Oxen in length almost twentye foote, havinge longe eares like a bludde hownde w[th] long heares about there eares, ther hornes be Crooked like Rames hornes, ther eyes blacke, there heares longe blacke, rough and hagged as a Goate, the Hydes of these Beastes are solde verye deare. These Beastes doe keepe Company only by couples a male and a female and doe always fighte w[th] others of the same kynde."*

The account also says, "He did alsoe see in that Countrye boathe Elephantes and Uunces. He did also see one other straunge Beaste bigger than a Beare, yt had nether heade nor necke, his eyes and mouthe weare in his brest." It also describes "redd Sheepe" which lived in herds of five hundred individuals. Since Ingram's route doubtless took him through a portion of the range of the buffalo, the above-quoted description of "Buffes" may refer to that animal, but there is nothing to show that the locality was on the Atlantic slope.

Cows also are innumerable, and oxen suitable for bearing burdens or for food; besides five other kinds of large beasts unknown to us, which our neighbors admit to their table. Sheep will have to be taken hence or from the Canaries; asses also, and mules and horses. The neighboring forests are full of wild bulls and heifers, of which five hundred or six hundred thousand are annually carried to Saville from that part which lies towards New Mexico. As many deer as you wish can be obtained from the neighing people. Add to this muskrats, rabbits, beavers, badgers, and martens, not however destructive, as with us, to eggs and hens."—*A Relation of the Colony of the Lord Baron of Baltimore, in Maryland, near Virginia, &c.* (FORCE'S *Coll. Hist. Tracts*, Vol. IV, No. 12, pp. 6, 7.)

In "A Perfect Description of Virginia," printed in London in 1649, is given a list of "*Beasts*, great and small as followeth: above 20 severall kinds," including all the larger species, but no reference is made to the buffalo.—FORCE'S *Coll. Hist. Tracts*, Vol. II, No. 8, p. 16.

In an "Account of *Virginia* in Generall, but particularly *Carolana*, which comprehends *Roanoak* and the southern parts of *Virginia*," printed in 1650, it is said, "Nor is the Land any lesse provided of native Flesh, Elkes bigger then Oxen, whose hide is admirable Buffe, flesh excellent, and may be made, if kept domesticke, as useful for draught and carriage as Oxen. Deere in a numerous abundance, and delicate Venison, Racoones, Hares, Conyes, Bevers, Squirrell, Beares, all of a delightfull nourishment for food, and their Furres rich, warme, and convenient for clothing and Merchandise."—FORCE'S *Coll. Hist. Tracts*, Vol. III, No. 11, pp. 11, 12.

Clayton, in his very detailed account of the natural products of Virginia, written in 1688, says, "There were neither Horses, Bulls, Cows, Sheep, or Swine, in all the Country, before the coming of the *English*, as I have heard, and have much reason to believe. . . . . *Wild Bulls* and *Cows* there are now in the uninhabited Parts, but such only as have been bred from some that have strayed, and become wild, and have propagated their kind, and are difficult to be shot, having a great Acuteness of Smelling."—FORCE'S *Coll. Hist. Tracts*, Vol. III, No. 12, p. 35.

This leads to the inference that the frequent allusions to *wild bulls* and *wild cows* in the early accounts of Virginia, etc., often really refer to domestic cattle that had run wild.

Many citations of a similar character might be added, containing curious and interesting descriptions of the "beasts," but none of the enumerations include the buffalo. As these descriptions of the country and its products were mostly prepared for the purpose of encouraging emigration, it is not presumable that so important an animal as the buffalo would have been omitted if these early writers had ever heard of it as existing in any part of the countries they describe.

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* The Land Travels of David Ingram and others in the years 1568–'69. From the Rio de Minas in the Gulph of Mexico to Cape Breton in Acadia. Edited from the original MS. (Sloane MSS., Mus. Brit., No. 1447, ff. 1–18) by P. C. J. Weston, in Doc. connected with the Hist. of S. Carolina. London, 1856, p. 14.

Champlain, as early as 1604, ascended the St. Lawrence River nearly to Lake Ontario, and although he obtained from the Indians quite distinct accounts of Lakes Ontario and Erie, and of the Copper Mines of Lake Superior, he seems not to have learned anything respecting the buffalo. The animal which he describes as the "Orignac" or "Original" is without doubt the moose. He mentions it as an animal "which is like an Ox,"* and Purchas in his marginal notes, adds, "Orignac, a beast like an oxe." He first met with it at the mouth of the Saguenay, and later encountered it among the animals he found at the mouth of the Richelieu, speaking of it as the "Orignac," and Purchas again adds, "Orignas are before said to bee like oxen, perhaps Buffes. *Lescarbot*, [says] that *Orignacs* are *Ellans*,"†—the French term for the moose. The name "orignac" or "original" of the early French explorers appears to have been applied indifferently to both the moose (*Alces malchis*) and the elk (*Cervus canadensis*), but never to the buffalo. Champlain, in speaking of the game he found about Lake Champlain, makes no reference to the buffalo, neither do any of the subsequent writers of the seventeenth century. In regard to the "Ellans," we find in Lescarbot's account the following: "The winter being come, the Savages of the Countrey did assemble themselves from farre to Port *Royall*, for to trucke with the *Frenchmen* for such things as they had, some bringing Beavers skins and Otters . . . . and also *Ellans* or Stagges, whereof good *buffe* be made."‡ We thus see that the term *buffe* was also applied to the products of the elk and moose. Charlevoix's description of the Original, however, is strictly applicable to the moose, and to no other animal. Charlevoix says: "What they here [in Canada] call the Original, is what in *Germany*, *Poland* and *Muscovy*, they call the Elk, or Great Beast. . . . . Its Horns are not less long than those of a Hart, and much wider. They are flat and forked like those of a Deer, and are renewed every Year."§

Hennepin ascended the St. Lawrence and crossed the lakes to the prairies of Indiana and Illinois in 1679–80, but Hennepin in his narrative of his travels does not speak of meeting with the buffalo until he had reached the Illinois River in December, 1679.‖ In his account of the productions of Canada, he says, "There are to be had Skins of Elks, or *Orignaux*, as they are called in Canada, of the white Wolf or Lynx, of black Foxes, ... of common Foxes, Otters, Martins, wild Cats, wild Goats, Harts, Porcupines," etc.¶ In the account he has given of his travels he describes the buffalo with such particularity** as to leave no doubt that if he had met with or known of the occurrence of the buffalo in what is now known as Canada, he would not have failed to enumerate it among the products of that country.

In 1763 Marquette passed up the St. Lawrence, and through the Great Lakes to the Mississippi Valley, by way of Lake Michigan and the Fox and Wisconsin Rivers, but he appears not to have met with the buffalo till he reached the Wisconsin River.††

Charlevoix, who traversed the same country in 1720, and who has left us in his letters a full account of his journey up the St. Lawrence,

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* Purchas, Pilgrims, Vol. IV, p. 1607.

† Ibid., p. 1613.

‡ Purchas, Pilgrims, Vol. IV, p. 1613.

§ Letters to the Dutchess of Lesdiguieres, Goadby's English Ed., London, 1763, p. 64.

‖ New Discovery of a great Country in America, English Ed., 1698, p. 90.

¶ Voyage into North America, English Ed., 1679, pp. 136, 137.

** New Discovery, etc., p. 91.

†† An Account of the Discovery of some new Countries and Nations in N. America in 1673. Translation in French's Hist. Coll. La., Part II, pp. 279–297.

and thence westward through Lakes Ontario and Erie, only heard of their existence on the southern shore of Lake Erie, he himself coasting along the northern shore. Concerning the game of the country bordering Lake Erie he says, "Water-fowl swarmed everywhere: I cannot say there is such Plenty of Game in the Woods, but I know that on the South Side there are vast Herds of wild Cattle."* Again he says, "But at the end of five or six leagues [from Detroit River], inclining towards the Lake *Erié* to the South West, one sees vast Meadows which extend above a hundred Leagues every Way, and which feed a prodigious Number of those Cattle which I have already mentioned several Times."† He gives, however, an account of the "chase" in Canada, in which he describes the method of hunting the buffalo, but the locality is specified as "the Southern and Western Parts of New France, on both Sides of the Mississippi,"‡ which was then generally called Canada.

In the account of the Voyage of Father Simon Le Moine to the country of the "Iroquois Onondagoes" in 1653–54 we find what at first sight seems to be indisputable evidence of the existence of the buffalo at the eastern end of Lake Ontario, in both New York and Canada. In this account we find the following: "At the other side of the Rapid § I perceived a herd of *wild cows* || which were passing at their ease in great state. Five or six hundred are seen sometimes in these regions in one drove." ¶ In the "Relation de la Nouvelle France en l'Année 1665, we find the following description of the St. Lawrence River: "This is one of the most important rivers that can be seen, whether we regard its beauty or its convenience, for we meet there almost throughout, a vast number of beautiful Islands, some large, others small, but all covered with fine timber and full of deer, bears, *wild cows*,** which supply abundance of provisions necessary for the travelers, who find it everywhere, and sometimes entire herds of fallow deer."††

We have here a term (*vaches sauvages*) employed which was often used by the early French writers to designate the buffalo, and also the account of large herds being seen, which seems still further to imply that the animals were unquestionably buffaloes, yet the locality is one which was frequently passed over by travellers during the previous fifty years, not one of whom mentions the occurrence of the buffalo on the St. Lawrence, nor is any mention of its occurrence there made by subsequent writers. The region is, furthermore, a heavily wooded country, situated several hundred miles from the prairies, and from the most easterly known range of the buffalo. These facts alone tend to render these accounts improbable, but fortunately we are not left in doubt as to the character of the animals here mentioned, for in the sequel of

* Letters, Goadby's English Ed., 1763, p. 170. Dodsley's English Edition says "a prodigious quantity of Buffaloes" (Vol. II, p. 3).

† Ibid, p. 178. Dodsley's Translation says again, "those buffaloes" (Vol. II, p. 18).

‡ Ibid., p. 68.

§ This locality is just below St. Ignatius, on the St. Lawrence, not far from Lake Ontario.

|| "Vaches sauvages," in the original. Relation de la Nouv. France en les Années 1653–54, p. 85.

¶ Documentary Hist. New York, Vol. I, p. 31.

** "Vaches sauvages." Relation de la Nouv. France en l'année 1665, pp. 49, 50. Mr. J. G. Shea also observes: "The animal called by the Canadian French *vache sauvage* was the American elk, or moose," and cites Boucher (Hist. Nat. du Canada) as authority. "Boucher," says Shea, "expressly states that the buffaloes were found only in the Ottawa country, that is, in the far West, while the *vache sauvage*, or original, and the *ane sauvage*, or caribou, were seen in Canada."—*Discovery and Exploration of the Mississippi Valley*, p. 16, footnote.

†† Documentary History of New York, Vol. I, p. 62.

Father Le Moine's Journal the following passages render it certain that the animals referred to were either deer or elk:—

"1st day of Sept. I never saw so many deer, but we had no inclination to hunt. My companion killed three, as if against his will. What a pity! for we left all the venison there, reserving the hides and some of the most delicate morsels.

"2nd of the month. Travelling through vast prairies, we saw in divers quarters immense herds of wild bulls and cows;* *their horns resemble in some respects the antlers of the stag.*

"3d and 4th. Our game does not leave us; it seems that venison and game follow us everywhere. Droves of twenty cows plunge into the water as if to meet us. Some are killed, for sake of amusement, by blows of an axe."†

From the context we learn that the locality was but a few leagues above Montreal, on the St. Lawrence. These bands of "bulls and cows" were doubtless elks (*Cervus canadensis*).‡

Peter Kalm says: "Wild cattle are" [1749] "abundant in the southern parts of Canada, and have been there from time immemorial. They are plentiful in those parts, particularly where the Illinois Indians live, which are nearly in the latitude of Philadelphia; but further north they are seldom observed."§ In respect to this passage it is almost needless to add that the portion of *Canada* here mentioned is the present State of Illinois.

Ogilby says: "Towards the South of New York are many Buffles, Beasts which (according to *Erasmus Stella*) are betwixt a Horse and a Stag. . . . . They have broad branching Horns like a Stag, short Tail, rough Neck, Hair colored according to the several seasons," etc. The animals here called *Buffles*, were of course elks, showing again that the use of the term *buffles* does not necessarily imply a reference to the buffalo. The same writer, however, in his description of Maryland, says: "In the upper parts of the Country are *Buffaloes*, *Elks*, *Tygers*, *Bears*, *Wolves*, *Racoons*, and many other sorts of Beasts."‖ What portion of the country may have been referred to as the "upper parts of the country" is uncertain, but the preceding narratives of exploration, on which Ogilby's work is based, make no mention of the existence of the buffalo in the region now known as Maryland.

Father Andrew White, in "An Account of the Colony of the Lord Baron of Baltimore, in Maryland, near Virginia," published in 1677, in his account of the animals previously quoted (p. 78, footnote), says: "There are also vast herds of cows and wild oxen, fit for beasts of burden and good to eat. . . . . The nearest woods are full of horses and wild bulls and cows. Five or six thousand of the skins of these animals are carried every year to Saville, from that part of the country which lies westward towards New Mexico."¶ It is evident that this reference to herds of wild cattle refers not at all to the buffalo, nor even to the region of country now known as Maryland, but to the Spanish Possessions in the southwest,

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* The original says, "grand troupeaux de bœufs & de vaches sauvages."—*Rel.* etc., 1653–54, p. 60.

† Ibid., pp. 43, 44. Translated from Relation de la Nouv. France, 1653–54, pp. 95, 96.

‡ Hunters, both in Northern New England and in the West, commonly speak of the male moose and elk as "bull moose" and "bull elk," and the females as "cow moose" and "cow elk."

§ Kalm's Travels in N. America, Forster's Translation, Vol. III, p. 60.

‖ Ogilby's America, pp. 172, 196 (London, 1681).

¶ Translation of Father White's "Account," in Force's Coll. Hist. Tracts, Vol. IV, No. 12, pp. 6, 7.

whence the exportation of hides of the domestic cattle to Spain had long before begun.*

Professor E. D. Cope,† however, recently says: "Of the ruminants [of Maryland], the bison (*Bos americanus*) and the elk (*Cervus canadensis*), the largest known of the true deer, have been destroyed by human agency," implying their former existence in that State. On inquiry of Professor Cope for the grounds of such an inference he states‡ that he has found their unfossilized bones in superficial deposits in Virginia, and adds: "I think, but will not now assert, from more northern localities."§

In Salmon's "Present State of Virginia," printed in 1737, we read that Sir William Berkeley sent (apparently about 1733) a small party of "about fourteen *English* and as many *Indians*, under the command of Captain Henry Batt," to explore the country to the westward of the settlements in Virginia. "They set out together," says Salmon, "from *Appomattox*, and in Seven Days March reach'd the Foot of the Mountains. The Mountains they first arriv'd at were not extraordinary high or steep, but after they had pass'd the first Ridge they encounter'd others that seem'd to reach the Clouds, and were so perpendicular and full of Precipices, that sometimes in a whole Day's March they could not travel three miles in a direct Line. In other Places they found large level Plains and fine Savanna's three or four Miles wide, in which were an infinite quantity of Turkies, Deer, Elks, and Buffaloes, so gentle and undisturbed that they had no Fear at the Appearance of the Men, but would suffer them to come almost within Reach of their Hands."|| This account shows that buffaloes were not seen by the explorers till they entered the mountains and encountered the herds that extended eastward from the valleys of West Virginia.

Another reference to the supposed occurrence of the buffalo on the eastern slope of the Alleghanies is the discovery by Sir Samuel Argoll of "Shag-haired Oxen" in Virginia. In his letter to "Master Nicholas Hawes (written June, 1613"), as given by Purchas, Sir Samuel says: .... "[I] returned my self with the ship into *Pembrook* River, and so discovered *to the head of it*, which is about 65. leagues into the Land, and navigable for any ship. *And then marching into the Countrie*, I found great store of Cattle as big as Kine, of which, the Indians that were my guides, killed a couple which wee found to be very good and wholesome meate, and are very easie to be killed, in regard they are heavy, slow, and not so wild as other beasts of the wildernesse."¶ Purchas also says, in his "*Virginias* Verger, or Discourse on Virginia," in enumerating the animals of Virginia, "I might adde Shag haired oxen, seen by Sir Samuel Argoll."

The "Pembrook," or "Penbrooke" mentioned in Argoll's account, has generally been considered as the "Patowomeck," or one of its

* See Clavigero's History of Mexico, Cullen's English Translation, Vol. II, p. 308, where Clavigero states, on the authority of Acosta, that in 1587 sixty-four thousand three hundred and fifty ox hides were taken to Spain, so rapidly had the domestic cattle increased in Mexico.

† New Top. Map of Maryland, p. 16, 1873.

‡ In a letter dated December 22, 1875.

§ In this connection I may add that I have examined remains from the banks of the Susquehanna, and other localities in Maryland, some partly fossilized and others nearly unchanged, which though collected for bison remains proved to be those of domestic cattle.

|| Salmon (T.), The Present State of Virginia, p. 14 (London, 1737).

¶ Purchas, Vol. IV, p. 1765.

affluents, but it was, I think, unquestionably the James.* The region visited by Captain Batt must have also been somewhere on the head-waters of the James. There is still traditional evidence that buffaloes formerly passed eastward from the head-waters of the Great Kanawha, in West Virginia, to this region. Professor Shaler, being aware of the existence of such names as "Buffalo Springs" and "Buffalo Ford," in the region of Amherst, Bath, and Pocahontas Counties, Virginia, has made successful effort to ascertain whether they indicated the former presence there of buffaloes. In answer to his inquiries respecting the matter, Mr. C. W. Pritchett has kindly sent him the following important information. Mr. Pritchett says that the "old men" of that country affirm "that the Buffalo Springs were so named from a Salt Lick near by of that name, to which their fathers were guided by the buffalo trails. The tradition is abundant and easily verified, that buffalo and elk were numerous in that part of Virginia within a period comparatively recent. These traditions are especially abundant in Bath and Pocahontas Counties, lying between the Blue Ridge and the Alleghanies. On the Cow Pasture River (which with the Jackson forms the James) in Bath County, a few miles below the Blowing Cave and Wallawhatoola Springs (Indian names for Crooked River) is a salt lick, near which they still show the deep-worn trail of the buffalo, at the point where they crossed the river, still called Buffalo Ford. . . . . There are men still living there whose fathers and grandfathers saw the buffalo, and even, *in one instance*, caught and domesticated them."† In corroboration of the above important statements, Mr. Pritchett refers to a number of the descendants of the first settlers of the region in question as being ready to vouch for his statements. The localities he mentions are all well up in the mountains, beyond the Blue Ridge, Pocahontas County being wholly west of the divide, on the Greenbrier River. Bath County adjoins it on the east, and embraces the extreme upper tributaries of the James. These counties are the ones referred to by Mr. Pritchett as those where the evidence of the former presence of the buffalo is still "abundant." Amherst County is some distance lower down the James, and if the name "Buffalo Springs," in that county, is to be considered as satisfactory evidence of the former existence there of the buffalo, these animals must have at times wandered to some distance down the James, as far at least as the Blue Ridge. Watson, in his "Annals of Philadelphia,"‡ says: "The latest mention of buffaloes nearest to our region of country is mentioned in 1730, when a gentleman from the Shanadore, Va., saw there a buffalo killed of 1,400 pounds, and several others came in a drove at the same time." This was probably a wandering herd from the region of the Upper James River.

There are also reasons for supposing that the buffalo at times crossed through the low valleys of the Alleghanies in Central Pennsylvania to the Atlantic slope. Professor Baird has reported the occurrence of its

* The "Patowomeck" mentioned by Argoll (or Argall) is evidently the Indian chief of that name, and not the river "Patowomeck." Purchas, in his marginal notes to Argoll's letter, says, "His first voyage to *Patawomec* and *Penbrooke* River," not *Rivers;* and again, "The second voyage to *Penbrooke* River." Argoll himself speaks of going to "fetch Corne from *Patawomeck*," for which purpose he "entered into *Pembrooke* River," and after obtaining his cargo of corn he "hasted to *James* Towne," and later arrived at Point Comfort. After distributing the corn he returned again "into *Pembrook* River," and made the discovery of a "great store of Cattle as big as Kine." Whilst engaged "in this business" he conceived the idea of going to the "great King *Patowomeck*" for the purpose of obtaining possession by "strategem" of the "Great *Powhatans* Daughter *Pokahuntis*."

† Letter to Professor Shaler, dated Glasgow, Mo., July 31, 1875.

‡ The locality, though not stated, is probably Cumberland County.

bones in the superficial deposits and caves of portions of the State, and there is the traditional evidence afforded by the occurrence of such names as "Buffalo Creek" and "Buffalo Valley," in Union County, near Lewisburg.

Through the kindness of Professor C. H. Hamlin, I am able to show that such names owe their origin to the former presence of buffaloes at this locality. Professor Hamlin, on writing to Professor J. R. Loomis, of the University at Lewisburg, received from him the following in reply to his inquiries. In a letter dated Lewisburg, Pa., March 14, 1876, Professor Loomis writes as follows: "I have made such inquiries as I could. One man whose grandfather he well remembers, as well as much of his conversation, and who lived here one hundred years ago, never heard of the bison being native of this valley. I went to see the oldest native-born citizen of our town, who is now eighty-six years old. He says there were no buffaloes in his early days, but it was a current notion in his boyhood days that there had formerly been. . . . . Since writing the above I have received the enclosed note from Mr. Wolfe, the first gentleman referred to on the other page. The information, ... coming so directly, ... is probably the best that can now be gathered up."

In the note from Mr. J. Wolfe to Professor Loomis, Mr. Wolfe states as follows: "Since seeing you this morning I have had a conversation with Dr. Beck, and he informs me that buffaloes, at an early day, were very abundant in this valley, and that the valley received its name from that circumstance. The Doctor received his information from Colonel John Kelly, who was a prominent and early settler in the valley. Kelly told the Doctor that he shot the last one that was seen in the valley. Kelly received his information of the abundance of buffaloes from an old Indian named Logan, friendly to the whites, and who remained among the whites after the Indians were driven away."

Under date of March 30, 1876, Professor Loomis wrote again to Professor Hamlin respecting the same matter, from which I quote the following: "I sought an interview with Dr. Beck. . . . . The Colonel Kelly referred to was a soldier and officer in the Revolutionary War, and was a leading man in some fight in New Jersey during the war. A small monument is in our cemetery to his memory, from which I take the following inscription: 'Col. John Kelly died Feb. 18th, 1832, aged 88 years & 7 days.' He owned a farm about five miles from Lewisburg, in Kelly township, which was named from him. About 1790 or 1800 (such is the indefiniteness) Colonel Kelly was out with his gun on the McClister farm (which joined that of Colonel Kelly), and just at evening saw and shot a buffalo. His dog was young, and at so late an hour he did not allow it to pursue. The next morning he went to hunt his game, but did not find it. Nearly a week later word was brought him that it had been found, dead, some mile or two away. He found the information correct, but the animal had been considerably torn and eaten by the wolves. He regarded the animal as a stray one, and had never heard of any in the valley at a later day. Dr. Beck had the account from Colonel Kelly about three months before his death. . . . . The Colonel also told him that the valley was wooded originally with large but scattered trees, so that the grass grew abundantly and furnished good pasturage for the buffalo, and that the animal had been from this circumstance very abundant in the valley. The Colonel repeated the statement of a friendly Indian, Logan (probably *not* the native chief of that name), who said that the buffalo had been very abundant. He, Dr. Beck, had the same statement from Michael Grove, also one of the first settlers in the valley. . . . . I was more particular than I should ordinarily have been, because this is about the last stage when reliable tradition can be had."

This, of course, affords satisfactory proof of the former existence of the buffalo in the region about Lewisburg, which forms the most easterly point to which the buffalo has been positively traced.*

The foregoing historical evidence is sufficient apparently to show the improbability of the occurrence of the buffalo, at the time of the first exploration of the country by Europeans, either north of the great lakes or over that part of the Atlantic slope adjacent to the sea-coast *north of North Carolina;* in other words, within the present limits of Canada, New England, or the maritime part of the eastern slope of the Appalachian Highlands, northward of the present southern boundary of Virginia. On the contrary, it seems to me that the evidence of its absence at that time over these regions is almost conclusive, for had it occurred there, there is every reason to believe that proof of the fact would not be wanting in the early records of the country, in which its products, and especially its larger animals, are so often minutely enumerated. We have also seen that such terms as *buffes*, *buffles*, *wild bulls*, *wild cows*, *wild cattle*, and *vaches sauvages*, not only do not necessarily imply the presence of buffaloes, but, on the contrary, have been repeatedly employed as the designation of both the moose and the elk. If we accept these terms as implying the presence of buffaloes in the region under consideration, we must allow, on similar evidence, that *wild goats* were found in the seventeenth century along the whole length of the St. Lawrence, throughout the Mississippi Valley and in Florida;† that *wild swine* were found in Canada at the mouth of the Saguenay River, and in the Middle States;‡ also *wild horses* in Newfoundland prior to the year 1600; *monkeys* and *apes* in Virginia;§ and that *wild lemons* formerly grew in Southern Michigan.‖ Goat Island, at the Falls of Niagara, probably derives its name from the custom of calling the deer that frequented it wild goats. The name of Buffalo River (*Rivière aux Bœufs*) in New York,¶ and the name of the city on Lake Erie now called Buffalo, are not necessarily, though probably, traditional evidences** of the occur-

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* In respect to the supposed remains of *Bison americanus* from the Carlisle bone-caves, Professor Baird, in a recent letter to me (dated May 13, 1876), expressed some doubt as to their being referable to that species. A re-examination of them he thinks would be necessary in order to determine "whether they are of the bison, and if so, of which species." During my recent visit to Washington, careful search was made for the specimens, but unfortunately without finding them, though they are doubtless still stored somewhere in the Museum of the Smithsonian Institution, and will some day be found.

† See the various accounts of the voyages of De Soto, La Salle, Hennepin, Marquette, and others, where the term *wild goat* is probably used for deer, but sometimes as though it referred to a distinct animal, both wild goats, stags, and deer being mentionnd in the same sentence.

‡ That bears were mistaken for swine, in the following account, is of course evident: "Wee might see in some places where Deere and Hares had beene, and by the rooting of the Ground, we supposed wilde Hogs had ranged there, but we could discerne no Beast, because our Noise still chased them away from us."—*George Weymouth's Voyage*, 1605, in Purchas, Pilgrims, Vol. IV, p. 1665.

§ See Strachey's Historie of Travaile into Virginia, p. 36; Hakluyt Society, volume for 1849.

‖ "There also grow in the Strait [Detroit River] Lemon-Trees in the natural Soil, the Fruit of which have the Shape and Colour of those of *Portugal*, but they are smaller, and of a flat Taste, They are excellent in conserve."—CHARLEVOIX, *Letters*, p. 178.

¶ Supposed to be the present Oak Orchard Creek, Orleans Co., N. Y. See Doc. Coll. Hist. N. Y., Vol. IX, p. 886.

** Schoolcraft, Hist. Cond. and Prospects of the Indian Tribes of the United States, Part IV, p. 92.

rence of the buffalo at those localities, since it is not very improbable, as will be shown later, that the buffalo formerly ranged along the southern shore of Lake Erie to its eastern end.

As previously stated, there is good reason also for assuming that the buffalo was not found in New England, nor along the coast of the Middle States, *during a long period antedating the exploration of the continent by Europeans*, or during the period of the formation of the Indian shell mounds of the North Atlantic coast, which contain no traces of the remains of the buffalo, as they probably would do if it had existed here at the time of their formation, since they do contain the bones of all the larger mammals found here by the earliest European travellers. There still remains to be examined, however, one supposed evidence of its existence in New England in prehistoric times.

Shortly after the second visit of Sir Charles Lyell to the United States, some teeth of a species of the ox tribe were found in a clay-bank at Gardiner, Maine. The late Mrs. Frederic Allen, of Gardiner, secured these teeth for her cabinet, where they were seen by Sir Charles Lyell, who took with him some of them to England for determination. Respecting these specimens, and others contained in Mrs. Allen's cabinet, Sir Charles speaks as follows: "At Mrs. Allen's I examined, with much interest, a collection of fossil shells and crustacea, made by Mrs. Allen, from the drift, or 'glacial' deposits of the same age as those of Portsmouth, already described. Among other remains I recognized the tooth of a walrus, similar to one procured by me in Martha's Vineyard, and other teeth, since determined by Professor Owen as belonging to the buffalo, or American bison. These are, I believe, the first examples of land quadrupeds discovered in beds of this age in the United States. The accompanying shells consisted of the common mussel (*Mytilus edulis*), *Saxicava rugosa*, *Mya arenaria*, *Pecten islandicus*, and species of the genera *Astartė*, *Nucula*, etc." *

These specimens of supposed bison's teeth having assumed a considerable degree of importance, I wrote, in January, 1873, to Professor Owen, to obtain, if possible, further information respecting them. In his reply, dated Cairo, Egypt, February 6, 1873, he says: "I do not recall the circumstance to which you refer, and no teeth of ruminants from the locality you name were in the Palæontological Department of the British Museum when the state of my health obliged me to winter here. I should be unwilling to accept the responsibility of any determination which I have not myself published, after the care requisite for such a step."

Upon the death of Mrs. Frederic Allen, her collection passed into the possession of her daughter, Mrs. Romeo Elton, now residing in Dorchester, Mass. Through Mrs. Elton's kindness I have been able to obtain the full history of the specimens in question, and to examine the three teeth still remaining in her collection, and which were figured by Dr. A. S. Packard, Jr., in his memoir on the Glacial Phenomena of Labrador and Maine, etc.† There is also a specimen from the original lot of four, in the Museum of the Boston Society of Natural History, presented to the Society by Dr. C. T. Jackson, with a collection of Maine tertiary fossils.

The circumstances of the finding of the teeth are fully set forth in a written statement, or deposition, made at the time by the person who collected the specimens. Through the kindness of Mrs. Elton, I have

* Second Visit to the United States of North America, Vol. I, pp. 43, 44, 1849.

† Mem. Boston Soc. Nat. Hist., Vol. I, plate vii, fig. 18.

before me the original document, which represents the teeth as occurring in a solid clay-bank, fifteen feet below the surface.* In respect to the character of the locality, and its present condition, I have the following additional information from Dr. A. S. Packard, Jr., in answer to special inquiries on this point. In a letter dated Salem, Mass., December 31, 1872, Dr. Packard writes: "In answer to your other query, I have examined hastily the locality, but many years after Lyell visited this country,—about twenty,—and great changes may have occurred in the locality, as when I was there the high clay-bank was being dug away to supply a brickyard."† Referring to a suspicion I had communicated to him that they would probably prove to be the teeth of a domestic ox, he adds further: "The teeth in question may have fallen over the embankment and got mixed up in the beds. The beds containing the shells lie below, in a vertical section, where the beds containing the supposed bison's teeth would have been, but the shell-bearing beds graduate into those situated fifteen feet below the surface." One of the teeth remaining in Mrs. Elton's collection was, at the time I saw it, still firmly imbedded in its original matrix of blue clay, of the same character as that enclosing the shells.

From the above it appears that the teeth were not taken from the clay-beds by Sir Charles Lyell, as some have supposed, nor by either a geologist or a scientific collector; that they could not have been associated with the fossil shells, but came from beds considerably above them; and that it is not at all improbable that they rolled down from the surface, and became firmly imbedded in the clay. Furthermore, the teeth are in a remarkably perfect state of preservation, looking as fresh and recent as a tooth would which had had but a short period of exposure to atmospheric or any other decomposing influences, having undergone, indeed, scarcely any perceptible change.

In the structural character of the teeth themselves there is nothing that positively settles the question of their identity, though the evidence favors the assumption of their being the teeth of the domestic ox. My first comparison of them with the teeth of the buffalo and of the common ox seemed to leave no doubt of their identity with the latter, as I had no difficulty in exactly matching them in every particular, and especially in respect to the character of the folds of the enamel with teeth of the domestic ox, while there was a constant variation in several points from those of the buffalo. Later I have found so much variation in the teeth, not only of the domestic species but also of the buffalo, that this test of their identity fails to be a valid one, as I have also found buffalo teeth that closely resemble those from Gardiner. The weight of evidence on this ground, however, is decidedly in favor of their identity with those of the domestic ox.[‡]

Upon the settlement of the question of the identity or nonidentity of these teeth with those of the bison hinges the validity of the only sup-

* The following is a literal transcription of the document: "The teeth that I dug out of the clay-bank about fifteen feet below the surface; was a solid bank of blue clay, so firm that it was impossible for anything to have got in there, there were no cracks or fissures that it could have fallen into as it was perfectly solid; there were four lying very nearly together in the solid clay and required such exertion to get them out that they could not at such a depth have got in by ordinary means.

"GEORGE SOULE of Avon. 1837."

† Mrs. Elton informs me that now the original bank has been wholly removed.

‡ [A re-examination of the subject, in the light of a larger series of specimens of the teeth of the domestic ox, confirms my conviction of the identity of the supposed bison teeth from Gardiner, Me., with those of the domestic ox.—J. A. A.]

posed evidence we have respecting the former existence of the bison in New England, or anywhere east of the Great Lakes.*

In addition to the original notice already quoted from Lyell, respecting the occurrence of bison's teeth in Maine, Dr. A. S. Packard, Jr., refers to it in the American Naturalist,† and in the Memoirs of the Boston Society of Natural History.‡ In each case, however, the authority is the same, that of Lyell, who is, however, represented as having himself discovered the specimens in the clay-beds. Dr. Packard, indeed, speaks of the "intermingling of the bones [teeth] of the walrus and the bison in the same beds," but there is no record showing that they were actually thus associated.§

Region South of Virginia.—As already remarked, the only well-authenticated instances of the occurrence of buffaloes east of the Blue Ridge is the apparently casual passage of small bands through the mountains from West Virginia, Kentucky, and Tennessee, into the upper parts of North and South Carolina, by way of the New, Holston, and French Broad Rivers.‖ Audubon and Bachman state that "the Bison formerly existed in South Carolina, *on the sea-board*, and we are informed," say these authors, "that from the last seen in that State two were killed in the vicinity of Columbia."¶ But they have neglected to add the date of the capture, or the authority on which the statement is made. They state, however, that "Lawson speaks of two buffaloes that were killed on Cape Fear River, in North Carolina." Lawson's statement in full is as follows: "This day [Sunday, February 1, 1700], the King sent out all his able Hunters, to kill Game for a great Feast that was to be kept at their Departure, from the Town. . . . . This Evening, [same day] came down some *Toteros*, tall, likely Men, having great Plenty of Buffeloes, Elks, and Bears, with other sort of Deer amongst them."** "The *Toteros*," he says, "a neighboring Nation came down from the Westward Mountains to the *Saponas*,"†† etc. Lawson was now on the "Sapona River," in or near the mountains,‡‡ which was apparently one

* A few months since these teeth, with Mrs. Elton's general collection of the tertiary fossils of Gardiner, Maine, were presented by her to Bowdoin College, Brunswick, Maine.

† Vol. I, p. 268, 1867; Vol. VI, p. 98, 1872.

‡ Vol. I, pp. 243, 246, pl. vii, fig. 18, 1867.

§ Says Dr. Packard: "The deposits of Gardiner possess great interest, owing to their unusual thickness, and the rich assemblage of marine invertebrates which occur from the lowest to the highest strata, and from the occurrence of the teeth of the bison and of the walrus, which were dug out of the beds at a distance of 15 feet from the top of the clay during Sir Charles Lyell's second visit to this country. . . . . The intermingling of the bones of the walrus and bison in the same beds shows the great range both of Arctic and Temperate forms during this period."—*Mem. Bost. Soc. Nat. Hist.*, Vol. I, p. 243.

Again he says: "Teeth of the walrus and the bison were discovered by Sir Charles Lyell in the clay-beds of Gardiner, Maine. These are still preserved in a private collection. The association in the glacial clays of the remains of the bison with those of the walrus, and the mingling of the Arctic animals and plants with those now confined to British North America and New England, show that the climate, during the glacial period, was a little warmer than that of Southern Greenland at present."—*Am. Nat.*, Vol. I, p. 268, footnote.

‖ Gallatin says: "The gap through which they [the buffaloes] passed to the Atlantic rivers is undoubtedly that of moderate elevation and gentle ascent, which divides a northeastern source of the Roanoke from the Great Kenawha, called the New River, and through which the State of Virginia is now attempting to open a communication from James River to the Ohio."—*Trans. Am. Ethnological Soc.*, Vol. II, p. li.

¶ Quadrupeds North America, Vol. II, p. 55.

** History of Carolina, p. 48 (London, 1718).

†† Ibid., p. 47.

‡‡ A rude map of North and South Carolina accompanies his journal, but on the map the word *Saponas* does not occur. The context, however, shows that he was in the

of the sources of the Cape Fear River. The journey here described commenced at Charleston. He travelled near the coast till he reached the Santee River, and then ascended that river as far, apparently, as Columbia, then turning northeastward, he kept in the highlands, crossing the sources of the Cape Fear, and thence eastward to the "Pamticough" River and the English settlements. In his preface he says: "Having spent most of my Time, during my eight Years Abode in *Carolina*, in travelling; I not only survey'd the Sea-Coast, and those Parts which are already inhabited by the Christians, but likewise view'd a spatious Tract of Land lying betwixt the Inhabitants and the Ledges of Mountains, from whence our noblest Rivers have their Rise, running toward the Ocean, where they water as pleasant a Country as any in *Europe;* the Discovery of which being never yet made publick, I have, in the following Sheets, given you a faithful Account thereof, wherein I have laid down every thing with Impartiality and Truth." But in the narrative of his travels he makes no further allusion to the buffalo, and does not appear to have found the Indians in possession of either its skins or meat. He speaks, however, of the various kinds of game he daily met with, and especially of the abundance of turkeys. In his chapter on the "Natural History of Carolina," concerning which he says, "I have been very exact, and for Method's Sake rang'd each Species under its distinct and proper Head," he again speaks of the buffalo, as follows: "The Buffalo is a wild Beast of *America*, which has a Bunch on his Back, as the Cattle of *St. Lawrence* are said to have. He seldom appears amongst the *English* Inhabitants, his chief Haunt being in the Land of *Messiasippi*, which is, for the most part, a plain Country; yet I have known some killed on the hilly Part of *Cape Fair* River, they passing the Ledges of vast Mountains from the said *Messiasippi*, before they can come near us."*

From Lawson's eight years' residence, and extensive travels in the Carolinas, about the year 1700, and from his mentioning only the instance of its capture by the Indians above cited, it was evidently not at that time numerous in the Carolinas.† A few years after the publication of Lawson's work, this same region was visited by John Brickell, who passed through nearly the same districts as those traversed by Lawson. Brickell wrote concerning the buffalo as follows: "The *Buffelo*, or *wild Beef*, is one of the largest wild Beasts that is yet known in these parts of *America;* it hath a Bunch upon it's Back, and thick, short Horns, bending forward. . . . . This Monster of the Woods seldom appears amongst the *European* Inhabitants, it's chiefest haunts being in the *Savannas* near the Mountains, or Heads of the great Rivers. . . . . And it is conjectur'd, that these Buffelo's being mix'd, and breeding with our tame Cattle, would much improve the Species for largeness and Milk; for these Monsters (as I have been inform'd) weigh from 1,600 to 2,400 pounds Weight. There are a very fierce Creature, and much larger than an Ox. . . . . There were two of the Calves of this Creature taken alive in the Year 1730, by some of the Planters living near *Neus* River, but

northeastern part of the present State of North Carolina, on the sources of the Cape Fear River. Brickell says, however, in his Natural History of North Carolina, published in 1737: "The Sapona Indians live at the West Branch of the Cape Fear or Clarendon River, which is very beautiful, and has good land about it," etc. (p. 343). He also says: "The Toteras are neighboring Indians to the Saponas, and live westward in the mountains" (p. 343).

* History of Carolina, p. 115.

† Yet, in the history of Long's expedition to the source of St. Peter's River (Vol. II, p. 26), it is stated that "from Lawson we find that great plenty of buffaloes, elkes &c. existed near Cape Fear River and its tributaries!"

whether they transported them to *Europe*, or what other uses they made of them, I know not, having occasion to leave that Country soon after."*

Catesby, who visited South Carolina and Georgia some fifty years later, describes the buffalo quite minutely in his Natural History of Carolina, published in 1743, showing most unquestionably that he was personally familiar with it. He says: "They frequent the remote parts of the country near the mountains, and are rarely seen within the settlements. They range in droves, feeding in open savannas morning and evening; and in the sultry time of the day, they retire to shady rivulets of clear water, glistening through thickets of tall cane, which, though a hidden retreat, yet their heavy bodies causing a deep impression of their feet in the moist land, they are often trac'd, and shot by the artful *Indians*."† Catesby tells us in his preface that he spent the first year of his sojourn in America in Carolina, in the settled district near the sea-shore, and passed thence to the "Upper uninhabited Parts of the Country, and continued at and about *Fort Moore*, a small Fortress on the Banks of the River *Savanna*, which runs from thence a Course of 300 Miles down to the Sea, and is about the same Distance from its Source, in the Mountains." This region, he says, "afforded not only a Succession of new vegetable Appearances, but most delightful Prospects imaginable, besides the Diversion of Hunting Buffalo's, Bears, Panthers, and other wild Beasts."‡

Bartram also speaks of the existence of a "Great Buffalo Lick, on the Great Ridges which separate the waters of the Savanna and Alatamaha, about eighty miles distant from Augusta."§ Again, in speaking of the middle region of the Carolinas, he says: "The buffalo (*Urus*), once so very numerous, is not at this date [1773] to be seen in this part of the country."||

Hewit, also, in his "Historical Account of the Rise and Progress of the Colonies of South Carolina," published originally in London in 1779, thus refers to the buffalo in enumerating the natural productions of "Carolina," in his description of its condition about the year 1674: "Numbers of deer, timorous and wild, ranged through the trees, and herds of buffaloes were found grazing in the savannas."¶ Keating also says, on the authority of Colhoun: "And we know that some of those who first settled the Abbeville district in South Carolina, in 1756, found the buffalo there."**

Further evidence of the existence of the buffalo in the western parts of North and South Carolina is furnished by maps of these States, prepared about 1771–1775,†† on which a tributary of Coldwater River, in what is now Cabarrus County, North Carolina, is called Buffalo Creek; while two of the upper tributaries of the Broad River bear the names respectively of Buffalo Creek and Bullock Creek. In South Carolina, on the sources of the Saluda River, in the present county of Abbeville, a swamp is laid down as Buffalo Swamp. I fail to find, however, any of these names preserved on recent maps.

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* Natural History of North Carolina, 1737, pp. 107, 108.

† Nat. Hist. Carol., Fla., etc., 1754, Vol. I, Appendix, p. xxvii.

‡ Ibid., p. viii of preface.

§ Travels through North and South Carolina, Georgia, East and West Florida, etc., 1773–75, pp. 35, 46.

|| Ibid., p. 46.

¶ Carroll's Hist. Coll. S. Car., Vol. I, p. 78.

** Long's Expedition to the Source of the St. Peter's River, etc., 1823, Vol. II, p. 26.

†† A map of North and South Carolina. Accurately compiled from the old maps of James Cook, published in 1771, and of Henry Mouzon, in 1775. Carroll's Hist. Coll. South Carolina, 1836, Vol. I.

Peter Kalm, in his "Travels in North America," under date of November, 1748, also thus alludes to their existence "in Carolina." "The *wild oxen* have their abode principally in the woods of *Carolina*, which are far up in the country. The inhabitants frequently hunt them and salt them like common beef, which is eaten by servants and the lower class of people. But the hide is of little use, having too large pores to be made use of for shoes. However, the poorer people in *Carolina* spread their hides on the ground instead of beds."* Again he speaks of "the wild *Cows* and *Oxen* . . . . which are to be met with in *Carolina*, and other provinces to the south of *Pennsylvania*. . . . . This *American* species of oxen," he says, "is *Linnæus's Bos Bison*, *β*."†

In the verbal relation, reported by Hakluyt, of "Nicholas Burgoignon, aliâs Holy," who spent six years "in Florida" prior to 1586, Burgoignon states that "the Spaniards, entring 50. leagues up Saint Helena, found Indians wearing golde rings at their nostrels and eares. They found also Oxen, but lesse than ours."‡ The St. Helena here mentioned was in the present State of South Carolina, and must have been either the Combahee or the Edisto River, though most probably the latter, the name St. Helena being still retained for the bay at the mouths of these rivers. It hence seems very probable that the locality referred to was the Abbeville district of South Carolina, where buffaloes at that time doubtless existed.

Governor Oglethorpe, in his "New and Accurate Account of the Provinces of South Carolina and Georgia," published in 1733, makes the following single reference to the buffalo: "The wild beasts are deer, elks, bears, wolves, buffaloes, wild boars, and abundance of hares and rabbits; they have also a catamountain, or small leopard; but this is not the dangerous species of the East Indies." §

Francis Moore, writing in 1744, referring to the absence of the buffalo from St. Simon's Island, adds that "there are large herds there upon the Main." ||

Governor Glen, in his "Description of Carolina," published in 1761, enumerates "Buffaloes" in his list of the "Wild Beasts, etc., of the Forest."¶

Drayton, writing in 1802, also enumerates the buffalo as one of the animals formerly existing in South Carolina. He says, "The buffalo and cat-a-mount are entirely exterminated on the eastern side of our mountains." **

While the former occurrence of the buffalo in the "upper parts" of the Carolinas "near the mountains" is a well-established fact of history, its absence at the same time from the low country near the coast seems equally certain. As early as 1562, Jean Ribault (or Ribaut) landed at Port Royal, and explored to some distance into the interior †† without meeting with buffaloes, as did also Hilton, ‡‡ in 1663, and numerous other travellers later, many of whom have given detailed enumerations of the animals they met with. While every species of mammal now known to exist there, from the squirrel to the deer, is mentioned, the buffalo is

* Travels into North America, Forster's Translation, Vol. I, p. 287.
† Ibid, Vol. I, p. 207.
‡ Hakluyt, Voyages, etc., Vol. III, p. 433.
§ Collections of the Georgia Historical Society, Vol. I, p. 51.
|| A Voyage to Georgia, etc., p. 55.
¶ Description of Carolina, p. 68.
** Drayton (John), View of South Carolina, p. 88.
†† See Laudonnière's narrative in Hakluyt's Voyages, Vol. III, pp. 367–427.
‡‡ Hilton (William), A Relation of a Discovery lately made on the Coast of Florida, etc., London, 1664 (Force's Coll. Hist. Tracts, Vol. IV, No. 2, p. 8).

absent from them all.* It was also absent from this region at the time when Lawson, Brickell, and Catesby explored the Carolinas with special reference to their natural products. In the extreme southeastern part of Georgia (Camden County), however, there is found a small creek emptying into the Santilla River, at its great bend to the eastward, which still bears the name of "Buffalo Creek." If this is to be taken as sufficient proof of the former presence there of buffaloes, it may imply that the region was casually visited by a roving band of buffaloes from the region northward some time probably between the years 1700 and 1770. As above noted, this region was traversed during the sixteenth and seventeenth centuries by several different explorers, who, as is evident from their writings, did not meet with or hear of buffaloes here. It is, however, quite possible that subsequently buffaloes may have occasionally wandered to Southeastern Georgia, and even to the northern portions of Florida. In all other cases the name "Buffalo Creek" proves to have had its origin in the former presence of buffaloes in the vicinity of the streams so named.

The Buffalo not found within the present limits of Florida.—The buffalo is also believed by some to have been found within the present limits of Florida, and throughout the Gulf States down to the Gulf of Mexico. This, however, is a mistake, mainly arising, probably, from the former vast extent of Florida as compared with its present limits.†

These writers are Forbes,‡ who as recently as 1821 wrote, "The buffalo is said to be among the number of wild beasts, but not commonly seen"! Davis also says, on the authority of Romans, that "their tracks have been seen as far south and southeast as the Withlacooche River."§ But from the context of Romans's work, and from the known range of the buffalo at the time he wrote (1776), he must have been mistaken in respect to the identity of the tracks. Romans says: ". . . . . at the junction of Flint River and the river in the south extreme of this division is the head of *Manatee* River, between which and the *Amaxura* I saw a vast number of deer, and the marks of many of the hunting-camps of the savages. We found the footsteps of six or eight buffaloes hereabouts, so plain as to be convinced of the track being made by those animals."‖ Professor Baird, in 1852, says,

* Among the authors here referred to are Robert Horn (Briefe Description of the Province of Carolina on the Coasts of Floreda, etc., 1666); Samuel Wilson (An Account of the Province of Carolina, in America, etc., 1682); "T. A." [Thomas Ash] (Carolina; or a Description of the Present State of that Country and the Natural Excellencies thereof, etc., by T. A., Gent., 1682); and John Archdale (A New Description of that fertile and pleasant Province of Carolina, etc., 1707). Reprinted in Carroll's Hist. Coll. of S. Car., Vol. II. See also Hakluyt, Voyages, etc., Vol. IV, for these papers.

† As is well known, for many years subsequent to the disastrous expedition of De Soto, Florida, as claimed by Spain, embraced all the Atlantic coast as far north as the Gulf of St. Lawrence, and for more than a century after, or till 1651, extended northward to the present southern boundary of Virginia, and comprised an immense unexplored region in the interior. Not till 1721 was its western boundary restricted to its present limits. In 1764, the year following its acquisition by the British crown, its western boundary was again temporarily extended to the Mississippi River.—*Monette's Hist. of the Valley of the Mississippi*, Vol. I, pp. 65–77.

In 1745 the British possessions in North America embraced not only that portion of the United States north of the present limits of Florida, east of the Alleghanies, exclusive, however, of those portions of New York and Vermont north of the 44th parallel. The whole vast interior belonged to the French, and while almost the whole basin of the Mississippi was denominated *Louisiana*, or the *Province of Louis*, the northeastern part, including not only the present Canadas, but nearly all the territory north of the Ohio, was called Canada, or New France.—*Ibid.*, Vol. I, map.

‡ Sketches, Historical and Topographical, of the Floridas; more especially of East Florida, p. 67.

§ Conquest of New Mexico, 1869, p. 67, footnote.

‖ A Concise Natural History of East and West Florida, pp. 280, 281.

"Thevet, in the very rare work entitled 'Les Singularitez de la France antarctique,' Paris, 1557 [1558], gives (p. 147), in a representation of a curious beast of West Florida, a readily recognizable figure of the buffalo."* The figure bears some resemblance to a bison, and the description seems to clearly indicate this animal. The locality, too, is near Palm River, south of Tampa Bay. Thevet's work, however, is merely a compilation, abounding with the grossest exaggerations. He cites no authority for the presence of "*une espece de grands toureax*" at this locality, where certainly no bison has ever been found. Maynard, writing in 1872, says, "The historians of De Soto's travels speak of herds of wild cattle being found in Florida. They probably refer to the buffalo (*Bos americanus*), which without doubt extended its range to the prairies of the west coast."† None of the references to the buffalo contained in these writings relate, however, to the present region of Florida,‡ De Soto not apparently hearing of the existence of this animal until he had reached the Mississippi, except in the single instance soon to be noticed in another connection.

The late Professor Wyman, in a posthumous paper, also says, "The buffalo was an inhabitant of Florida, and it could have been no other than this animal which the French met with in their ill-fated retreat from Fort Caroline"; and he adds in a footnote: "De Challeux, the carpenter of Ribaut's expedition, says, 'near the break of day we saw a great beast, like a deer, at fifty paces from us, who had a great head, eyes flaming, the ears hanging, and the huger parts elevated. It seemed to us monstrous because of its gleaming eyes, wonderfully large, but it did not come near us to do us any harm.' There is no other animal," adds Professor Wyman, "which corresponds with this animal but the buffalo, though that animal is as unlike 'a deer' as possible."§ It seems to me, however, that the reference is in no way applicable to the buffalo, and if not really a deer, the beast here described must have been a creation of the excited imagination of the much terrified Frenchman, having no more real foundation than the accounts of other strange creatures found in the narratives of numerous other early explorers of America,—a supposition borne out by the general character of De Challeux's account of that night's experiences.

In the detailed account by M. Réné Laudonnière of Ribaut's attempt to plant a colony on the St. John's River, in Florida, however, there is no mention of this incident reported by the carpenter. Laudonnière says the only game found was deer, leopards, bears, etc., while in his "description of the West Indies in generall, but chiefly and particularly of Florida," as translated by Hakluyt,|| he says, "The Beastes best known in this Countrey are Stagges, Hindes, Goates, Deere, Leopards, Ounces, Luserns, divers sortes of Wolves, wilde Dogs, Hares, Cunnies, and a certain kinde of beast that differeth little from the Lyon of Africa."¶ No allusion is made to the existence of any animal like a buffalo in Laudonnière's whole narrative of the fortunes of the French in Florida during the period embracing the founding and aban-

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* Patent Off. Rep., Agricult., 1851–52, Part II, p. 124.

† Bull. Essex Institute, Vol. IV, p. 149.

‡ Schoolcraft says that the distinction between the former and present boundaries of Florida "is overlooked, in reference to the buffalo in Florida, by the translator of De Soto's first letter."—*History, Condition, and Prospects of the Indian Tribes*, etc., Part V, p. 68, footnote.

§ Fresh-Water Shell Mounds of the St. John's River, Florida, p. 80, and footnote, December, 1875.

|| Voyages, etc., Vol. III, pp. 368–484.

¶ Ibid., p. 369.

donment of Fort Caroline, covering a period of five years and quite extended explorations along the St. John's River.

Professor Wyman also quotes Buckingham Smith as saying, in a note to his (Smith's) translation of the "Memoir of Fontaneda respecting Florida" (p. 49), "The bison appears to have ranged in considerable numbers through Middle Florida a hundred and fifty years ago. It was considered in 1718 that the Spanish garrison at Fort San Marco, on a failure of stores, might subsist on the meat of the buffalo." The text in Fontaneda's Memoir (written about 1575), to which this note refers, contains the following: "The men of Abalachi go naked, and the women have waistbands of the straw that grows from the trees, which is like wool, of which I have given some account before; they eat deer, wolves, *woolly cattle*, and many other animals."* Smith in his commentary on this passage cites Barcia as authority for making this passage a reference to the buffalo. But I find nothing in Barcia that seems to refer to the occurrence of the buffalo within the region embraced by the present boundaries of Florida.

Professor Wyman further cites Stow ("p. 19") as saying, "The buffalo is found in the savannahs, or natural meadows of the interior parts," but as no title is given of Stow's work I have been unable to find it in order to ascertain on what authority he based his statement. Wyman further quotes Baird as authority for the occurrence of the buffalo in Florida, but Professor Baird, as previously noticed, only makes the general statement that it "was formerly found throughout the eastern portion of the United States to the Atlantic Ocean, *and as far south as Florida*."†

The first explorers not only did not meet with the buffalo in any part of the present States of Florida or Georgia, but probably had not at this time even heard of its existence anywhere. Among these are Ponce de Leon, who visited Florida in 1512, landing near the present site of St. Augustine, and Vasquez de Ayllon, who landed, it is supposed, on the coast of Georgia in 1520, and again in 1525; but neither of them made extended excursions into the interior, and make no reference to the buffalo.

In 1528 Pamphilo de Narvaez marched from Tampa Bay northwardly into the interior, to the source of the Suwanee River, in Southern Georgia, without, however, either meeting or hearing of the buffalo. De Soto, on the occasion of his journey through Florida, disembarked at Tampa Bay, from which point he made his long journey into the interior, finally crossing the Mississippi and reaching the edge of the plains beyond. His course was first northward through Central Florida, and thence nortwestward nearly to the site of the present town of Tallahassee, and then northeastward across Central Georgia to the Savannah River. From this point his course was again northwestward to the mountains of Northern Georgia. In all this long journey he obtained no information of any animal resembling the buffalo, only hearing of it later on sending out soldiers to the northward from his camp in the extreme northern parts of Georgia, to search for gold, who returned at length with the report that they had seen in the possession of the Indians ox-hides an inch in thickness, which were undoubtedly skins of the buffalo.‡ These facts

* Smith's Fontaneda, p. 27.

† Mam. N. Amer., p. 684.

‡ Irving's account of this expedition is as follows: He says two fearless soldiers were sent northward from the village of Ichiaha, which is supposed to have been near the site of the modern town of Rome, Ga. "After an absence of ten days they returned to the camp and made their report. Their route had lain part of the way through excellent land for grain and pasturage, where they had been well received and feasted

certainly show that the buffalo was absent both from Florida and Georgia during the early part of the sixteenth century, and I have found no writers who claim to have ever seen the living buffalo at any time in any part of Florida, or of Southern and Eastern Georgia. In the many enumerations of the natural productions of Florida (as at present restricted) made prior to the beginning of the present century, *based on personal observations*, the buffalo is absent from all. Romans, it is true, supposed he saw its tracks, but this, in the light of other contemporaneous history of the region, seems wholly improbable. Roberts, writing a few years before Romans wrote, says, "The wild animals found in this country are the panther, bear, catamountain, stag, goat, hare, rabbit, beaver, otter, fox, raccoon, and squirrel."*

Had the buffalo formerly inhabited Florida, it seems probable that its remains would occur in the shell-mounds of that State; but Professor Wyman specializes the buffalo as one of the animals whose remains he had *not* found in the mounds of Florida, although he had obtained the bones of most of the other large species of Florida mammals from them, among which he enumerates those of the bear, raccoon, hare, deer, otter, and opossum, together with those of the turkey and alligator, and of several different species of turtles and fishes.† If the buffalo was ever an inhabitant of the present State of Florida, it seems to me fully evident that it must have existed there at a comparatively recent date, and for only a very short period. As will be presently shown, the buffalo temporarily occupied portions of the Gulf States during the early part of the eighteenth century, from which it was absent in De Soto's time.

SOUTHERN BOUNDARY OF THE RANGE OF THE BUFFALO EAST OF THE MISSISSIPPI.

As already shown, there is apparently no record of the occurrence of the buffalo in the present States of Florida and Georgia, except over a small area west of the Savannah River adjoining the Abbeville District in South Carolina. It was apparently also altogether absent from the rest of the Gulf States east of the Mississippi, at the time this region was visited by Europeans. Certainly it was not met with by De Soto in his journey across this region in 1540–'41, during which journey he explored the Coosa River from its source to its junction with the Alabama, and descended the latter to its union with the Tombigbee. He thus crossed the State of Alabama diagonally from northeast to southwest, and afterward traversed what is now the State of Mississippi, also diagonally, from the southeast to the northwest.‡ De Soto learned

by the natives. They had found among them a buffalo hide *an inch in thickness*, with hair as soft as the wool of a sheep, which, as usual, they mistook for the hide of a beef. In the course of their journey they had crossed mountains [supposed to be the Lookout Mountains] so rugged and precipitous that it would be impossible for the army to traverse them."—IRVING (THOMAS), *Conquest of Florida*, p. 244.

The Gentleman of Elvas says (Hakluyt's translation), they "brought an oxe hide, which the Indians gave them, *as thinne as a calves skinne*, and the haire like a soft wooll, betweene the course and fine wooll of sheepe."—*Discovery and Conquest of Terra Florida* (Hakluyt Society), p. 66.

* Roberts (Wm.), An Account of the First Discovery and Natural History of Florida, 1763, p. 4.

† Mem. Peabody Acad. Sciences, Vol. I, pp. 78, 80.

‡ For authorities on the Route of De Soto, see Biedma's Narrative, and that of the Gentleman of Elvas, in French's Historical Collection of Louisiana, Vol. II, and in the Hakluyt Society's publications (1851), with an Introduction, Notes, and a Map by W. B. Rye; McCulloch's Researches; Gallatin's Synopsis of the Indian Tribes (Archæologia Americana, Vol. II); Pickett's History of Alabama, etc.; Nuttall's Journal of Travels into the Arkansas Territory; Meek's Sketches of the History of Alabama (Southron

nothing respecting the buffalo, save the report brought him by the soldiers whom he sent northward from Northern Georgia into the present State of Tennessee, till after he crossed the Mississippi.

According to Du Pratz, the buffalo later visited the northern and western portions of the present State of Mississippi, where, according to this author, the buffalo was abundant in the early part of the eighteenth century. Du Pratz's statement in full on this point is as follows: "This buffalo is the chief food of the natives, and of the *French* also for a long time past. . . . . They hunt this animal in winter; for which purpose they leave *Lower Louisiana* and the river *Missisipi*, as he cannot penetrate thither on account of the thickness of the woods; and besides loves to feed on long grass, which is only to be found in the meadows of the high lands."*

In his detailed account of the "Lands of Louisiana" Du Pratz says: "From the sources of the river of the *Paska Ogoulas*, quite to those of the river of *Quesoncté*, which falls into the Lake *St. Louis*, the lands are light and sterile, but something gravelly, on account of the neighborhood of the mountains, that lye to the North. This country is intermixt with extensive hills, fine meadows, numbers of thickets, and sometimes woods, thick set with cane, particularly on the banks of rivers and brooks; and is extremely proper for agriculture. The mountains which I said these countries have to the North, form nearly the figure of a chaplet, with one end pretty near the *Missisipi*, the other on the banks of the *Mobile*. The inner part of this chaplet or chain is filled with hills; which are pretty fertile in grass, simples, fruits of the country, horse-chestnuts, and wild-chestnuts, as large and at least as good as those of *Lyons*. To the North of this chain of mountains lies the country of the *Chicasaws*, very fine and free of mountains: it has only very extensive and gentle eminences, or rising grounds, fertile groves, and meadows. . . . . All the countries I have just mentioned are stored with game of every kind. The buffalo is found on the rising grounds; the partridge in thick open woods, such as the groves in meadows; the elks delight in large forests, as also the pheasant; the deer, which is a roving animal, is every where to be met with, because in whatever place it may happen to be, it always has something to browse on."†

Later he says in speaking of the country further north: "But to the east [of the Mississippi River], the lands are a good deal higher [than on the present Louisiana side], seeing from *Manchac* [near the present site of Baton Rouge] to the river Wabache [Ohio] they are between an hundred and two hundred feet higher than the *Missisipi* in its greatest floods. . . . All these high lands are, besides, surmounted, in a good many places, by little eminences, or small hills, and rising grounds running off lengthwise, with gentle slopes. . . . All these high lands are generally meadows and forests of tall trees, with grass up to the knees. . . . Almost all these lands are such as I have described; that is, the meadows are on those high grounds, whose slope

Monthly Magazine and Review, 1839); Monette's History of the Discovery and Settlement of the Valley of the Mississippi; Bancroft's History U. S.; Irving's Conquest of Florida; Schoolcraft's History, Condition, and Prospects of the Indian Tribes of the United States, Part III, pp. 37–50, pl. xliv; etc., etc.

*The History of Louisiana, etc., English Ed., Vol. II, p. 49. The original reads as follows: "Ce Bœuf est la viande principale des Naturels, & a fait long-tems aussi celle des François. . . . . On va à la chasse de cet Animal dans l'hyver, & on s'écarte de la Basse Louisiane & du Fleuve S. Louis, parce qu'il ne peut y pénétrer, à cause de l'épaisseur des Bois, & que d'ailleurs il aime la grande herbe qui ne se trouve que dans les Prairies des terres hautes."—*Histoire de la Louisiane*, etc., Tom. II, p. 67.

†The History of Louisiana, Vol. II, pp. 251–253.

is very gentle; we also find there tall forests, and thickets in the low bottoms. In the meadows we observe here and there groves of very tall and straight oaks, to the number of fourscore or an hundred at most. There are others of about forty or fifty, which seem to have been planted by men's hands in these meadows, for a retreat to the buffaloes, deer, and other animals, and a screen against storms, and the sting of the flies. . . . Those rising meadows and tall forests abound with buffaloes, elk, and deer, with turkeys, partridges, and all kinds of game; consequently wolves, catamounts, and other carnivorous animals are found there."*

On one of his accompanying maps this region is marked as "Terres Hautes," while the low country, or "drowned lands," of the present Lower Louisiana is marked "Terres Plates." Hence, when in his description of the buffalo he speaks of the Indians leaving "Lower Louisiana" to hunt this animal, he simply means that they leave the low flat country immediately bordering the coast and the river, especially the low country south and west of Baton Rouge, to hunt in the higher lands of the present State of Mississippi, where, if we take Du Pratz as trustworthy authority, the buffalo must, at that time (about 1720 and later), have been abundant. Yet when this very region was crossed by De Soto, two hundred years earlier, the buffalo was evidently not to be found there. It hence appears to have spread in the mean time from the region more to the northward. West of the Mississippi, also, the buffalo, in Du Pratz's time, extended southward over regions where it was not met with by De Soto or by La Salle, which affords further evidence that the buffalo extended its range considerably to the southward and eastward in the valley of the Lower Mississippi between 1540 and 1720, or even between 1685 and the latter date, as seems to have been also the case in South Carolina and Georgia.

It hence appears that at one time the buffalo occupied probably most of the region between the Tennessee and Mississippi Rivers. On Du Pratz's map, however, the course of the Tennessee is very incorrectly laid down, as it is also on the earlier map of De l'Isle and on maps published much later even than Du Pratz's, its southern bend on Du Pratz's map not reaching the 36th parallel, while it actually crosses the 33d. He seems not to have himself passed above the Chickasaw Bluffs, and his knowledge of the country beyond on the east side of the river was evidently very vague.

The presence of "Bœufs" in the country drained by the Mobile River is also mentioned by *un Officier de Marine*, in a letter published with Chevalier de Tonti's "Relation"† (the authorship of which work, however, Tonti disowns).

The presence of a creek in Southwestern Mississippi still bearing the name of "Buffalo Creek" may be considered as further evidence of the former existence of the buffalo in this region.

It is to be regretted that Adair, who spent many years (1735 to 1767) as a trader and government official among the tribes south of the Tennessee River, has left so little on record respecting the range of the buffalo at that period. In his "General Observations on the North American Indians" he refers to their use of buffalo flesh as food, and its skins, horns, wool, and sinews in the manufacture of clothing and uten-

* The History of Louisiana, Vol. II, pp. 262–267. The last quotation reads in the original as follows: "Ces Côteaux en Prairies & ces futayes sont abondantes en Bœufs, Cerfs & Chevreuils, en Dindes, en Perdrix & en toute sorte de gibier," etc.—*Histoire de la Louisiane*, Tom. I, p. 287.

† Relation de la Louisianne, 1720, Vol. I, p. 11.

sils, but without specifying by what tribes or at what localities. Among the tribes mentioned are those that lived north of the Tennessee River, and hence where the buffalo was at that time abundant. In an account of one of his journeys he mentions the killing of buffaloes somewhere, apparently, in the mountains of Northern Georgia, in 1749, and this is the only allusion in his work that bears directly upon the range of the buffalo. He states also, however, that "the buffaloes are now become scarce, as the thoughtless and wasteful Indian used to kill great numbers of them, only for the tongues and marrow-bones, leaving the rest of the carcase to the wild beasts." Elk, deer, bears, and turkeys, however, are frequently mentioned as affording a supply of food to the southern tribes of Indians, but in these statements he never alludes to the buffalo.

Gallatin* gives the Tennessee River as their southern limit. On an old map,† published originally in 1718, and reproduced in *fac simile* in French's "Historical Collections of Louisiana (Vol. II), the region between the Cumberland and Ohio Rivers is marked as follows: "*Desert de six vint lieues detendue ou les Ilinois font la Chasse des bœufs.*" They are well known to have been formerly abundant in the region about Nashville.

THE EXTENT OF THE REGION EAST OF THE MISSISSIPPI FORMERLY INHABITED BY THE BUFFALO, WITH A HISTORY OF ITS EXTIRPATION THEREFROM.

The accounts of the first exploration of the region between the Alleghany Mountains and the Mississippi River show that the buffalo, early in the seventeenth century, existed in vast herds not only on the prairies bordering the Mississippi, but throughout nearly the whole of the more open portions of the area drained by the Ohio River and its tributaries. Its range eastward extended nearly or quite to the eastern end of Lake Erie, and throughout the valleys among the mountains of Western Pennsylvania, West Virginia, Eastern Kentucky, and Eastern Tennessee. It also inhabited the region drained by the Illinois River, and by some of the lesser upper eastern tributaries of the Mississippi. The country between the Ohio and the Great Lakes was quite generally occupied by them, as was that south of the Ohio, between this river and the Tennessee. There is less certainty in regard to their former occupation of Southern Michigan and Wisconsin, though it is probable that they also at times roamed over most of this region also, notwithstanding the fact that they were not found there by the first Europeans who visited this section of the country. Considerable documentary evidence relating to their former presence over the region between the Mississippi and the Alleghanies, together with many references to their extermination there, has been brought together in the following pages, and is presented generally in the words of the original narrators. Beginning with the northwestern portion of the region in question, we shall pass thence southward and eastward, giving the facts bearing upon particular localities somewhat in a chronological order.

On the eastern side of the Mississippi River buffaloes were found by the early Jesuit explorers occupying the country from the sources of

* "Colonies of the buffaloes had traversed the Mississippi, and were at one time abundant in the forest country between the lakes and the Tennessee River, south of which I do not believe they were ever seen."—*Trans. Am. Ethnological Soc.*, Vol. II, p. 1.

† Carte de la Louisiane et du Cours du Mississippi. Dressée sur un grand nombre de Memoires entrautres ceux sur de Mr. le Maire par GUILLAUME DE L'ISLE de l'Academie R'le des Sciences.

the Mississippi almost uninterruptedly southward nearly to the mouth of the Ohio River. Hennepin, as early as 1680, met with them in considerable numbers in the vicinity of the St. Francis River, above the Falls of St. Anthony, where they were also seen later by other explorers. In 1766 Jonathan Carver found them on the plains around Lake Pepin, he speaking of them as "the largest buffaloes of any in America."* Pike, in ascending the Mississippi in the autumn of 1804, met with the first signs of this animal about two hundred miles above the Falls of St. Anthony; † and Schoolcraft reports their existence in the same vicinity as late as 1820. On the map accompanying Schoolcraft's narrative of his expedition to the sources of the Mississippi River, he has marked the plains above the Falls of St. Anthony as the "Buffalo Plains"; and in the text he says: "Here also (mouth of De Corbeau River) the Buffalo Plains commence and continue down on both sides of the river to the Falls of St. Anthony."‡ The buffaloes may never have existed in Northeastern Wisconsin, though they probably ranged over the prairies of the western and southern portions of the State. They were not met with, however, even there by the first European explorers of that region.

Father Marquette does not appear to have met with them in crossing from Green Bay to the Wisconsin River, in 1673, nor did he see them in his subsequent descent of that river.§ La Hontan, in 1687, also found none on either the Fox or Wisconsin Rivers, first meeting with them on the Mississippi not far above the mouth of the Wisconsin.|| Marquette first found them on the Mississippi River, in latitude "41° 28′," in July, 1673. "Having descended the river," he says, "as far as 41° 28′, we find that turkeys have taken the place of game, and the *Pisikious* that of other beasts. We call the Pisikious wild buffaloes, because they very much resemble our domestic oxen.¶ Following this is a description of the "pisikious," or buffaloes, and the uses made of them by the Indians, and he adds, "they graze upon the banks of rivers, and I have seen four hundred in a herd together."** Hennepin, Marest, Gravier, Charlevoix, and other Jesuit missionaries appear not to have met with it on the St. Joseph's River, nor anywhere in Southern Michigan,†† although they found it abundant on the Kaskaskia and further south-

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* Travels, p. 56.

† Expedition to the Sources of the Mississippi, etc., Pt. I, App., p. 53.

‡ Narrative Journal of Travel to the Sources of the Mississippi, etc., p. 275.

§ In an English translation of Marquette's narrative of his discoveries (French's Hist. Coll. of Louisiana, Part II, p. 284), we find the following passage. In speaking of the Wisconsin ("Mesconsin") he says: "The country through which it flows is beautiful; the groves are so dispersed in the prairies that it makes a noble prospect"; and he adds: "We saw neither game nor fish, but roebuck and *buffaloes* in great numbers." Mr. J. G. Shea says: "The French word here is *vaches*, which has generally been translated bison or buffalo." In this instance, Mr. Shea says, it is clearly a mistake, as Marquette and his party had not yet reached the buffalo grounds, and the missionary afterward describes the animal when he meets it.—*Discoveries and Explorations in the Mississippi Valley*, p. 16.

|| La Hontan, Voyages, Eng. ed., Vol. i, pp. 111, 112.

¶ As Henderson has remarked, "Father Marquette was doubtless the first white man who penetrated to the habitat of the buffalo by way of the Great Lakes, although, according to Marquette, their skins had been previously exported to Europe."—*Am. Naturalist*, vol. vi, p. 82.

** French's Historical Collection of Louisiana, Part II, p. 285.

†† Schoolcraft says, but I know not on what authority: "It not only ranged over the prairies of Illinois and Indiana, but spread to Southern Michigan, and the western skirts of Ohio. *Tradition* says it was sometimes seen on the borders of Lake Erie."—*History, Condition, and Prospects of the Indian Tribes*, Vol. IV, p. 92. It would, however, be quite strange if it had not at times extended its range over the prairie portions of both Michigan and Wisconsin.

ward.* Marquette, in his description of the Illinois River, says: "I never saw a more beautiful country than we found on this river. The prairies are covered with buffaloes, stags, goats, and the rivers and lakes with swans, ducks, geese, parrots, and beavers."†

That buffaloes were formerly abundant over the greater part of Illinois is well attested. Father Hennepin, in describing the journey he made from Fort Miamis, at the mouth of the Chicago River, to the village of the Illinois, on the Illinois River, "one hundred and thirty leagues from Fort Miamis," in December, 1679, says: "There must be an innumerable quantity of wild Bulls in that Country, since the Earth is covered with their Horns. The *Miami's* hunt them towards the latter end of *Autumn*." Again he says: "We suffer'd very much on this Passage; for the Savages having set the Herbs of the Plain on fire, the wild Bulls were fled away, and so we could kill but one and some Turkey-Cocks." "They change their Country," he adds, "according to the Seasons of the Year; for upon the approach of the Winter, they leave the North, and go to the Southern Parts. They follow one another, so that you may see a Drove of them for above a League together, and stop all at the same place. . . . . Their Ways are as beaten as our great Roads, and no Herb grows therein. They swim over the Rivers they meet in their Way, to go and graze in other Meadows."‡

Father Marest, in passing from the southern end of Lake Michigan to the Kankakee, in 1712, by way of the St. Joseph's River, says, in his narrative of the journey: "At last [after having passed the portage, and embarked on the Kankakee] we perceived our own agreeable country, the wild buffaloes, and herds of stags, wandering on the border of the river," etc.§ Charlevoix, in 1721, in crossing over from the St. Joseph's River to the "Theakiki" (Kankakee) soon found them in abundance. About fifty leagues from the source of the Kankakee, he says: "The country begins to be fine: The Meadows here extend beyond Sight, in which the Buffalo go in Herds of 2 or 3 hundred."‖ In describing the country bordering the Illinois River, below the junction of the Kankakee, he says: "In this Route we see only vast Meadows, with little Clusters of Trees here and there, which seem to have been planted by the Hand; the Grass grows so high in them, that one might lose one's self amongst it; but everywhere we meet with Paths that are as beaten as they can be in the most populous Countries; yet nothing passes through them but Buffaloes, and from Time to Time some Herds of Deer, and some Roe-Bucks." Later he writes: "The 6th [of October, 1721] we saw a great Number of Buffaloes crossing the River in a great Hurry"; and adds that they soon provided themselves with food "by killing a Buffalo or Roe-Buck, and of these we had the Choice."¶

Vaudreuil alludes to their abundance on Rock River in 1718. From the bluffs along this river, he says, "you behold roaming through the prairie herds of buffalo of Illinois."** Pittman, writing fifty years later, describes the country of the Illinois Indians as abounding with "buffalo, deer, and wild fowl."††

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* J. G. Shea, Discoveries and Explorations of the Mississippi, pp. 18, 20.

† French's Hist. Coll. of Louisiana, Part II, p. 297.

‡ A New Discovery of a vast Country in America, etc., pp. 90, 91, 92.

§ Kip's Jesuit Missions, p. 224.

‖ Letters, Goadby's English edition, pp. 280, 281.

¶ Letters, Goadby's English edition, p. 290.

** New York Coll. of MSS., Paris Doc. VII, p. 890.

†† Pittman (Captain Philip), Present State of the European Settlements on the Mississippi, p. 51, 1770. The region referred to is described in the context as being enclosed by the Mississippi on the west, the Illinois on the north, the Ohio on the south, and the Wabash (Ouabache) and "Miamis" on the east.

The buffalo seems also to have been abundant over large portions of Indiana. Charlevoix, writing of the Ohio River in 1720, says: "All the Country that is watered by the Ouabache [Ohio], and by the Ohio [Wabash] which runs into it, is very fruitful: It consists of vast Meadows, well-watered, where the wild Buffaloes feed by Thousands."* Vaudreuil, writing at about the same time, says, in his "Memoir on the Indians between Lake Erie and the Mississippi": "Whoever would wish to reach the Mississippi easily would need only to take this Beautiful river [Ohio] or the Sandosquet [Sandusky]; he could travel without any danger of fasting, for all who have been there have repeatedly assured me that there is a vast quantity of Buffalo and of all other animals in the woods along that Beautiful River; they were often obliged to discharge their guns to clear a passage." †

There is further evidence also of the former abundance of the buffalo in Ohio, along the southern shore of Lake Erie, particularly toward its western end. La Hontan, in his description of Lake Erie, as he saw it about 1687, says: "I cannot express what quantities of Deer and Turkeys are to be found in these Woods, and in the vast Meads that lye upon the South side of the Lake. At the bottom of the Lake, we find beeves upon the Banks of two pleasant Rivers that disembogue into it, without Cataracts or rapid Currents."‡ Vaudreuil, describing Lake Erie in 1718, says: "There is no need of fasting on either side of this lake, deer are to be found there in such abundance; buffaloes are found on the south, but not on the north shore." Again he says: "Thirty leagues up the [Maumee] river is a place called La Glaise [now Defiance, Ohio], where buffaloes are always to be found; they eat the clay and wallow in it." § The occurrence of a stream in Western New York called Buffalo Creek, which empties into the eastern end of Lake Erie, is commonly viewed as traditional evidence of its occurrence at this point, but positive testimony to this effect has thus far escaped me. This locality, if it actually came so far eastward, must have formed the eastern limit of its range along the lakes.

I have found only highly questionable allusions to the occurrence of buffaloes along the southern shore of Lake Ontario. Keating,‖ on the authority of Colhoun, however, has cited a passage from Morton's "New English Canaan" as proof of their former existence in the neighborhood of this lake. Morton's statement is based on Indian reports, and the context gives sufficient evidence of the general vagueness of his knowledge of the region of which he was speaking. The passage, printed in 1637, is as follows: "They [the Indians] have also made descriptions of great heards of well growne beasts that live about the parts of this lake [Erocoise], such as the Christian world (untill this discovery) hath not bin made acquainted with. These Beasts are of the bignesse of a Cowe, their flesh being very good foode, their hides good lether, their fleeces very usefull, being a kinde of wolle, as fine almost as the wolle of the Beaver and the Salvages doe make garments thereof. It is tenne yeares since first the relation of these things came to the eares of the English." ¶ The "beast" to which allusion is here made is unquestionably the buffalo, but the locality of Lake "Erocoise" is not so easily settled. Colhoun regards it, and probably correctly, as identical with Lake Ontario, while other writers (among them Marcy) have

* Letters, Goadby's English edition, p. 303.

† New York Coll. of MSS., Paris Doc., VII, p. 886.

‡ La Hontan, New Voyages to North America, English ed., Vol. I, p. 217.

§ New York Coll. MSS., Paris Documents, VII, pp. 885, 891.

‖ Long's Expedition to the Source of St. Peter's River, etc., Vol. II, p. 25.

¶ Morton (Thomas), New English Canaan, p. 98, Amsterdam, 1637.

applied this reference to Lake Champlain.* The context states that this lake is three hundred miles west of Massachusetts Bay, and that it may be reached by the Hudson River, while it is also given as the source of the Potomac.†

The extreme northeastern limit of the former range of the buffalo seems to have been, as above stated, in Western New York, near the eastern end of Lake Erie. That it probably ranged thus far there is fair evidence. As also already noticed, buffaloes at times passed over to the eastern slope of the Alleghanies, near Lewisburg, Union County, where is a stream still bearing the name of Buffalo Creek. The earliest evidence of their former existence in this region is afforded by a map published by Forster, in 1771, accompanying the English translation of Peter Kalm's travels. On this map a marsh called "Buffalo Swamp" is indicated as situated between the Alleghany River and the West Branch of the Susquehanna, near the heads of the Licking and Toby's Creeks (apparently the streams now called Oil Creek and Clarion Creek). The most explicit testimony, however, is that furnished by Mr. Ashe,‡ who has given an account not only of their former abundance here, but of their extirpation. The following circumstantial account of their former abundance in this region, and their sudden extermination upon the arrival of the first white settlers, was obtained by him from one of the participants in the work of destruction. "An old man," says Mr. Ashe, "one of the first settlers in this country, built his log house on the immediate borders of a salt spring. He informed me that for the first several seasons the buffaloes paid him their visits with the utmost regularity; they travelled in single files, always following each other at equal distances, forming droves, on their arrival, of about three hundred each. The first and second years, so unacquainted were these poor brutes with the use of this man's house, or with his nature, that in a few hours they *rubbed* the house completely down; taking delight in turning the logs off with their horns, while he had some difficulty to escape from being

* Marcy (R. B.) says, "Formerly buffaloes were found in countless herds over almost the entire northern continent of America, from the 28th to the 50th degree of north latitude, and from the shores of Lake Champlain to the Rocky Mountains," and cites this passage from Morton in proof of its existence around Lake Champlain.—*Exploration of the Red River of Louisiana*, pp. 103, 104, 1853.

† "And from this Lake Southwards, trends that goodly River called of the Natives Patomack, which dischardgeth herselfe in the parts of Virginea, from whence it is navigable by shipping of great Burthen up to the Falls (which lieth in 41. Degrees, and a halfe of North latitude:) and from the Lake downe to the Falls by a faire current." He adds: "It is well knowne, they [the Dutch] aime at that place, and have a possibility to attaine unto the end of their desires therein, by meanes, if the River of Mohegan, which of the English is named Hudsons River (where the Dutch have settled: to well fortified plantations already. . . . . The Salvages make report of 3 great Rivers that issue out of this Lake, 2 of which are to us knowne, the one to be Patomack, the other Canada, and why may not the third be found there likewise, which they describe to trend westward, which is conceaved to discharge herselfe into the South Sea [probably a reference to the Mississippi]."—*New English Canaan*, p. 99; Force's Hist. Tracts, Vol. II, No. 5, p. 67.

‡ Mr. Ashe speaks of the fondness "all the animals of those parts" have for salt, and of their resorting in large numbers to "Onondargo" Lake to drink of its brackish waters, and adds that the best roads to this lake were the "buffalo tracks; so called from having been observed to be made by the buffaloes in their annual visitations to the lake from their pasture-grounds; and though this is a distance of above two hundred miles, the best surveyor could not have chosen a more direct course, or firmer or better ground." The region about Onondaga Lake was thoroughly explored as early as 1670, and settlements were made and a fort erected before 1705. Prior to 1738, lines of communication had been established between both the Susquehanna and Alleghany Rivers, but not a buffalo is mentioned as having been met with anywhere in the Onondaga region. Hence Mr. Ashe was undoubtedly misinformed in respect to the trail to Onondaga Lake having been made by buffaloes.

trampled under their feet, or crushed to death in his own ruins. At that period he supposed there could not have been less than two thousand in the neighborhood of the spring. They sought for no manner of food, but only bathed and drank three or four times a day, and rolled in the earth, or reposed, with their flanks distended, in the adjacent shades; and on the fifth and sixth days separated into distinct droves, bathed, drank, and departed in single files, according to the exact order of their arrival. They all rolled successively in the same hole, and each thus carried away a coat of mud to preserve the moisture on their skin, and which, when hardened and baked in the sun, would resist stings of millions of insects, that otherwise would persecute these peaceful travellers to madness or even death.

"In the first and second years this old man with some companions, killed from six to seven hundred of these noble creatures, merely for the sake of their skins, which to them were worth only two shillings each; and after this 'work of death' they were obliged to leave the place till the following season, or till the wolves, bears, panthers, eagles, rooks, ravens, etc., had devoured the carcasses, and abandoned the place for other prey. In the two following years, the same persons killed great numbers out of the first droves that arrived, skinned them, and left their bodies exposed to the sun and air; but they soon had reason to repent of this, for the remaining droves, as they came up in succession, stopped, gazed on the mangled and putrid bodies, sorrowfully moaned or furiously lowed aloud, and returned instantly to the wilderness in an unusual run, without tasting their favorite spring, or licking the impregnated earth, which was also once their most agreeable occupation; nor did they, nor any of their race, ever revisit the neighborhood.

"The simple history of this spring," he adds, "is that of every other in the settled parts of this Western world; the carnage of beasts was everywhere the same; I met with a man who had killed two thousand buffaloes with his own hand; and others, no doubt, have done the same. In consequence of such proceedings, not one buffalo is at this time [in 1806] to be found east of the Mississippi, except a few, domesticated by the curious, or carried through the country on a public show." *

Warden also refers to the former existence of buffaloes in the western part of Pennsylvania, and to their early extinction there and in Kentucky.† Gallatin says: "The name of Buffalo Creek, between Pittsburg and Wheeling, proves that they had spread thus far eastwardly when that country was first visited by the Anglo-Americans."‡ Further to the southward, in West Virginia, in the valleys of the Kanawha and its tributaries, as well as thence westward, the former abundance of the buffalo is well attested.

One of the earliest references to the existence of the buffalo in West Virginia is that contained in the journal of the Rev. Daniel Jones, who in 1772 made a journey to the Indian tribes west of the Ohio River. Under date of June 18, 1772, he writes: "Went out to view the land on east side [of the Little Kanawha] to kill provisions. Mr. Owens killed several deer and a stately buffalo bull. The country is here level, and the soil not despicable."§ In speaking of that part of the valley of the Ohio near the mouth of the "Great Guiandot," he says, under date of January, 1773: "In this part of the country even in this season,

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* Ashe (Thomas) Travels in America, performed in 1806, for the purpose of exploring the Rivers Alleghany, Monongahela, Ohio, and Mississippi, etc. pp. 47–49. London, 1808.

† Warden (D. B.), Statistical, Political and Historical Account of the United States, Vol. I, p. 250.

‡ Trans. Am. Ethnol. Soc., Vol. II, p. 1.

§ Journal of Two Visits, etc., p. 17.

pasturage is so good that creatures are well supplied without any assistance. Here are great abundance of buffalo, which are a species of cattle, as some suppose, left here by former inhabitants." In describing the country about Wheeling ("Weeling"), he says: "The wild beasts met with here are bears, wolves, panthers, wild cats, foxes, raccoons, beavers, otters, and some few squirrels and rabbits; buffaloes, deer, and elks, called by the Delawares *moos*."*

Buffaloes are well known to have existed on the Monongahela,† and throughout the region between this river and the Ohio, over the area drained by the Little Kanawha, Buffalo, Fishing, Wheeling, and other small tributaries of the Ohio, where is said to have been much interval or open land,‡ and thence southward to the Great Kanawha. As already noticed, there is abundant evidence of its former existence on the sources of the Kanawha, extending even to the head of the Greenbrier River, in Pocahontas County, and thence eastward, at times at least, over the sources of the James.

Gallatin states that in his time (1784–1785) "they were abundant on the southern side of the Ohio, between the Great and Little Kenawha. I have," he adds, "during eight months lived principally upon their flesh." § The following additional testimony, contained in a letter written by Dr. Charles McCormick, dated "Fort Gibson, Cherokee Nation, August 18, 1844," is furnished by Dr. Elliott Coues. Dr. McCormick says: "I have just seen Captain [Nathan] Boone, and he promises to write and tell you all about it. In the mean time, he says, he killed his first buffalo somewhere about 1793, on the Kenawha in Virginia. He was then quite a small boy. He has also killed buffalo on New River, and near the Big Sandy in Virginia, in '97 and '98." ||

Ample evidence of the former existence of the buffalo in Northern Ohio has already been given; it seems to have been also found abundantly in other parts of the State. Colonel John May met with it on the Muskingum in 1788,¶ and Atwater says, "we had once the bison and the elk in vast numbers all over Ohio." ** Hutchins says that in the natural meadows or savannahs, "from twenty to fifty miles in circuit," situated northwestward of the Ohio River, from the mouth of the Kanawha far down the Ohio, the herds of buffalo and deer were innumerable, and also mentions their abundance over the region drained by the Scioto.†† In answer to recent inquiries of mine, Mr. George Graham, of Cincinnati, well known as a reliable authority on matters relating to the early history of the West, has kindly given me reference to notices of the buffalo as an inhabitant of Ohio in Craig's *Olden Time*, and also unpublished traditional facts bearing upon the date of its extirpation from that State.

The "Journal of George Croghan,"‡‡ published in *Olden Time*,§§ states

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* Ibid., pp. 30, 84.

† Trans. Amer. Antiq. Soc., Vol. II, pp. 139, 140, footnote.

‡ Hutchins (Thomas), Topog. Descrip. of Virginia, Pennsylvania, and North Carolina, comprehending the Rivers Ohio, Kanawha, Scioto, Cherokee, Wabash, Illinois, Mississippi, etc. (London, 1778), p. 4.

§ Trans. Am. Ethnol. Soc., Vol. II, p. 1.

|| Amer. Naturalist, Vol. V, p. 720.

¶ Journal and Letters of Colonel John May of Boston, etc., Hist. and Phil. Soc. of Ohio, New Series, Vol. I, pp. 81, 83.

** Atwater (Caleb), History of the State of Ohio, Natural and Civil, 1838, p. 67.

†† Topog. Descrip. of Virginia, Pennsylvania, etc., pp. 11–15.

‡‡ Not Colonel Croghan of Kentucky.

§§ The Olden Time; a Monthly Publication devoted to the Preservation of Documents and other Authentic Information in relation to the Early Explorations, and the Settlement and Improvement of the Country around the Head of the Ohio. Edited by Neville B. Craig, Esq. Two volumes, small 4to. Pittsburg, 1846–1848.

that buffaloes, bears, turkeys, and other game abounded about the mouth of the "Conhawa," in 1765, as well as at the mouth of "Bottle River," and also on the prairies bordering the "Ouabache."* They were also found and killed by Washington, according to the "Journal of a Tour to the Ohio River in 1770," at the mouth of the Kanhawa and also near the "Great Bend" of the Ohio, in 1770.† According to the "Journal of General [Richard] Butler," buffaloes were killed by his party at the mouth of Big Sandy Creek, in October, 1785, and also on Buffalo Lick Creek and Licking Creek the same year,‡ at which time the buffaloes were there still quite abundant.

"In 1791," says Mr. Graham in one of his letters to me (dated "Cincinnati, April 11, 1876"), "General Massie laid out the town of Manchester in the Virginia Military District of Ohio, about thirty-five miles from Cincinnati. This was the first settlement in the Virginia Military District. The woods in the neighborhood supplied game—deer, elks, buffaloes, bears, and turkeys—while the river furnished a variety of excellent fish. In 1794 and 1795 McArthur § was settling a plan for his winter operations, when he fell in with George Hardick, an experienced hunter and trapper, who was never at ease but when he was ranging through the solitary woods. Agreeing to go into partnership for a winter hunt, they made a light canoe, procured ammunition and beaver-traps, and set off from Manchester, travelling down the Ohio River to the Kentucky River, thence up the Kentucky far above the settlements. Game of every description was found in abundance; deer and buffalo were killed for their hides and tallow. Beaver and otter were the principal game pursued, and were caught in great numbers. They went up the river as far as they could find water to float their canoe, and spent the winter in the spurs of the Cumberland Mountains, more than a hundred miles from the habitations of civilized men," returning in spring by the same route to Manchester.

"The last reliable account of killing buffalo," says Mr. Graham, in the same letter, "is taken from the Lacross manuscripts, and partly from tradition from the lips of the children and grandchildren of those who were present. Of the French who settled at Gallipolis, Ohio, in 1790, but one person ever killed a buffalo. This man's name was Duteil. He was out hunting in the summer of 1795, about two miles west from Gallipolis, and saw a herd of buffaloes. He fired without aiming at any particular one, and luckily killed a large one. He was so elated with this feat that without stopping to examine the animal he ran as fast as he could to the town, and, having announced his luck, came back, followed by the entire body of colonists, men, women, and children. They quickly formed a procession, with musicians playing violins, flutes, and hautboys in front, the fortunate hunter proudly marching with his gun on his shoulder, and the animal swinging from poles thrust through between its tied feet, followed by the crowd, singing and rejoicing at the prospect of good and hearty fare. The animal was quickly skinned and dressed on its arrival at the town, and for several days there was feasting, as the first and last buffalo of Gallipolis was served up in such a variety of ways and means as none but the French could devise; Charles Francis Duteil remaining until his death the renowned marksman who

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* *Olden Time*, Vol. I, pp. 405, 410, 411.

† *Olden Time*, pp. 426, 427.

‡ Ibid., Vol. II, pp. 447, 450, 453, 456, 458, 497.

§ "'McDonald's Sketches,' published in Cincinnati, in 1838, by E. Morgan, gives the life of General McArthur."

killed the first and last buffalo of all the emigrants from France who settled the town of Gallipolis."

Mr. Graham adds that he has "no information that can be relied upon of buffalo being killed in Ohio after the year 1795 or 1796." In a later letter he says, "From all that I know of the early settlement and history of the West, I am under the impression that the buffalo disappeared from Ohio, Illinois, Indiana, and Kentucky about the year 1800."

Its former occurrence over considerable portions of Kentucky is also most abundantly substantiated, as the subjoined extracts from trustworthy authorities sufficiently attest.

M'Clung, in his sketch of Simon Kenton, "taken from a manuscript account, dictated by the venerable pioneer himself," relates the following: "Kenton, with two companions, set out from Cabin Creek, a few miles above Maysville, apparently about 1773 and 1774, to explore the neighboring country. In a short time they reached the vicinity of May's Lick, where they fell in with the great buffalo trace, which in a few hours brought them to the Lower Blue Lick. The flats upon each side of the river were crowded with immense herds of buffalo, that had come down from the interior for the sake of salt; and a number of elk were seen upon the bare ridges which surround the springs. . . . . After remaining a few days at the lick, and killing an immense number of deer and buffalo, they crossed the Licking, and passed through the present counties of Scott, Fayette, Woodford, Clarke, Montgomery, and Bath, where, falling in with another buffalo trace, it conducted them to the upper Blue Lick, where they again beheld elk and buffalo in immense numbers."*

In an account of the adventures of Colonel Daniel Boone, published by Filson, Boone states that he left his "family and peaceable habitation on the Yadkin River, in North Carolina, the 1st of May, 1769, to wander through the wilderness of America, in quest of the country of Kentucke." Crossing the "mountain wilderness," he and his five companions found themselves on Red River, on the seventh of June following. Here they encamped and began to reconnoitre the country. Boone writes: "We found everywhere abundance of wild beasts of all sorts, through this vast forest. The buffaloes were more frequent than I have seen cattle in the settlements, browzing on the leaves of the cane, or cropping the herbage on those extensive plains, fearless, because ignorant, of the violence of man. Sometimes we saw hundreds in a drove, and the numbers about the salt springs were amazing."† During the severe winter of 1780 and 1781, Boone says that the inhabitants of Kentucky "lived chiefly on the flesh of the buffalo."

Filson says (writing in 1784): "I have heard a hunter assert, he saw above one thousand buffaloes at the Blue Licks at once; so numerous were they before the first settlers had wantonly sported away their lives. There still remain a great number in the exterior parts of the settlement."‡ Again he says, after describing the salt licks of Kentucky: "To these [the licks] the cattle repair, and reduce high hills rather to valleys than plains. The amazing herds of Buffaloes which resort thither, by their size and number, fill the traveller with amazement and terror, especially when he beholds the prodigious roads they have made from all quarters, as if leading to some populous city; the vast

* Western Adventures, p. 86.

† Filson (John), Discovery, Settlement, and Present State of Kentucky, 1784, pp. 50, 51.

‡ Filson (John), Discovery, Settlement, and Present State of Kentucky, 1784, pp. 27, 28.

space of land around these springs desolated as if by a ravaging enemy, and hills reduced to plains; for the land near these springs is chiefly hilly."*

Cuming, in describing the salt licks along the Licking and Ohio Rivers, thus refers to the former abundance of the buffalo at these localities: "These licks were much frequented by buffaloes and deer, the former of which have been destroyed or terrified from the country. It is only fourteen or fifteen years since no other except buffalo or bear meat was used by the inhabitants of this country." He was informed by Captain Waller that "buffalo, bears, and deer were so plenty in the country, even long after it began to be generally settled, and ceased to be frequented as a hunting-ground by the Indians, that little or no bread was used, but that even the children were fed on game, the facility of gaining which prevented the progress of agriculture, until the poor innocent buffaloes were completely extirpated and other wild animals much thinned; and that the principal part of the cultivation of Kentucky had been within the last fifteen years. He said the buffaloes had been so numerous, going in herds of several hundreds together, that, about the salt licks and springs they frequented, they pressed down and destroyed the soil to a depth of three or four feet, as was conspicuous yet in the neighborhood of the Blue Lick, where all the old trees have their roots bare of soil to that depth."†

Other references to the abundance of the buffalo in Kentucky, at the time this region was first visited by the white settlers, might be given, but those above cited seem sufficient for the present occasion.

The buffalo seems also to have existed in considerable numbers in portions of Tennessee, particularly about the salt springs on the Cumberland River, as shown by Putnam's "History of Middle Tennessee."‡ This author gives extracts from the journal of John Donelson, respecting a voyage made by him from Fort Patrick Henry, on the Holston River, to the French Salt Springs on the Cumberland River, in December, 1780. Donelson says that he "procured some buffalo meat on the Cumberland, near its mouth," and two days further up this river, he says, "We killed some more buffalo." The next day, he writes: "We are now without bread, and are compelled to hunt the buffalo to preserve life."§ Subsequently, in speaking of the salt or sulphur springs on the Cumberland, apparently near the present site of Nashville, we find the following passages: "The open space around and near the sulphur or salt springs, instead of being an 'old field,' as had been supposed by Mr. Mausker, at his visit here in 1769, was thus freed from trees and underbrush by the innumerable herds of buffalo and deer and elk that came to these waters. . . . . Trails, or buffalo paths, were deeply worn in the earth from this to other springs. . . . . All the rich lands were covered with cane-brakes; through these there were paths made by the buffalo and other wild animals."||

Ramsey states that in 1769 and 1770 an exploring party of ten persons passed up the Cumberland, and that "where Nashville now stands they discovered the French Lick, and found around it immense numbers of buffalo and other wild game. The country was crowded with them. Their bellowings sounded from the hills and forest."¶ According to the same

* Ibid., pp. 32, 33.
† Cuming (John), Sketches of a Tour to the Western Country, etc., 1810, pp. 155, 156.
‡ Counties *Davidson*, *Sumner*, *Robertson*, and *Montgomery*.
§ Putnam's Middle Tennessee, pp. 74, 75.
|| Ibid., p. 81.
¶ The Annals of Tennessee, to the End of the Eighteenth Century, etc., p. 105.

authority, the buffalo was at one time also numerous in the valleys of East Tennessee. He states that in 1764 Daniel Boone left his home on the Yadkin to explore, in company with others, the then unknown country to the westward. "Callaway," says Ramsey, "was at the side of Boone when, approaching the spurs of the Cumberland Mountain, and in view of the vast herds of buffalo grazing in the valleys between them, he exclaimed: 'I am richer than the man mentioned in Scripture, who owned the cattle on a thousand hills,—I own the wild beasts of more than a thousand valleys!'"* Whether or not the buffalo ranged formerly to the Tennessee River, I have been unable to determine, although, as already noticed, there is pretty good evidence that it did not extend beyond this boundary. The existence of a stream named Buffalo River, near the Great Bend of the Tennessee, seems to render it probable that it extended nearly or quite to the Tennessee itself. Gallatin gives the range of the buffalo east of the Mississippi as being "between the Lakes and the Tennessee River";† but he also says that it formerly ascended the Valley of the Tennessee "to its sources," and adds: "They were but rarely seen south of the ridge which separates that river from the sources of those which empty into the Gulf of Mexico, and nowhere, in the forest country, in herds of more than from fifty to two hundred."‡ I have found, however, no positive reference to their being found anywhere south of the Tennessee.

As previously stated, the range of the buffalo east of the Mississippi, with the exception of its occasional appearance on the eastern slope of the Alleghanies in North and South Carolina, on the head-waters of the James River in Virginia, and possibly in Union County, Pennsylvania, was restricted to the area drained by the Ohio and Illinois Rivers and their tributaries, and the lesser eastern tributaries of the Mississippi in Northern Wisconsin and Minnesota. It was also absent from the lowlands of the lower portion of the Ohio River. The foregoing citations, however, show it to have been originally very numerous and uniformly distributed over the prairies of Illinois and Indiana, and also throughout the country immediately bordering the Ohio and its upper tributaries, as the Licking, Great and Little Kanawha, and the Alleghany and Monongahela Rivers. It seems to have been somewhat less uniformly and less numerously dispersed over the States of Ohio, the western parts of Pennsylvania, West Virginia, Kentucky, and the northern parts of Tennessee, although it regularly frequented portions of each of these States, and was probably more or less abundant throughout the open woods and "barrens" of the two last named. Its range was hence restricted to the prairies, the scantily wooded districts, and the narrow belts of open land along the streams.§

Its Extirpation.—Upon the establishment of the first permanent white

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* Ibid., p. 69.

† Transactions Amer. Ethnological Society, Vol. I, p. 1.

‡ Transactions Amer. Antiquarian Society, Vol. II, p. 139.

§ The area of wooded and woodless territory is thus given by Gallatin: As is well known, the whole Atlantic slope "was covered with a dense and uninterrupted forest when the European settlers landed in America;" and the country south of the 40th parallel excepting "the Barrens" of Kentucky, westward to the Mississippi Valley, and north of the Great Lakes as far west as Winnipeg, was similarly forested. Between the 40th parallel and Lake Erie there were areas destitute of wood, or prairies, which increased in size westward, till in Central and Northern Illinois they equalled the timbered areas, while west of the Mississippi the forests were confined to narrow belts along the rivers.—*Trans. Amer. Antiq. Soc.*, Vol. II, pp. 137, 138, 1836.

In respect to the former distribution of forests in the United States, see also Professor W. H. Brewer's map of the distribution of woodland recently published in General Francis A. Walker's "Statistical Atlas of the United States," Plates III and IV (1873).

settlements over this region, the extermination of the buffalo progressed with wonderful rapidity. Its history is a shameful record of wasteful and wanton destruction of life, like that which ever marks the contact of man with the larger mammalia. The extermination of the buffalo in Western Pennsylvania, West Virginia, Ohio, Kentucky, and Tennessee, was very rapid, this animal surviving at most points for but a few years after the first permanent settlements were made. In Illinois and Indiana it existed for about a century and a quarter after the country was first explored by the Jesuit missionaries, and for more than half a century seems to have scarcely diminished in numbers. As late as 1773 it was abundant on both sides of the Kaskaskia River, and also along the Illinois, and apparently over all the prairies of the intermediate region.* Later its extermination was more rapid, its disappearance here apparently antedating by several years its extirpation along the upper tributaries of the Ohio. The date of its disappearance from Illinois and Indiana, however, I can give less definitely than that of its extermination at points more to the eastward. In Pennsylvania, according to Mr. Ashe, they were all destroyed within a few years after the arrival of the first settlers, being apparently wholly exterminated prior to the year 1800. It lingered in West Virginia till a few years later, as it did also in portions of Kentucky. Toulmin, writing about 1792, says, "The buffalo are mostly driven out of Kentucky. Some are still found upon the head-waters of Licking Creek, Great Sandy, and the head-waters of Green River."† It appears, according to Audubon, to have lingered here, however, only a few years longer. "In the days of our boyhood and youth," says this author, "buffaloes roamed over the small and beautiful prairies of Indiana and Illinois, and herds of them stalked through the open woods of Kentucky and Tennessee; but they had dwindled down to a few stragglers, which resorted chiefly to the 'barrens,' towards the years 1808 and 1809, and soon after entirely disappeared."‡ Cuming adds that all had been driven from the salt licks of the Licking and Ohio Rivers before 1807, while Mr. Ashe,§ an apparently reliable authority, affirms that as early as 1806 not one was to be found in a wild state east of the Mississippi, referring, doubtless, to the Mississippi below latitude 41°. Brackenridge,|| in 1814, says the buffalo may be said to have retired to the northward of the Illinois and to the westward of the Mississippi, and other writers confirm this statement.¶

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* See Kennedy's Journal of an Expedition from Kaskaskia Village to the Head-waters of the Illinois River, in Hutchins's Topog. Descrip. of Virginia, Pennsylvania, etc., pp. 51–64; also Hutchins's Topog. Descrip., etc., pp. 35, 41, 44.

† Toulmin (Henry), Description of Kentucky, p. 85.

‡ Quadrupeds of North America, Vol. II, p. 36.

§ Travels in America, etc., p. 49.

|| Views of Louisiana, p. 56.

¶ Ellsworth states, in his "Notes on the Wild Animals of Illinois," published in 1831, that "the buffalo has entirely left us. Before the country was settled, our immense prairies afforded pasturage to large herds of this animal, and the traces of them are still remaining in the 'buffalo paths' which are to be seen in several parts of the State. These are well-beaten tracks, leading generally from the prairies in the interior of the State to the margins of the large rivers; showing the course of their migrations as they changed their pastures periodically, from the low marshy alluvion to the dry upland plains. In the heat of summer they would be driven from the latter by prairie flies; in the autumn they would be expelled from the former by the mosquitoes; in the spring, the grass of the plains would afford abundant pasturage, while the herds could enjoy the warmth of the sun, and snuff the breeze that sweeps so freely over them; in the winter the rich cane of the river-banks, which is evergreen, would furnish food, while the low grounds thickly covered with brush and forest would afford protection from the bleak winds."—ELLSWORTH (H. L.), *Illinois in* 1837, p. 38. (First published in the Illinois Magazine, July, 1831, and republished in Featherstonhaugh's Monthly American Journal of Geology and Natural Science, October, 1831, p. 180.)

Schoolcraft, writing in 1821, says that "the only part of the country east of the [Mississippi] river where the buffalo now remains, is that included between the Falls of St. Anthony and Sandy Lake, a range of about six hundred miles." Sibley says that "two individuals were killed in 1832 by the Dacotahs or Sioux Indians, on the Trempe à l'Eau [Trempeleau] River, in Upper Wisconsin," and adds, "They are believed to be the last specimens of the noble bison which trod, or will ever again tread, the soil of the region lying east of the Mississippi River."*

Most writers, in alluding to the extirpation of the buffalo throughout the region east of the Mississippi River, speak of it as having been "driven out" by the encroachment of settlements.† While a few of the herds may have migrated westward, it seems more probable that it was *exterminated* rather than *driven out*, as it appears to have existed in West Virginia and in Eastern Kentucky to quite as late, or even to a later period, than on the prairies adjoining the Mississippi. The extension of settlements down the Mississippi River would tend to hem the buffalo in on that quarter, and, as will be shown later, it disappeared at nearly the same time over a considerable breadth of country bordering the western shore of this river.

Schoolcraft says that the buffalo "was found in early days to have crossed the Mississippi above the latitude of the mouth of the Ohio, and at certain times to have thronged the present area of Kentucky," etc.; from which it may be inferred that he deemed its presence east of the Mississippi River to have been of comparatively brief continuance. Gallatin also always speaks of it as having "spread from the westward" over the region east of the Mississippi. Professor Shaler has referred to the probability of its having been unknown to the mound-builders,‡ since they have left nothing indicating that they were acquainted with it, which is not the case with most of the other large mammals of the interior of the continent.§ He also states that in his exploration of the salt licks of Kentucky he had found its bones in great abundance "just below the recent mould, in a bed about eighteen inches thick"; but that "in the rich deposits of extinct mammals just beneath, immediately above which traces of worked flint were also found, no buffalo bones were discovered."

THE FORMER RANGE OF THE BUFFALO WEST OF THE ROCKY MOUNTAINS.

The vast region situated between the Mississippi River and the Rocky Mountains, excepting the lowlands bordering the Lower Mississippi, is

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* Sibley (H. H.) in Schoolcraft's History, Condition, and Prospects of the Indian Tribes, Part IV, p. 94. Major Long states that in 1822 its wanderings down the St. Peter's River did not extend beyond Great Swan Lake (Camp Crescent).—*Exped. to the Sources of the St. Peter's River, etc.*, Vol. II, p. 29.

† Even scientific writers speak of it as having "gradually retired westward in advance of the migrating column of the white race of man."—LEIDY, *Mem. Ext. Sp. Amer. Ox*, 1852.

"At the time of the discovery by the Spaniards an inhabitant even down to the shores of the Atlantic, it has been beaten back by the westward march of civilization, until, at the present day, it is only after passing the giant Missouri and the headwaters of the Mississippi that we find the American bison or buffalo. Many causes have combined to drive them away from their old haunts; the wholesale and indiscriminate slaughter by the whites, the extension of settlements, the changes of the face of the country; but above all, the mysterious dread of the white man, which pervades animal life in general as a congenital instinct."—BAIRD, *Pat. Off. Rep., Agricult.*, 1851–52, Part II, p. 124.

‡ Proc. Bost. Soc. Nat. Hist., Vol. XIII, p. 136.

§ See further Professor Shaler's remarks on this point already given.

well known to have been formerly embraced within the range of the buffalo. So well established is this fact that a special consideration of this region will be deferred till the former boundaries of its range to the westward and southward have been traced.

Although the main chain of the Rocky Mountains has commonly been supposed to form the western limit of the range of the buffalo, there is abundant proof of its former existence over a vast area west of this supposed boundary, including a large part of the so-called Great Basin of Utah, the Green River Plateau, and the plains of the Columbia. It is probably not yet half a century since it ranged westward to the Blue Mountains of Oregon and the Sierra Nevada Mountains of California.

Respecting its former occurrence in Eastern Oregon, Professor O. C. Marsh, under date of New Haven, February 7, 1875, writes me as follows: "The most western point at which I have myself observed remains of the buffalo was in 1873, on Willow Creek, Eastern Oregon, among the foot-hills of the eastern side of the Blue Mountains. This is about latitude 44°. The bones were perfectly characteristic, although nearly decomposed."

The former existence of the buffalo in the Great Salt Lake Valley is established by the occurrence of its remains there in a still good state of preservation, as well as by the testimony of those who have seen them there. Along the railroad leading from Ogden City to Salt Lake City I examined, in September, 1871, numbers of skulls in a nearly perfect state of preservation, which had been exposed in throwing up the road-bed across the marshes a few miles north of Salt Lake City. I also saw a few on the terraces north and west of Ogden City, but generally in a disintegrated condition, as were all that I saw which had not been buried in the recent deposits about the Great Salt Lake. I was also informed that there is a tradition among the Indians of this region that the buffaloes were almost entirely exterminated by deep snows many years since. Mr. E. D. Mecham, of North Ogden, a reliable and intelligent hunter and trapper of nearly forty years' experience in the Rocky Mountains, and at one time a partner of the celebrated Joseph Bridger, informed me that few had been seen west of the great Wahsatch range of mountains for the last thirty years, but that he had seen their weathered skulls as far west as the Sierra Nevada Mountains.* In 1836, according to Mr. Mecham, there were many buffaloes in Salt Lake Valley, which were nearly all destroyed by deep snow about 1837, when, according to the reports of mountaineers and Indians, the snow fell to the depth of ten feet on a level. The few buffaloes that escaped starvation during this severe winter are said to have soon after disappeared. Mr. Henry Gannet, astronomer of Dr. Hayden's Survey, informs me that the Mormon Danite, "Bill" Hickman, claims to have killed the last buffaloes in Salt Lake Valley about 1838. How long the buffalo inhabited the Basin of the Great Salt Lake it is of course now impossible to determine, but it seems probable that their occupation must date back to a remote period, since their skulls occur wholly buried in the marshes about the lake, where the deposition appears to have been quite slow. I am also informed by Mr. H. W. Henshaw, the well-known ornithologist of Lieutenant Wheeler's Survey, that their skulls have been found in Utah Lake. Mr. Henshaw, under date of Washington, D. C., March 6, 1875, writes as follows:

* I was informed by several persons whom I met in the Salt Lake Valley, that they had seen skulls of buffaloes as far west as the eastern slope of the Sierra Nevada Mountains. These persons were unknown to each other, and their accounts were wholly distinct in respect to date and locality, and hence seem all the more entitled to credence.

"The only information I have regarding its [the buffalo's] presence in Utah was derived from Mr. Madsen, a Danish fisherman, living on the borders of Utah Lake; and, I may add, I am perfectly convinced of the trustworthiness of his statement. In using the seine in the waters of the lake, he has on several occasions brought up from the bottom the skulls of buffaloes in a very good state of preservation. Their presence in the lake may perhaps be accounted for on the supposition that, in crossing on the ice, a herd may at some time have broken through, and thus perished. From him I also learned that he had talked with Indians of middle age whose fathers had told them that in their time the buffaloes were numerous, and that they had hunted them near the lake. If this can be accepted as truth, it would place the existence of these animals in Utah back to a not very distant date. I learn from my friend W. W. Howell that during the past season he obtained the cranium of a buffalo which was unearthed by some laborers while digging a mill-race at a depth of ten feet below the surface. This was in a broad cañon near Gunnison. While, from the fact of its being in a cañon, no very exact estimate can be made of the time of its deposit, there seemed every evidence that the soil above it had remained undisturbed for a long time. The lower portion of the cranium is gone, leaving the part above the orbits and the horn-cores intact, and in an excellent state of preservation. A comparison of this with a recent specimen of the *B. americanus* shows that in certain characters it exhibits an approach to the *Bison latifrons*, as described by Leidy. In size it varies little from the *B. americanus*, but in all other characteristics is much nearer the *B. latifrons*."*

The buffalo seems, however, to have lingered later on the head-waters of the Colorado than in either the Great Salt Lake Valley, or the valley of Bear River, or on the head-waters of the two main forks of the Columbia. Frémont found them on St. Vrain's Fork of Green River, and on the Vermilion in 1844,† and Stansbury, in 1849, found them on the northern tributaries of the Yampah, and the upper tributaries of Green River; but the scarcity of water seemed to have forced the greater part of them southward. Respecting their occurrence near Bridger's Fork of the Muddy, Stansbury says: "As long as the water lasted, the whole plain must have been covered with buffalo and antelope, as the profusion of 'sign' abundantly proved; but as this indispensable article was absorbed by the sandy soil, they seemed, from the direction of their trails, to have struck a course for the Vermilion."‡

They have, however, long since disappeared from the head-waters of Green River, and, indeed, from all the country drained by the tributaries of the Colorado. Although their bleached skulls are still found throughout the valleys, I was informed by old hunters whom I saw there in the autumn of 1871, that no buffaloes had been seen in this region for more than twenty years.

The best account of their range in recent times, west of the Rocky Mountains, and of their extermination over this vast region, is that given by Frémont, based on his own extensive travels and on the still more extended experience of Mr. Fitzpatrick. Frémont states that in the spring of 1824 "the buffalo were spread in immense numbers over the Green River and Bear River Valleys, and through all the country lying between the Colorado, or Green River of the Gulf of California,

*Its agreement in size with *Bison americanus* is sufficient to indicate its identity with that species.

†First and Second Expeditions, etc., p. 281.

‡Stansbury's Expedition to the Great Salt Lake, p. 238.

and Lewis's Fork of the Columbia River; the meridian of Fort Hall then forming the western limit of their range. The buffalo then remained for many years in that country, and frequently moved down the valley of the Columbia, on both sides of the river, as far as the *Fishing Falls*. Below this point they never descended in any numbers.* About 1834 or 1835 they began to diminish very rapidly, and continued to decrease until 1838 or 1840, when, with the country we have just described, they entirely abandoned all the waters of the Pacific north of Lewis's Fork of the Columbia. At that time the Flathead Indians were in the habit of finding their buffalo on the heads of Salmon River and other streams of the Columbia, but now [1843] they never meet with them farther west than the three forks of the Missouri or the plains of the Yellowstone River.

"In the course of our journey it will be remarked that the buffalo have not so entirely abandoned the waters of the Pacific, in the Rocky Mountain region south of the Sweet Water, as in the country north of the Great Pass. This partial distribution can only be accounted for in the great pastoral beauty of that country, which bears marks of having long been one of their favorite haunts, and by the fact that the white hunters have more frequented the northern than the southern region—it being north of the South Pass that the hunters, trappers, and traders have had their rendezvous for many years past; and from that section also the greater portion of the beaver and rich furs were taken, although always the most dangerous, as well as the most profitable, hunting-ground.

"In that region lying between the Green or Colorado River and the head-waters of the Rio del Norte, over the *Yampak*, *Kooyah*, *White*, and *Grand* Rivers,—all of which are the waters of the Colorado,—the buffalo never extended so far westward as they did on the waters of the Columbia; and only in one or two instances have they been known to descend as far west as the mouth of White River. In travelling through the country west of the Rocky Mountains, observation readily led me to the impression that the buffalo had for the first time crossed that range to the waters of the Pacific only a few years prior to the period we are considering; and in this opinion I am sustained by Mr. Fitzpatrick, and the older trappers in that country. In the region west of the Rocky Mountains we never meet with any ancient vestiges which, throughout all the country lying upon their eastern waters, are found in the *great highways*, continuous for hundreds of miles, always several inches and sometimes several feet in depth, which the buffalo have made in crossing from one river to another, or in traversing the mountain ranges. The Snake Indians, more particularly those low down upon Lewis's Fork, have always been very grateful to the American trappers for the great kindness (as they frequently expressed it) which they did to them in driving the buffalo so low down the Columbia River."†

It would thus seem to be Frémont's belief that their occupation of the Snake River country was temporary, and that they did not pass west of the mountains till driven thither, at a comparatively recent period, by persecution east of the mountains. That they were absent from this region not long previously appears evident from the fact that Lewis and Clarke, in 1805, met with no buffaloes west of the mountains, nor

* The locality at which Professor Marsh found the crumbling bones of the buffalo (referred to on a preceding page) is some two hundred and fifty miles further northwest, or lower down the river.

† Report of the Exploring Expedition to the Rocky Mountains, in the year 1842, and to Oregon and California, in the years 1843–'44, p. 144.

even on the upper portion of the three forks of the Missouri, although there was evidence of their former existence in immense herds on the Jefferson Fork. In their enumeration of the animals of the Pacific slope these travellers make no allusion to the buffalo. They also state that the Indians on Clarke's River crossed the mountains in spring to traffic for buffalo robes with the Indians of the eastern slope.*

In 1820 Major Long also states: "They have not yet crossed the entire breadth of the mountains at the head of the Missouri, though they penetrate, in some parts, far within that range, to the most accessible fertile valleys, particularly the valley of Lewis's River. It was there that Mr. Henry and his party of hunters wintered, and subsisted chiefly upon the flesh of these animals, which they saw in considerable herds, but the Indians affirmed that it was unusual for the bisons to visit that neighborhood." This would seem to fix the date of their arrival at the head-waters of the Columbia between 1805, when Lewis and Clarke visited them, and Mr. Henry's visit, about 1817.

From Washington Irving's entertaining narrative of Captain Bonneville's tour across the continent † we learn that Captain Bonneville first met with the buffalo west of the Rocky Mountains on the head-waters of Bear River, in November, 1833.‡ Passing thence northward, they found these animals in abundance on the plains of Portneuf, where the Bannack Indians were engaged in hunting them.§ But in his subsequent long winter march up the Snake River, no buffaloes appear to have been met with. Returning, however, to Bear River Valley, he again encountered large herds. The following summer (July, 1834) they again found them in great numbers on the sources of the Blackfoot River,‖ but in a subsequent long journey northwestward, from the Upper Snake River nearly to Fort Walla Walla and back, they met with none, and rejoiced to find them again "in immense herds" near their old camping-ground on an eastern tributary of the Snake River. Captain Bonneville's party passed the winter of 1834–35 in camp on the upper part of Bear River, surrounded by immense herds of buffaloes, which came down to them from the north. "The people upon Snake River," says the narrative, "having chased off the buffalo before the snow had become deep, immense herds now came trooping over the mountains, forming dark masses on their sides, from which their deep-mouthed bellowing sounded like the peals and mutterings from a gathering thunder-cloud. In effect, the cloud broke, and down came the torrent into the valley. It is utterly impossible, according to Captain Bonneville, to convey an idea of the effect produced by the sight of such countless throngs of animals of such bulk and spirit, all rushing forward as if swept on by a whirlwind."¶ In the autumn of 1835 Parker met with great herds on the east fork of the Salmon River and on other tributaries of the Snake River.**

Dr. J. S. Newberry, writing in 1855, says: "The range of the buffalo does not *now* extend beyond the Rocky Mountains, but there are many Indian hunters who have killed them in great numbers to the west of

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* Lewis and Clarke's Expedition to the Sources of the Missouri, and down the Columbia to the Pacific Ocean, Vol. I, p. 469.

† The Rocky Mountains; or, Scenes, Incidents, and Adventures in the Far West,—a Digest of the Journal of Captain B. L. E. Bonneville. 2 vols., 12mo, 1837.

‡ Ibid., Vol. I, pp. 125, 129.

§ Ibid., Vol. II, p. 33.

‖ Irving's Rocky Mountains, Vol. II, p. 179.

¶ Irving's Rocky Mountains, pp. 208, 211.

** Parker (Samuel); Journal of an Exploring Tour beyond the Rocky Mountains, pp. 88, 107, 108.

the mountains, on the head-waters of Salmon River, one of the tributaries of the Columbia. While I was at the Dalles, the party of Lieutenant Day, U. S. A., came in from an expedition to the Upper Salmon River, and I was assured by the officers that they had not only seen Indians who claimed to have killed buffalo there, but that, in many places, great numbers of buffalo skulls were still lying on the prairie."*

Dr. Suckley, writing under date of December, 1853, also says: "Buffalo were formerly in great numbers in this valley [the valley of the Bitter Root, or St. Mary's River, one of the sources of Clarke's Fork of the Columbia], as attested by the number of skulls seen and by the reports of the inhabitants. For a number of years past, none had been seen west of the mountains; but, singular to relate, a buffalo bull was killed at the mouth of the Pend d'Oreille River on the day I passed it. The Indians were in great joy at this, supposing that the buffalo were coming back to them."† Just east of the mountains separating the sources of the Jefferson and Salmon Rivers, buffaloes still existed in immense numbers. Lieutenant Mullan reports meeting, on December 4, 1853, with several bands of the Nez Percés Indians returning from their hunt east of the mountains, with many animals loaded with meat and furs. "This," he says, "has been a great hunting-season with all the Indians, both east and west of the mountains. Hundreds of thousands of buffalo have been slain, and small game—consisting of antelope, deer, beaver, etc.—has been innumerable."‡

It thus appears that the buffalo formerly existed west of the Rocky Mountains, nearly to the northern boundary of the United States, and that they had become completely exterminated there as early, according to Frémont (as above cited), as 1840, although they swarmed there in immense herds as late as 1835. The valleys of the streams in that region are represented as abounding in fertile prairies, and as being generally covered with perennial grasses. As the adjoining country westward is barren and wholly unproductive of grass, it is probable that the buffalo ranged further westward only irregularly, and in straggling bands. Bonneville, at least, failed to meet with any between the sources of Snake River and Fort Walla-Walla in 1834 and 1835, and no other explorer seems to have met with them living so far west. Dr. Hayden informs me that a few still exist in the valley of the Gros Ventres, and in the extreme upper part of the Snake River,—merely straggling old bulls, the last survivors of former populous herds. Professor O. C. Marsh writes me that the last one shot on Henry's Fork was killed in 1874. Professor J. Marcou informs me that a single old buffalo bull made his appearance at Fort Bridger last summer (1875), but that none had been seen there before, according to Dr. Carter, for thirty years. This solitary straggler was probably a wanderer from the remnants of his race still left in the valleys of the Wind River Mountains.

Range westward south of the Thirty-ninth Parallel.—According to Lieutenant Whipple, "there do not seem to be any well-authenticated accounts of the existence of the buffalo west of the Rio Grande." He adds: "On inquiring how far west the buffalo had been seen, a Tegua Indian stated that many years ago his father killed two at Santo

* Newberry's Zoölogical Report of Lieutenant Abbot's Report of Explorations for a Railroad Route from the Sacramento Valley to the Colorado River. Pacific R. R. Explor. and Surv., Vol. VI, Zoölogical Report, p. 72.

† Suckley (Dr. George), Canoe Voyage from Fort Owen to Fort Vancouver. Pacific R. R. Explor. and Surv., Vol. I, Governor Stevens's Report, p. 297.

‡ Mullan (Lieutenant John), Report of a Reconnaissance from Bitter Root Valley to Fort Hall, etc., Pacific R. R. Explorations and Surveys, Vol. I, Governor Stevens's Report, p. 325.

Domingo. A Mexican from San Juan de Caballeros added that in 1835 he saw buffalo on the Rio del Norte." Lieutenant Whipple further says that "Father Escalante, in a manuscript journal of a trip from New Mexico to the Great Salt Lake,* in 1776, mentioned having seen signs of their existence on his route;† still, notwithstanding the location of the famous kingdom of Cibola by the early explorers, there do not seem to be any well-authenticated accounts of the existence of these animals west of the Rio Grande."‡ It appears, however, that two centuries ago these animals were not unknown to the Indians of the Gila and Zuñi Rivers, who obtained their skins from the tribes living several hundred miles to the eastward. Thus Friar Marco de Niça, in 1539, found "ox-hides" in the possession of the Indians living on the tributaries of the Gila, which they had obtained by trading with the people of the kingdom of Cibola;§ the ancient pueblo of Cibola being generally supposed to be near the site of the present pueblo of Zuñi, on the river of that name.|| The people of Cibola at this time not only used the skins as articles of dress, but for shields and other purposes.

From the Yampah and Grand, and other tributaries of the Colorado, the buffalo formerly ranged eastward to the Parks and Great Plains, but I have found no record of their existence in the highlands of New Mexico, or anywhere to the westward or southward of Santa Fé. Coronado, during his great expedition in search of the "Kingdom of Cibola" (1540 to 1543), in marching northward from the western provinces of Mexico across Arizona to the plains east of Santa Fé, met with no buffaloes till he reached a place called Cicuic, situated on the Pecos near the site of the present town of that name,¶ "four leagues eastward from which place they met a new kind of oxen, wild and fierce, whereof, the first day, they killed fourscore, which sufficed the army with flesh."

Dr. Elliott Coues, however, in his paper on the "Quadrupeds of Arizona," published in the American Naturalist in 1868,** states that "there is abundant evidence that the buffalo (*Bos americanus*) formerly ranged over Arizona, though none exist there now." On requesting recently more detailed information of Dr. Coues respecting this evidence, he writes†† that he finds himself now unable to substantiate the statement, but adds, "I distinctly remember being satisfied *at the time* of what I said." I have myself made extensive inquiries of naturalists and Army officers who had either passed through Arizona or had been stationed there for a considerable length of time without being able to elicit any corroborative evidence of Dr. Coues's statement.‡‡

* Utah Lake, according to General G. K. Warren (see the next footnote).

† According to General G. K. Warren (Pacific R. R. Expl. and Surveys, vol. xi, p. 35), "Father Escalante, in 1776, travelled from near Santa Fé, New Mexico, in a northwesterly direction to the Great Colorado. . . . . During this journey he was probably in the vicinity of Utah Lake." This route would take him across the range of the buffalo west of the Rocky Mountains, since, as already stated, they at that time existed on the headwaters of the Colorado, and extended as far west as Utah Lake.

‡ Whipple's Itinerary, Pacific R. R. Explorations and Surveys, Vol. II, Part I, p. 35.

§ See Niça's account of his journey as translated by Hakluyt.—*Hakluyt's Voyages*, Vol. III, p. 439.

|| Davis's Spanish Conquest of New Mexico, pp. 119, 120, footnote.

¶ See R. H. Kern's Map of Coronado's route in Schoolcraft's History, Condition, and Prospects of the Indian Tribes of the United States, Part IV, plate iii.

** Vol. I, p. 540.

†† Under date of "Washington, D. C., May 5, 1875."

‡‡ Dr. W. J. Hoffman, under date of "Reading, Penn., June 19, 1875," writes me that he "found no tradition amongst any of the tribes in Arizona, by which we might infer that their ancestors were acquainted with this animal. The tribes visited are located in the northern part of Arizona (Plateau del Colorado), in the Mogollon Mts., Sierra Blanca, and along the Rio Gila and as far eastward as the Rio Colorado-chiquito."

Extreme Southwestern Limit.—Respecting the extreme southwestern limit of the former range of the buffalo, Keating, on the authority of Colhoun, wrote, in 1823, as follows: "De Laët says, on the authority of Herrera, that they grazed as far south as the banks of the Yaquimi.* In the same chapter the author states that Martin Perez had, in 1591, estimated the Province of Cinaloa, in which this river runs, to be three hundred leagues from the city of Mexico. This river is supposed to be the same which, on Mr. Tanner's map of North America (Philadelphia, 1822), is named Hiaqui,† and situated between the 27th and 28th degrees of north latitude. Perhaps, however, it may be the Rio Gila, which empties itself in latitude 32°."‡

On referring to the works cited by Keating, I find that Herrera gives the statement on the authority of Nuña de Guzman, who made a journey to Cinaloa in 1532. According to a map accompanying De Laët's work, the province of Cinaloa included the parallels of twenty-seven and twenty-eight degrees. Herrera's statement is as follows: "En la ribera de Yaquimi ay algunas vacas, y muy grandes ciervos";§—simply that many cattle and many deer of very large size were found on the banks of the Yaquimi. In the context, nor in any of the old writings descriptive of this region at the time it was first visited by the Spaniards, do I find any further statements that could by the freest license of translation be rendered bison or buffalo. As the only species of the deer family found in this region is the little *Cervus mexicanus*, *one of the smallest deer found in North America*, the phrase *muy grandes ciervos* can only refer to this species, and gives at once sufficient evidence of the exaggerated style of the narrative,—a fault well known to be common to the descriptive writings of those times. This obscure statement does not apparently afford satisfactory ground for doubting what historians have so generally accepted in respect to the buffalo, namely, that it was first met with in its native haunts by Cabeça de Vaca, on the plains of Texas, in 1530, and next by Coronado's expedition in 1542. In rebuttal of this supposed proof of the existence of the buffalo in Western Mexico, on the Yaquimi or Yaqui River, during the middle of the sixteenth century, we have the rather weighty evidence that the other early Spanish explorers who traversed this region did not even hear of the buffalo till they reached the Gila, where they found, as before stated, its robes in the possession of the Indians, which the latter had obtained from the tribes living far to the northeastward. In 1539, for example, Friar Marco de Niça set out from the town of San Miguel, in the Province of Culiacan, situated far to the southward of the Rio Yaqui, in search of the famed Kingdom of Cibola. In this journey he reached the Zuñi River, whence he retraced his steps to San Miguel and passed on to Compostella, situated in latitude about 21°. The following year (1540) Coronado, with his large army, passed over nearly the same route, both crossing the Rio Yaqui. Niça, however, saw only the prepared skins of the buffalo, which was also all that Coronado saw till after he had passed Cicuic and reached the Great Plains east of the Rocky Mountains. It is from these explorers and from Cabeça de Vaca that we get the first specific account of the buffalo. It hence follows that there is good reason for supposing the buffalo to have been absent from the western provinces of Mexico,

* "Juxta Yaquimi fluminis ripas tauri vaccæque et prœgrandes cervi pascuntur."—De Laët, *Americæ Utriusque Descriptio*, Lugd. Batav. Anno 1633, Lib. Cap. 6." p. 286.

† The Rio Yaqui, doubtless, of modern maps.

‡ Long's Expedition to the Source of the St. Peter's River, Vol. II, p. 28.

§ Herrera (Antonio de), Historia de las Indias Occidentales, Tomo III, p. 16. (Ed. of 1728.)

and from that part of the United States west of the Rio Grande del Norte from a period antedating the sixteenth century till the present time. Why it may not during some earlier period have existed throughout this whole region would be hard to say, since, as will be soon shown, its existence on the Yaqui River would not carry its range south of points the buffalo is known to have reached on the Atlantic slope.

FORMER RANGE SOUTH OF THE RIO GRANDE DEL NORTE.

Most writers give the southern limit of the former habitat of the buffalo as latitude 28° to 30°, believing it never to have extended south of the Rio Grande. There is, however, sufficient proof of its former extension over the northeastern provinces of Mexico, including certainly portions of the present States of Tamaulipas, Nuevo Leon, Coahuila, Chihuahua, and Durango. It thus extended southward to at least the 25th parallel. It seems not, however, to have been abundant over much of this region, and to have been mainly extirpated prior to the beginning of the present century. As late as 1806, however, Pike enumerated the buffalo among the animals of "Cogquilla"* (a province then extending on both sides of the Rio Grande, and embracing a portion of what is now Southwestern Texas), but whether found north or south of the Rio Grande is not stated. The buffalo is not enumerated by Pike in his lists of the animals of any of the other Mexican Provinces situated south of the Rio Grande.†

De Laët‡ mentions the buffalo (under the name "Armenta"), on the authority of Gomara, as an inhabitant of Quivira, which he describes as a country consisting of plains destitute of trees, and well known as situated far to the northward of the present northern boundary of Mexico. It is to be noticed also that all the references to the buffalo by the older writers on the natural history of Mexico, including Hernandez, and Nieremburg, and even Clavigero, refer to the region of Quivira.

Dr. Berlandier, who was for a long time a resident of the northeastern provinces of Mexico, and who at his death left in MSS. a large work§ on the Mammals of Mexico, speaks of the buffalo as formerly ranging far to the southward of the Rio Grande. I am unable to say, however, what are his authorities. In his chapter on this animal he thus refers to its former range in Mexico:—

"Au Mexique, lorsque les espagnols, toujours avides de richesses, poussaient leurs excursions dans le nord ouest, ils ne tardèrent pas à rencontrer des bisons. En 1602, les moines Franciscains qui découvrirent le Nouveau Leon, rencontrerent dans les environs de Monterey de nombreux troupeaux de ces quadrupèdes. Ils étaient aussi assez répandus dans la Nouvelle Biscaye (états de Chihuahua et Durango) et s'avançaient quelquefois très au sud de ce pays. Dans le dix-huitième siècle, ils se concentrèrent de plus en plus vers le nord, et restaient encore fort-communs dans les environs du presidio de Bexar. Au commencement du dix-neuvième

*"*Animals.*—Deer, wild horse, a few buffalo, and wild hogs."—PIKE'S (Z. M.) *Western Expeditions*, App. to Part III, p. 28, 1810.

† Catlin in his "North American Indians," Vol. I, gives a map illustrative of the distribution of the Indian tribes in 1833. On this map an attempt is made to also show the range of the buffalo. Although this is done very imperfectly, it may be worthy of mention in this connection that he here represents the buffalo as ranging over the greater part of the above-named provinces of Northeastern Mexico.

‡ America, p. 303.

§ Now in the Smithsonian Institution. For access to this important MS. I am indebted to the kindness of Professor S. F. Baird, Assistant Secretary of the Smithsonian Institution.

siècle, on les vit se rapprocher graduellement de l'intérieur des terres à un tel point qu'ils deviennent de jour en jour, de plus en plus rares autour des lieux habités. Ce n'est maintenant que dans leurs émigrations périodiques qu'on les trouve près de Bexar. Chaque année, au printemps en Avril et Mai, ils s'avançent vers le nord, pour de nouveau se rapprocher des régions méridionales en Septembre et en Octobre. Les limites de ces émigrations annuelles sont presque inconnues; il est cependant probable que dans le sud, ils ne dépassent jamais les rives du Rio Bravo, du moins dans l'état de Coahuila et Texas, et dans celui de Tamaulipas. Vers le nord pas même retenus par les courants du Missouri, ils arrivent jusque dans le Michigan, et se trouvent en été sur les territoires et les états internes des États-Unis de l'Amérique Septentrionale. La route que ces animaux suivent dans leurs voyages occupe plusieurs milles de front et devient tellement tracée qu'independamment de la verdure détruite, on croirait voir de champs labourés couverts de fiente.

"Ces émigrations ne sont pas générales, car certains troupeaux ne paraissent pas suivre la masse générale de leurs semblables, et restent stationnaires toute l'année dans des prairies couvertes d'une riche végétation sur les rives du Rio de Guadeloupe et du Rio Colorado de Texas, non loin des côtes du golfe, à l'est de la colonie de San Felipe de Austin entre Brazosia et Matagorda, précisément dans le même endroit où La Salle et ses compagnons de voyage les virent, il y a près de deux cents ans. Le R. P. Damian Mansanet les vit aussi, mais de nos jours, les côtes du Texas, couvertes d'habitations, de hameaux, de petites villes et de villages des nouveaux colons, en sont dépourvues quoiqu'en 1828, il y en eut encore. D'après les observations faites à ce sujet, on peut conclure que les Bisons habitent la zone tempérée du nouveau-monde, et qu'ils l'ont habité en tout temps. Au nord, ils ne s'avancent guère au-delà du 48^{me} ou 58^{me} degré de latitude, et au sud, quoiqu'ils soient venus le 25^{me}, maintenant ils ne dépassent plus le 27^{me} ou 28^{me} degré, du moins dans les localités habitées et connues du pays."

FORMER OCCURRENCE OF THE BUFFALO OVER THE REGION BETWEEN THE MISSISSIPPI RIVER AND THE ROCKY MOUNTAINS, AND ITS GRADUAL RESTRICTION TO ITS PRESENT NARROW LIMITS.

For convenience of treatment, this region will be considered as embracing the whole area between the Rio Grande and the British boundary, over nearly the whole of which immense territory the buffalo is well known to have been formerly more or less abundant. It seems to have been absent from only the lowlands of the Lower Mississippi, it formerly ranging throughout nearly all of Texas, the higher prairie-lands of Northwestern Louisiana and Arkansas, and thence uniformly northward and westward to the Rocky Mountains, including also the Parks and the principal valleys within the Rocky Mountains. Beginning at the southward, we find that the earliest allusions to the buffalo refer to this region. Thus Cabeça de Vaca we are informed, met with the buffalo (he being the first European who saw this animal in its native haunts) in "Florida," in 1530, at which time this name "was given to all that country lying south of Virginia, and extending westward to the Spanish possessions in Mexico."* Davis, in his "Conquest of New Mexico," claims that Vaca was wrecked at some point on the coast of Louisiana west of the Mississippi.† Vaca journeyed thence westward, and in his jour-

* French's Historical Coll. of Louisiana, Part II, p. i.

† The Spanish Conquest of New Mexico, pp. 41, 42, footnote.

nal thus speaks of the buffalo, the locality referred to being somewhere in the southeastern part of Texas: "Cattle come as far as this. I have seen them three times and eaten of their meat. I think they are about the size of those of Spain. They have small horns like those of Morocco, and the hair long and flocky like that of the merino. Some are light brown (*pardillas*), and others black. To my judgment the flesh is finer and sweeter than that of this country. The Indians make blankets of those that are not full-grown, and of the larger they make shoes and bucklers. They come as far as the sea-coast of Florida, and in a direction from the north, and range over a district of more than four hundred leagues. In the whole extent of plain over which they roam, the people who live bordering upon it descend and kill them for food, and thus a great many skins are scattered throughout the country."*

They were also found in immense herds on the coast of Texas, at the Bay of St. Bernard (Matagorda Bay), and on the lower part of the Colorado (Rio Grande, according to some authorities), by La Salle, in 1685, and thence northward across the Colorado, Brazos, and Trinity Rivers. Joutel says that when in latitude 28° 51′, "the sight of abundance of goats and bullocks, differing in shape from ours, and running along the coast, heightened our earnestness to be ashore."† They afterwards landed in St. Louis Bay (now called Matagorda Bay), where they found buffaloes in such numbers on the Colorado River that they called it La Rivière aux Bœufs. "These bullocks," says the account, "are very like ours; there are thousands of them, but instead of hair they have a very long curled sort of wool."‡

In describing the country about their establishment at St. Louis, at the mouth of the Rivière aux Bœufs, M. Joutel says: "We were in about the 27th degree of north latitude,§ two leagues up the country, near the Bay of St. Louis,|| and the bank of the Rivière aux Bœufs, on a little hillock, whence we discovered vast and beautiful plains, extending very far westward, all level, and full of greens, which afford pasture to an infinite number of beeves and other creatures."¶ Setting out from St. Louis on the 12th of January, 1687, they crossed a succession of rivers, between which were "spacious plains" covered with "a multitude of beeves and wild fowl." In crossing the streams, they were often guided by the buffalo paths to the best fords. They crossed the Colorado, called by them *La Maligne*, probably near the present site of Austin, and the Brazos probably somewhat below Fort Graham. Before they reached the Trinity, the country had become more barren, and buffaloes had become scarcer. Here M. de la Salle was assassinated, and a portion of his party under M. Cavelier, his brother, continued their northward march, soon reaching the Trinity River. From the Trinity they took a northeasterly course, crossing the Red River near the mouth of the Sulphur Fork, and bore thence more easterly, crossing the Wachita and reaching the Arkansas, which they struck near its mouth. During this journey from the Trinity to the mouth of the Arkansas, they seem to have met with few buffaloes, and these mainly

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* Davis's Translation, in his "Conquest of New Mexico," p. 67. See also the account in Purchas (Pilgrims, Vol. IV, p. 1513),—an "abbreviated" translation from Ramusio.

† Joutel's Historical Journal of Monsieur de la Salle's last voyage to discover the Mississippi River, French's Hist. Coll. Louisiana, Part I, p. 98.

‡ Ibid., p. 116.

§ The latitude here given is obviously erroneous, as the context and subsequent account of their journey northward clearly show. The latitude must have been nearly 29° instead of 27°.

|| Later called Bay of St. Bernard, which is the same as the present Matagorda Bay.

¶ Joutel's Journal, French's Hist. Coll. Louisiana, Part I, pp. 120, 121.

in the vicinity of the Wachita. Their route was thence somewhat eastward of the great range of the buffalo. The point where M. Cavelier reached the Arkansas is supposed to be only a few miles above its junction with the Mississippi, and in speaking of the surrounding country he says: "The plains on one side [probably to the westward] are stored with beeves, wild goats, deer, turkeys, bustards, swans, teal, and other game," thus showing that the buffalo ranged eastward nearly to the mouth of the Arkansas.

Ferdinando de Soto, during his march from Florida through Northern Alabama and Northern Mississippi into Arkansas, 1539–'41,* did not, as previously noticed, enter the habitat of the buffalo until he had crossed the Mississippi and ascended the valley of the Arkansas for some distance. Although they found the Indian tribes well supplied with their robes, none of De Soto's party saw the buffalo alive. A party sent from Pacaha, near the mouth of the Arkansas, to search for "the province of Caluça," did not, in a journey of seven days, get apparently beyond the low grounds, and on their return reported to their chief that from the termination of their journey "thenceforward towards the north the Indians said that the country was very ill inhabited, because it was very cold; and that there was such store of oxen, that they could keep no corn for them; and that the Indians lived upon their flesh."† The Indians of Coligoa, the highest or most northerly point they reached, "reported that five or six leagues from thence toward the north, there were many of these oxen." The "ox-hides" they obtained from the Indians are described as being "very soft and wooled like sheep," showing clearly that what they called ox-hides were the skins of buffaloes. Again it is stated, "Not far from thence, toward the north, were many oxen. The Christians [Spaniards] saw them not, nor came into the country where they were."‡

Passing from Coligoa across the Washita to the mouth of the Red River, they again (after the death of De Soto, and under the lead of Moscoso) turned westward and reached the Trinity above the point where La Salle crossed it; though they entered the highlands, they turned back before meeting with buffaloes.

It hence appears that at this early date the buffalo frequented none of the lowlands of the Mississippi, nor those of the Washita and the Red Rivers, and only reached the Gulf coast at the mouth of the Gaudaloupe and San Antonio Rivers; and that it probably extended thence southward along the coast as far at least as the mouth of the Rio Grande del Norte.

The former existence of the buffalo in the valley of the Pecos seems to be well substantiated. Speaking of Espejo's march down the Pecos River in 1584, Davis says: "They passed down a river they called *Rio de las Vacas*, or the river of oxen [the river Pecos, and the same Cow River that Vaca describes], and was so named because of the great number of buffaloes that fed upon its banks. They travelled down this river the distance of one hundred and twenty leagues, all the way passing through great herds of buffaloes."§

* See "A Narrative of the Expedition of Hernando de Soto into Florida. By a Gentleman of Elvas. Published at Evora, 1557. Translated from the Portuguese by Richard Hakluyt." London, 1609. Original edition reprinted by the Hakluyt Society in 1851. The edition of 1611 reprinted by French in 1850, in his "Historical Collections of Louisiana," Part II.

† French's Hist. Coll. Louisiana, Part II, p. 175.

‡ Ibid., pp. 177, 181.

§ Davis's Spanish Conquest of New Mexico, p. 260. See also Hakluyt, Voyages, Vol. III, p. 472.

As already noticed, Coronado met with vast herds of buffaloes in 1542 on the plains near Cicuic, on the upper Pecos River. From Cicuic Coronado marched eastward across the plains of Northern Texas to about the one hundredth meridian, and thence returned again to Quivira,* making a journey of "three hundred leagues." "All that way & plaines are as full of crooke-backed oxen, as the mountaine Serena in Spaine is of sheepe."†

These "crooke-backed oxen" Gomara (as translated by Hakluyt) has thus described: "These Oxen are of the bignesse and colour of our Bulles, but their hornes are not so great. They have a great bunch upon their fore shoulders, and more haire on their fore part than on their hinder part: and it is like wooll. They have as it were an horsemane upon their backe bone, and much haire and very long from the knees downeward. They have great tuffes of haire hanging downe their foreheads, and it seemeth that they have beardes, because of the great store of haire hanging downe at their chinnes and throates. The males have very long tailes, and a great knobbe or flocke at the end: so that in some respect they resemble the Lion, and in some other the Camell. They push with their hornes, they runne, they overtake and kill an horse when they are in their rage and anger. Finally, it is a foule and fierce beast of countenance and forme of bodie. The horses fledde from them, either because of their deformed shape, or else because they had never seene them. Their masters have no other substance: of them they eat, they drinke, they apparel, they shooe themselves."‡

According to Davis, Castañeda thus describes the buffalo and the Plains where it was met with by the people of Coronado's Expedition: "The first time we encountered the buffalo, all the horses took to flight on seeing them, for they are horrible to the sight. . . . . They have a broad and short face, eyes two palms from each other, and projecting in such a manner sideways that they can see a pursuer. Their beard is like that of goats, and so long that it drags the ground when they lower the head. They have, on the anterior portion of the body, a frizzled hair like sheep's wool; it is very fine upon the croup, and sleek like a lion's mane. Their horns are very short and thick, and can scarcely be seen through the hair. They always change their hair in May, and at this season they really resemble lions. To make it drop more quickly, for they change it as adders do their skins, they roll among the brush-wood, which they find in the ravines.

"Their tail is very short, and terminates in a great tuft. When they run they carry it in the air like scorpions. When quite young they are tawny, and resemble our calves; but as age increases they change color and form. . . . . Their wool is so fine that handsome clothes would certainly be made of it, but it cannot be died, for it is a tawny red. We were much surprised at sometimes meeting innumerable herds of bulls without a single cow, and other herds of cows without bulls. It would sometimes be forty leagues from one herd to another, and that in a country so level that from a distance the sky was seen between their legs, so that when many were together, they would have been called pines whose foliage united, and if but one was seen his legs had the effect of four pines. When near, then it was impossible by an effort to see the ground beyond, for all this country is so flat that turn which way we will the sky and the grass are alone to be seen.

* See R. H. Kern's Map of Coronado's route, as before cited.

† Hakluyt, Voyages, Vol. III, p. 455. (Translated from Gomara's Historia de las Indias, Cap. 214.)

‡ Hakluyt, Voyages, Vol. III, p. 456.

"Who would believe that a thousand horses, one hundred and fifty cows of Spanish breed, and more than five thousand sheep, and fifteen hundred persons, including Indian servants, would not leave the slightest trace of their passage in the desert, and that it was necessary to raise, from point to point, heaps of stones and buffalo-bones, in order that the rear-guard might follow us, for the grass, short as it was, rose up after having been trodden down, as straight and fresh as ever.

"Another very astonishing thing is that on the eastern margin of one of the salt lakes, toward the south, was found a spot almost half a musket-shot long, entirely covered with buffalo-bones, to the height of twelve feet, and eighteen feet broad, which is surprising in a desert country, where no one could have brought these bones together. It is pretended that when the lake is troubled by the North winds, it throws upon the opposite shore the bones of all animals which have perished in coming to drink."*

Any one who has seen the buffaloes on their native plains can but recognize the faithfulness of these details, which are remarkable for their minuteness and exact truthfulness. They are further worthy of note from being the first descriptions of the buffalo ever published.

During the exploration of the different portions of the Great Plains, from the time of Lewis and Clarke, Pike, Long, and others, down to the later expeditions of Frémont, Stansbury, Emory, Marcy, Stimpson, Pope, Sitgreaves, and others, and the explorations for "a railroad route from the Mississippi River to the Pacific Ocean" in 1853–'55, buffaloes, or recent traces of them, were found everywhere from the Missouri and Upper Mississippi Rivers westward to the remotest valleys of the eastern slope of the Rocky Mountains, from the plains of Texas northward to 49th parallel. In the further account of this vast territory it is hence necessary to trace only their extirpation over the very large portion from which they disappeared.

Extirpation in Texas and New Mexico.—Long prior to the time of the later explorations above mentioned, the buffalo had disappeared from the eastern border of the plain south of the Platte River. Even as early as the beginning of the present century the range of the buffalo had begun to be materially restricted, these animals having at that time been apparently wholly exterminated south of the Rio Grande, while they had also disappeared from the adjoining portions of Texas. They appear also to have wholly disappeared in Texas south of the Colorado River prior to the year 1840. Before this date they had also receded far from the coast, and no longer ranged west of the Pecos River, either in Texas or New Mexico; they occupying at this time only a narrow oblique belt through the middle portion of the State, varying from one hundred miles in breadth, and widening rapidly as it approached the northern border of the State. From Texas northward, however, they still occupied nearly all the Great Plains, from the Rocky Mountains almost to the Mississippi River.

I have as yet met with but few data relating to the extermination of the buffalo, either south of the Rio Grande or in Texas, prior to 1840, but since that period the record is reasonably full. Beginning with the year 1841, we find that at this time Kendall, in travelling north from Austin, Texas, first met with buffaloes seventy-five miles north of Austin, on Little River, a southern tributary of the Brazos, where he found them in immense herds. In speaking of them he says: "There are perhaps larger herds of buffalo at present in Northern Texas than any-

* Davis's Spanish Conquest of New Mexico, pp. 205, 207, foot-note.

where else on the western prairies, their most formidable enemies, the Indians, not ranging so low down in large parties on account of the whites; but I was told that every year their numbers were gradually decreasing, and their range, owing to the approach of white settlers from the east and south, becoming more and more circumscribed." Kendall also found them numerous on the Brazos, and states that they occasionally took shelter in the Cross Timbers, and that he last met with them, in going westward, on the upper part of the Big Washita, one of the sources of the Red River, near the one hundredth degree of longitude.*

Kennedy, writing in the same year, says, "The bison is still to be met with in the mountainous districts between the Guadeloupe and the Rio Grande."† According to Gregg, however, they had already disappeared *east of the Cross Timbers* as early as 1840.‡

In 1849, in an expedition from Fort Smith, Arkansas, to Santa Fé, Lieutenant J. H. Simpson first saw signs of buffaloes near the 97th meridian, a few miles south of the Canadian, but adds that he saw not more than two buffaloes on the whole journey. In speaking of the game, he says: "In regard to the buffalo, there can be no question that they have been in the habit of infesting the route in places during certain seasons of the year. Indeed, Gregg mentions them as swarming on the plains on his return trip from Santa Fé, in the spring of 1840. During our journey, however, I did not see more than two, from the beginning to the end of the trip, and therefore I am not at liberty to hold them up as any certain source upon which to rely for subsistence." §

Roemer, in 1849, says that the buffalo was then found only in the hilly parts of the State, far from the coast, and that herds of a thousand together were still seen between the Brazos and Austin.‖ It would seem, however, that at this time there were very few buffaloes south of the Red River, as during the years 1849, 1850, and 1851 a series of military reconnaissances were made in Texas, forming a network of lines covering a large part of the State, during the running of which no buffaloes seem to have been met with. Lieutenant Michler surveyed a line from Fort Washita southward along the 97th meridian,¶ from 34° 30′ to about 31°, and thence southwestward to San Antonio. Another line was run from Fort Washita southwestward, in a nearly direct line to the Pecos River striking it in longitude 103°, and latitude 31° 20′. A line was continued from this point eastward again to the 100th meridian, and thence southeastward to Corpus Christi Bay, in longitude 96°, and latitude 28° 40′. Another line was carried down the Pecos to longitude 101° 40′, and thence to the head-waters of the Nueces, and down this river also to Corpus Christi Bay. The narratives of these explorations make no mention of buffaloes, as they doubtless would if buffaloes had been met with.** In 1850 Marcy met with a few stragglers south of the Canadian, near the divide between the Canadian and Washita Forks of the Red River, and saw their tracks and other indications of their presence there. He reports that the Kiowas and Comanches went

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* Kendall (G. W.), Narrative of the Texan Santa Fé Expedition, Vol. I, pp. 78, 79.

† Kennedy, (Wm.), Texas: The Rise, Progress, and Prospects of the Republic, Vol. I, p. 122.

‡ Commerce of the Prairies, Vol. II, p. 122.

§ Congress. Rep., 31st Congr., 1st Session, Senate Ex. Doc. No. 12, pp. 6, 20.

‖ Roemer (Ferdinand), Texas, p. 462.

¶ The central portion of the wooded belt known as the "Cross Timbers" lies along this meridian.

** Congress. Rep., 31st Congr., 1st Session, Sen. Doc. No. 64, and accompanying maps.

north in summer to hunt the buffalo on the plains of the Arkansas, only a few buffaloes crossing at this time to the south of the Canadian.

In 1852, according to the "Topographical Sketches of the Military Posts" in Texas, buffaloes had entirely disappeared from the region about Fort Worth* (on west fork of the Trinity, just west of the 97th meridian); they are not mentioned among the animals found at this date about Fort Belknap† (on the Brazos, longitude about 98° 30′), neither were they then found about Fort Terret‡ (on the 100th meridian). Very few are said to have been found as far south as Fort Phantom Hill since 1837.§ At Camp Johnston,|| on the Concho River (near the present Fort Concho), one only is reported as having been seen, and the region is said to have been then not within their favorite range; but they are at the same time enumerated among the animals met with about Fort McKavett,¶ situated some fifty miles to the southward of Fort Concho.

Lieutenant Whipple, in his report of the survey of the thirty-fifth parallel, made in 1853, found buffalo bones bleaching near a brackish spring, just west of the Cross Timbers, and nearly on the 99th meridian. A few days later they saw the first living buffalo, and met with a few stragglers on succeeding days on the sources of the Washita branch of the Red River. He speaks of seeing buffalo signs as far west as Camp 44, a little east of the 102d meridian. The main herds, however, were north of the Canadian, from which these were merely stragglers.** Professor Jules Marcou, who accompanied Lieutenant Whipple's expedition as geologist, has kindly furnished me with a few additional particulars from his note-books. He informs me that the first bones of the buffalo were met with as far east as the Cross Timbers, or near the 98th meridian; but the region appeared not to have been visited by these animals for ten or twelve years. The first living buffalo was seen between Camps 33 and 34, or about 99° 40′, just south of the Canadian. The next day many carcasses were observed, and two days later five old bulls were seen. An old bull was killed between Camps 36 and 37, near the meridian of 100° 25′, but no living buffaloes were seen west of the 101st meridian, and no fresh signs were seen west of the 102d. All the recent indications of buffaloes were thus met with between the meridians of 98° 30′ and 102°. The journey being made in September, the herds had not returned from the north, the individuals met with being only stragglers which had wandered somewhat to the southward of the usual southern limit of the summer range.

Captain (now Major-General) Pope in 1854 surveyed the 32d parallel, from El Paso and Doña Aña, on the Rio Grande, to Preston, on the Red River, passing northerly, and crossing the Pecos and the head-waters of the Colorado, Trinity, and Brazos Rivers. Mr. J. H. Byrne, in his diary of the expedition, reports meeting *bois de vache* "for the first time" at Camp No. 10, near the Ojo del Cuerbo, or Salt Lakes, west of the Guadeloupe Mountains, and in the Valley of the Rio Grande. This is the only allusion to buffalo or buffalo "sign" contained in the narrative, although the kinds and quantity of game met with each day appear to

* Med. Statistics U. S. Army, 1839–1854, p. 373.
† Ibid., p. 372.
‡ Ibid., p. 395.
§ Ibid., p. 376.
|| Ibid., p. 380.
¶ Med. Statistics, U. S. Army, 1839–1854, p. 391
** Pacific R. R. Explorations and Surveys, Vol. III, Lieutenant Whipple's Report on the 35th Parallel, Part I, pp. 26, 28, 29, 35.

be duly chronicled.* We are further led to infer the entire absence at this time of buffaloes in Texas by some remarks made by Captain Pope in his General Report, respecting the Comanche Indians, whose country was on the head-waters of the Canadian and Red Rivers, in the extreme northern part of Texas. He says: "During the summer months nearly the whole tribe migrates to the north to hunt buffalo and wild horses on the plains of the Upper Arkansas."†

Captain H. M. Lazelle, 8th U. S. Infantry, informs me that in 1859 there were no buffaloes in New Mexico, nor in Texas west of the 99th meridian, but that there were vast numbers in Northern Texas between the meridians of 99° and 96°; but that they did not extend so far south as Pope's old trail of 1854.‡

Hence it appears that for quite a number of years the buffaloes nearly abandoned Texas, or visited only its northwestern portions, and were of somewhat uncertain occurrence, in summer at least, as far north as the Canadian. Of late, however, they have again become common over a considerable portion of the northwestern part of the State, occasionally extending southward along the 100th meridian almost to the Rio Grande. Major-General M. C. Meigs, Quartermaster-General of the United States Army, says, in some valuable MS. notes on the buffalo,§ that in the winter of 1869–70 he saw their carcasses near Fort Concho, Texas, "showing that the buffalo had been abundant in that neighborhood the previous year." The prairies having been extensively burned that winter about Concho, the buffaloes had not appeared within twenty miles of the post that season. He also says that in the winter of 1871–72 they extended their migrations westward to the Staked Plains.||

Mr. J. Boll, the well-known entomological collector, also informs me that during the winter of 1874–75 they were still more abundant over quite a large part of Northern Texas, doubtless in consequence of their persecution by the hunters in Southwestern Kansas. Respecting the eastern boundary of their range at the present time (January, 1876), he says: "So viel mir bis jetzt bekannt, so geht der Bison östlich im Texas nicht mehr über die Linie hinaus welche von der Mündung der Little Wichita in den Red River in gerader Richtung fast südlich bis zur Mündung des Pecan Bayou in den River Colorado sich austreckt. Wie sich diese Linie vom Colorado River bis zum Rio Grande gestaltet ist schwer zu sagen, doch glaube ich dass von der Mündung des Pecan Bayou sie mehr eine stark sudwestliche Richtung bis zum 30° nordlich Breite annehmen wird."

Respecting their present southern limit in Texas, a letter written by Mr. J. Stevens in answer to my inquiries on this point, and kindly transmitted to me by Mr. C. E. Aiken, of Colorado Springs, Colorado, states, on the authority of Mr. W. H. Case, who has lived for the last two or three years at Fort Concho, that buffaloes have of late been quite numerous there in winter, and that they were especially so last winter. He says that "after severe storms they come in from the north in large numbers, at which times he has seen larger herds there than anywhere else, not excepting Kansas and the Indian Territory. East of Fort Concho he says they do not go south of the latitude of that post, but that to

* Pacific R. R. Explorations and Surveys, Vol. II, Pope's Exploration of the 32d Parallel, from the Red River to the Rio Grande, pp. 51–93.

† Ibid., p. 15.

‡ Pope's trail crosses the 96th meridian in about latitude 33° 30′, and strikes the Pecos in longitude 103° and latitude 31° 30′, at Emigrant Crossing.

§ For access to this interesting paper I am indebted to the kindness of Dr. Elliott Coues, the eminent ornithologist.

|| MS. Notes on the Buffalo.

the westward they go twenty to fifty miles further to the southward, but only occasionally. Mr. Stevens adds that none are found very far to the westward of Fort Concho, and that none have been found for a long time in any part of New Mexico, and that probably none ever will be found there again. From the best information I have been able to obtain, their present western limit seems to be the eastern border of the Staked Plains. [*]

Extermination in Arkansas, Missouri, Iowa, and Minnesota.—Passing now to the region north of Texas, the history of the extermination of the buffalo throughout the tier of States adjoining the Mississippi River—namely, Arkansas, Missouri, Iowa, and Minnesota—will be first given, and afterward an account of its extermination over the region between the Platte River and the northern boundary of Texas.

According to Nuttall, the bison was still to be met with in Arkansas as late as 1819, a few then existing near the Arkansas River, in the present county of Conway, not far from the centre of the State.†

In a journey from Fort Smith southwestward to the Red River, his party also met with large herds on Riameche Creek, in the present Indian Territory, near the southwestern border of Arkansas.‡ Major Long found their skulls and other remains at Massern and Vache Grasse Creeks, in Western Arkansas, in 1820, showing that they had existed at that point at a not very remote period.§

Gregg, writing about 1844, says: "Even within thirty years they were abundant over much of the present States of Missouri and Arkansas," or as late as 1815.‖ In 1820 settlements had extended up the Arkansas nearly to the western border of the State, and probably soon after this date the buffaloes were wholly extirpated throughout the present State of Arkansas.

Beck states that in Missouri, as late as 1823, "immense herds" of buffaloes were "frequently seen covering the extensive plains which stretch along the west part of the State. During the dry seasons," he says, "they remain in the neighborhood of rivers, but they uniformly migrate to the south at the approach of winter."¶

It thus appears that the buffalo also lingered in Western Missouri till about 1820 to 1825. They probably disappeared from Southern Iowa at about the same period, but they existed for a much longer time in the northern half of the State. In earlier times Charlevoix found "magnificent meadows" in Southeastern Iowa, on the Des Moines River, "quite covered with buffalo, and other wild creatures."** Major Long, in a trip eastward from Council Bluffs in 1819, found "their skulls and other remains on the plains of the Nishnabatona, and in one instance discovered the tracks of a bull; but," he adds, "all the herds of these animals appear to have deserted the country east of Council Bluffs."†† According to Assistant Surgeon Charles C. Keeney, the buffalo was sometimes met with on the open prairies a few miles west of Fort Dodge, on the Des Moines River, as late as 1852. ‡‡

M. Belon, an old French *voyageur*, whom I met in 1873 on the Yellow-

[* According to a correspondent ("H. M. H.") of the Mason News-Item, April 28, 1877, buffaloes are plentiful at the present time in the vicinity of Fort McKavett.—J. A. A.]

† Travels into the Arkansas Country, p. 118.

‡ Ibid., pp. 149, 150.

§ Long's Expedition from Pittsburg to the Rocky Mountains, Vol. II, p. 264.

‖ Gregg, Commerce of the Prairies, Vol. II, p. 113.

¶ Beck (L. J.), Gazetteer of the States of Illinois and Missouri, p. 167.

** Letters, Goadby's English ed., p. 295.

†† Expedition to the Rocky Mountains, Vol. I, p. 421.

‡‡ Med. Statistics U. S. Army, 1839–1854, p. 55.

stone, acting as interpreter for the expedition of that year, and who moved to Minnesota in 1837, informed me that buffaloes were abundant within fifty miles of St. Paul as late as 1836, and were common on the head-waters of the Cedar and Des Moines Rivers, on both sides of the Iowa and Minnesota boundary, as late as 1845. They have, however, been for many years extinct throughout the present State of Iowa, with the exception of the occurrence of a few stragglers in the extreme western counties. When I was in the western part of the State in 1867, I was informed that a few still remained in that section, and that up to that time one or more had been killed every year as far south as Greene County. They were represented as being more common further north, but that no herds were met with south of the Sioux River, and rarely east of the Missouri. Those found further east were only stragglers from distant herds.* Professor Bessey, of the Iowa Agricultural College, informs me that a few were seen in the bottom-lands below Council Bluffs as late even as about 1869, and also, at about the same time, in the northwestern part of the State,—stragglers, of course, from remote herds.

In Minnesota, west of the Mississippi, buffaloes remained until a recent period. In 1823 Major Long found herds numbering thousands of individuals about the sources of the Red and Minnesota (or St. Peter's) Rivers. He states that in 1822 they did not descend the Minnesota River below Great Swan Lake, and that in 1823 "the gentlemen of the Columbia Fur Company were obliged to travel five days in a northwest direction from Lake Travers before they fell in with the game, but they soon succeeded in killing sixty animals."† The buffaloes are said, however, to have lingered about Fort Ridgely, situated a few miles above Swan Lake, till about 1847, and that as late as 1856 they were found one hundred miles to the northwestward of this point.‡ As late as 1844 Captain Allen found large herds in the southwestern part of the present State of Minnesota. He says: "Seventy-five miles west of the source of the Des Moines we struck the range of the buffalo, and continued in it to the Big Sioux River, and down that river about eighty-six miles. Below that we did not see any recent signs of them. They were sometimes seen in droves of hundreds. . . . . . While among the buffalo we killed as many as we wanted, and without trouble."§ Pope states that in 1850 buffaloes were still killed in the immediate vicinity of the settlements at Pembina, and that they existed in great abundance between the Pembina and the Shayenne River,‖ or along the present western boundary of the State. They appear, however, to have very soon after left the whole valley of the Red River, being rapidly slaughtered and pressed westward by the incursions of the Red River halfbreed hunters, who are reported to have killed annually, at about this time, twenty thousand buffaloes south of the United States and British Boundary.¶ A few lingered in the southwestern part of the State till within a very few years, or occurred there rather as stragglers from the herds west of the Big Sioux River, in Southwestern Dakota.

From the foregoing it hence appears that the buffalo was more or less abundant over large portions of the States of Arkansas and Missouri as late as 1812 to 1815, but that few remained in either State later than

* See Proc. Bost. Soc. Nat. Hist., Vol. XIII, p. 186, 1869.

† Expedition to the Source of the St. Peter's River, etc., Vol. II, pp. 9–24, 29.

‡ Assistant Surgeon A. B. Hasson, in Med. Statis. U. S. Army, 1839–1854, p. 67.

§ Allen, (Captain J.), Congress. Rep., 29th Congr., 1st Session, Doc. No. 168, p. 5.

‖ Pope, (General John), Report of an Expedition to the Territory of Minnesota, Congress. Reports, 31st Congr., 1st Session, Sen. Doc. No. 42, p. 27.

¶ Rice (H. M.), Pope's Report (cf.), p. 4.

1820. At about this date they seemed to have also disappeared from Eastern and Southern Iowa, but were quite numerous in the northwestern part of the State, and adjoining parts of Minnesota, as late as 1840 to 1845, where occasionally an old bull was met with as late as 1869. As already stated, they disappeared in Minnesota east of the Mississippi River prior to 1832;* and they appear to have been exterminated over the whole region east of the Red River as early as 1850, and to have survived later elsewhere in the State only in the extreme southwestern counties, where a few lingered till about 1869.

Permanent Division of the Buffalo into two distinct Herds, and their Extermination over the greater Part of the Region between the Northern Boundary of Texas and the Platte River.—As is well known to those who have given much attention to the subject, the great buffalo herd that once extended continuously from the plains of the Saskatchewan to the Rio Grande was divided about 1849 into two bands by the California overland immigration, and that since that time the two herds have never united. The great overland route, as is well known, followed up the Kansas and Platte Rivers, and thence westward by the North Platte, crossing the Rocky Mountains by way of the South Pass. The buffaloes were all soon driven from the vicinity of this line of travel, thousands being annually slaughtered, a large proportion of them being killed wantonly.† The increase of travel, and finally the construction of the Union Pacific Railroad and the consequent opening up of the country to settlement, has effected a wider separation of the herds, the buffaloes retiring every year further and further from their persecutors. None are now found for a long distance to the north of this road, and they approach it from the southward only along that portion situated between Fort Kearney and the forks of the Platte. In treating of the "Southern Herd," as the southern division is commonly termed, it will be found convenient to trace first its extirpation over the region to the eastward, and afterwards to the westward, of its present range.

As previously stated, Nuttall found buffaloes in 1819 in Southwestern Arkansas and the adjoining portions of the Indian Territory.‡ Pike, however, in 1806, first met with these animals on the divide between the sources of the Osage River and those of the Neosho Fork of the Arkansas, near the 98th meridian, or near Council Grove in Eastern Kansas, and reports that they were already nearly exterminated over the hunting-grounds of the Osages and Pawnees.§ In 1820 Major Long found no large herds east of the mouth of the Little Arkansas, near the 98th meridian. At the Great Bend of the Arkansas, however, he met with them for several days "in vast and almost continuous herds."||

* See *antea*, p. 117.

† Respecting the influence of the overland emigration upon the buffalo, we find Captain Stansbury, who passed over the emigrant trail in the summer of 1849, speaking as follows: Under date of June 27, he says, "To-day the hunters killed their first buffalo, but in order to obtain it had to diverge some four or five miles from the road and to pass back of the bluffs, the instinct or experience of these sagacious animals having rendered them shy of approaching the line of travel. This has always been the case, for it is a well-attested fact, that when the emigration first commenced, travelling trains were frequently detained for hours by immense herds crossing their track, and in such numbers that it was impossible to drive through them. In many instances it was quite difficult to prevent their own loose cattle from mingling with the buffaloes, of which they did not seem to be at all afraid."—*Salt Lake Expedition*, p. 34.

‡ Travels into the Arkansas Country, pp. 149, 150.

§ Pike (Z. M.), Expedition to the Sources of the Mississippi, and to the Sources of the Arkansas, Kansas, La Platte, and Pierre Jaune Rivers, etc., in the years 1805, 1806, and 1807.

|| Long's Exped. from Pittsburg to the Rocky Mts., Vol. II, pp. 204, 207.

Catlin's "Outline Map of Indian localities in 1833"* purports to give also the range of the buffalo, but none are represented as occurring between the Kansas and Arkansas Rivers east of the 99th meridian, but in his account of his visit to the Comanche country he speaks of meeting with buffaloes about forty miles east of the junction of the False Washita and Red Rivers, or near the 96th meridian.†

General Doniphan, during his march in 1846 from Fort Leavenworth to Santa Fé, used *bois de vache* for fuel when passing the head of the Little Arkansas, and first met with herds of buffaloes on the Arkansas at Pawnee Ranch, near the present site of Fort Larned.‡ The previous year Lieutenant J. W. Abert found them as far east as 97° 32′.§ Lieutenant Abert reports meeting with them the following year near the 98th meridian, just west of which he found them in immense herds.||

Lewis and Clarke, in ascending the Missouri River in 1804, first met with buffaloes at the mouth of the Kansas River, but state that they did not become common till they reached the Sioux River.¶ Bradbury found them in 1810 at Floyd's Bluff. Audubon says that when he and his party went up the Missouri River in 1843, "the first buffalo were heard of near Fort Leavenworth, some having a short time before been killed within forty miles of that place. We did not, however," he says, "see any of these animals until we had passed Fort Croghan, but above this point we met with them almost daily, either floating dead on the river or gazing at our steamboat from the shore."**

As early as 1834 Murray, in his journey westward from Fort Leavenworth into the Indian country, first met with buffaloes on the Republican,†† showing that they had already become extinct or of uncertain occurrence in Eastern Kansas. Frémont, in 1842, in marching northwestward from Fort Leavenworth to the Platte River, by way of the Kansas River, came suddenly upon great herds just above Grand Isle, in about longitude 99° 30′, or near the present site of Fort Kearney. The following year (1843), in crossing the plains considerably to the southward of his route of the previous year, he first met with the buffalo on the divide between the Solomon and the Republican Forks, also near the 99th meridian.‡‡ Emory, in 1846, says that the range of the buffalo along the Arkansas was "westward, between the ninety-eighth and the one hundred and first meridians of longitude."§§ In 1849 Stansbury saw no buffaloes east of the forks of the Platte, but found them in abundance to the westward of this point. Captain Stansbury's guide reported to him that not many years before the plains somewhat to the east of Fort Kearney were black with herds of buffaloes "as far as the eye could reach."||||

In July, 1853, Captain Gunnison's party first met with fresh signs of the buffalo on the Saline, and on the Kansas near the mouth of the Saline; their first buffalo was killed on the Little Arkansas; somewhat

* Catlin (G.), North American Indians, Vol. I, map.

† Ibid., Vol. II, p. 46.

‡ Hughes (J. T.), Doniphan's Expedition, pp. 43, 47.

§ Congress. Rep., 29th Congr., 1st Sess., House Ex. Doc. No. 2, p. 217.

|| Notes of a Military Reconnaissance from Fort Leavenworth, Mo., to San Diego, Cal. Congress. Rep., 30th Congr., 1st Sess., Sen. Doc. No. 7, p. 11.

¶ Expedition to the Rocky Mountains, Vol. I, pp. 19, 67.

** Quadrupeds of North America, Vol. II, p. 50.

†† Travels in North America, Vol. I, pp. 208, 227.

‡‡ Frémont's Explorations during 1842, '43, and '44, pp. 18, 25, 49, 57, 109, *et seq.*

§§ Emory (W. H.), Notes of a Military Reconnaissance from Fort Leavenworth to San Diego, Cal., p. 16.

|||| Stansbury's Expedition to the Great Salt Lake, pp. 29, 36.

later they found themselves in the midst of immense herds on the Republican Fork.*

Dr. Hayden, writing of his journey across the plains in the summer of 1858, says, "Before going into the interior of the Territory [of Kansas] we had expected to find the whole country immediately west of Fort Riley comparatively sterile; on the contrary, however, we were agreeably disappointed at meeting with scarcely any indications of decreasing fertility, as far as our travels extended, which was about sixty miles west of Fort Riley. Here we found the prairies clothed with a luxuriant growth of grass, and literally alive with vast herds of buffalo, that were quietly grazing as far as the eye could reach, in every direction."†

Lieutenant E. S. Godfrey, of the 7th United States Cavalry, who has recently spent several years in the department of the Missouri, informs me that when Fort Harker was established, in 1866, the buffaloes ranged regularly as far east as this point, and even passed beyond it. They were taken here for several years after, but in 1870 had almost wholly retired to points further westward.

Professor B. F. Mudge, of the Kansas State Agricultural College, has given me the following general statement respecting their extermination in Eastern Kansas. Under date of February 7, 1873, in kind response to my inquiries, Professor Mudge wrote as follows:

"The buffalo ranged to the eastern border of Kansas as recently as 1835. About that time the United States authorities removed the Delaware, Pottawattamie, Kaws, and other tribes of Indians to 'reservations' in the eastern part of what is now Kansas. These Indians soon drove the buffalo as far west as the Blue River (one hundred miles west of the Missouri River), which was as far as the reservations extended. The buffalo held that range till 1854, when Kansas was made a Territory and whites began to settle here. For fifteen years from that time the buffalo receded, on an average, about ten miles a year. For three years past they have been hunted in summer for their hides for *tanning;* this is exterminating them very rapidly. Now they are not found in Northern Kansas east of 100° of longitude; in Southern Kansas as far easterly as longitude 98°, the western boundary of Kansas being 102°. In a few years I think they will not range north of the Arkansas River."

None of the government expeditions sent across the plains since 1840 seem to have met with the buffalo east of the longitude of Fort Riley, or east of the 97th meridian, from the Platte southward to Texas. In the Indian Territory they have not for a number of years ranged to the eastward of Fort Sill.‡ It thus appears that the buffaloes were exterminated in Eastern Kansas and in the eastern part of the Indian Territory over a breadth of about four degrees of longitude between 1835 and 1870.

The extermination along the western border of the southern herd has also extended over a considerable area. In 1806 Pike found them throughout his march across the plains from the western edge of Arkansas to the eastern base of the Rocky Mountains, meeting with them in

* Beckwith's Report of Captain Gunnison's Exploration of the Thirty-eighth and Thirty-ninth Parallels, Pacific Railroad Explorations and Surveys, Vol. II.

† Geological Report of the Exploration of the Yellowstone and Missouri Rivers, p. 122.

‡ Captain J. W. Powell, of the 8th United States Infantry, informs me that in 1872 the buffalo did not range as far east as Fort Sill, but occurred fifty miles west of this point in considerable numbers. Lieutenant Godfrey (7th Cavalry) also states that during 1871 and 1872 he met with them throughout that part of the Indian Territory west of Fort Sill.

the greatest abundance between the Smoky Hill Fork and the Arkansas.* In 1845 Lieutenant Turner found buffaloes abundant in the valley of the Arkansas from Bent's Fort thence eastward for over two hundred miles.† The following year (1846) Dr. Wislizenus reports that on Colonel Doniphan's march across the plains all signs of the buffalo, even including the *bois de vache*, disappeared near the meridian of 101°, between the Arkansas and Cimarron.‡

Frémont states that in 1842, at 103° 30′, between the two forks of the Platte, they absolutely covered the plains, and were abundant thence westward to St. Vrain's Fort, situated a little to the southward of the present town of Cheyenne. Between the forks of the Platte and along the North Platte to Fort Laramie but few were found, but recent signs of them were abundant. On the Laramie plains westward as far as Laramie River, large herds were constantly met with, but this year none were seen on the North Platte above the junction of Laramie River, the grasshoppers and the dry weather having destroyed every blade of grass.§

In June, 1844, Frémont found them in immense numbers in North, Middle, and South Parks, in the present State of Colorado, as well as on the tributaries of the Green River on the western slope of the mountains, and on the Sweet Water, and the other extreme head-waters of the North Platte, from all of which extensive region they were nearly or quite exterminated during the following twenty years.

When the miners first visited the parks and mountains of Colorado, in the summer of 1859, they found them occupied by small bands of buffaloes, which afforded them an abundance of meat for several years. They have been scarce there, however, for the last ten years, during which time only stragglers have been met with. In the summer of 1871 I found their skulls still frequent in South Park and up the valley of the South Platte to its extreme source. They were very frequent at and above Montgomery, and even on the neighboring mountains above timber-line, showing that not many years ago the buffalo ranged over the grassy slopes of the mountains even to above the limit of the timber. I heard of a single small band of two or three dozen individuals near the southern borders of South Park, in the vicinity of Buffalo Springs, and saw a calf at one of the ranches that was captured in June of that year as the band passed up the valley of the South Platte into the Park.‖ Mr. Wm. N. Byers, of Denver, Colorado, writes me that a band of twelve were seen in South Park in 1873, and that "occasionally a little band is still seen in the northern edge of Middle Park and in North Park." "About seventy-five wintered on the head of Muddy or Milk River, Middle Park, last winter [1874–75]. Another band was seen on the head-waters of Willow Creek, ranging thence over the divide into North Park. Most of our people call these mountain animals Bisons, and think them smaller than the Plains Buffalo, but they are evidently the same animal, resorting to the mountains of their own choice."

One of these small parties, according to western newspapers, seems to have recently fallen a prey to the Indians, a Denver paper of a recent

* Pike (Z. M.), Expedition to the Sources of the Mississippi, and to the Sources of the Arkansas, Kansas, La Platte, and Pierre Jaune Rivers, etc., in the years 1805, 1806, and 1807.

† Cong. Rep., 29th Congress, 1st Session, House Ex. Doc. No. 2, p. 217.

‡ Wislizenus (Dr. A,), Memoir of a Tour to Northern Mexico in company with Colonel Doniphan's Expedition in 1846–47, Cong. Rep., 30th Congress, 1st Session, Miscel. Doc. No. 26.

§ Frémont's Exploration during 1842, 1843, and 1844, etc.

‖ Bull. Essex Inst., Vol. VI, pp. 54, 55.

date containing the following: "A party of Indians in the northwestern edge of the Middle Park came upon a herd of buffalo the other day, and killed them all—forty-two in number. All they saved was the skins, leaving the meat to rot. Such waste of the game ought to be stopped, and the sooner the better."

Dr. Hayden informs me that a band of eighteen was seen by one of his parties near Pike's Peak in 1873, and that in 1875 there was a band of about nineteen on the west side of Pike's Peak, and another band of about sixty near Mount Lincoln, in the South Park. Mr. C. E. Aiken, probably referring to these, writes me that he knows of but two bands existing at the present time (February, 1876) in the mountains about South Park, one of which "grazes on the mountains at the head of Tarryall Creek, and is frequently found above timber-line; the other ranges in the rugged mountains south of Pike's Peak, and numbers some thirty or forty individuals."

In 1871 their bleached skulls were still frequent in the valley of the North Platte, in Western Wyoming, as well as on the Laramie Plains, but I was assured that only stragglers had been seen in all this region during the previous ten or fifteen years.* Stansbury reports meeting with them in abundance on Pass Creek and other head-waters of the North Platte, in 1849.†

In respect to the extermination of the buffalo along the western edge of the plains in Colorado, and the present western boundary of the Southern Herd, I have been favored with a valuable communication from Mr. William N. Byers, editor and proprietor of the "Rocky Mountain News." In kindly answer to my inquiries he thus refers (writing under date of July 3, 1875) to the gradual extermination of the buffalo along the eastern base of the Rocky Mountains. He says: "Perhaps the best idea I can give you of the shrinkage of the column on this side is gathered from the history of the early trading-posts established here, mainly for barter in their hides. The first trading-post in this [South Platte] valley was built in 1832, six miles below Denver, and about fifteen miles, direct, from the mountain foot. A trader employed here from 1832 to 1836 told me that he thought that he never looked out over the walls of the fort without seeing buffalo, and sometimes they covered the plain. At that time their moving columns surged up against the mountain foot. Five or six years later the next fort was built five or six miles down the river, then a third a few miles below the second, and, about 1840, a fourth, nearly twenty miles below the third, or forty odd miles from the mountains. There the trade was concentrated and the up-river forts were successively abandoned, owing to the decrease of the buffalo in their vicinity. But great herds of buffaloes occasionally ranged over the present site of Denver as late as 1846.

"The trading-posts in the valley of the Arkansas possess a similar history. The earliest, built about 1826, was some twenty miles from the mountains. Others succeeded, one after another, until *New Fort Bent*,—afterward Fort Bent, now Fort Lyon,—about eighty miles from the mountains, closed the history of these early trading outposts. They were placed so as to be most convenient to the camps of the hunters, to enable the traders to supply the latter with goods and to buy their skins.

"The present range of the buffalo in Colorado," he says, "is bounded substantially on the west by a line about one hundred miles east of the

* See Bulletin Essex Institute, Vol. VI, p. 59.

† Salt Lake Expedition, pp. 243–247.

foot of the mountains, and parallel therewith. The herds are thin on the edge, thickening to the eastward. Small bands occasionally wander ten or twenty miles further west, but the line is quite distinctly marked. In the fall they move gradually but slowly southward, and in late winter and spring return in the same way north; but the eastern edge of Colorado is really occupied all the winter by herds that come from and return to the north. In summer very few remain upon the Colorado range. I have no idea of the relative movement of individual herds north and south during the year, but there seems to be a regular *ebb and flow* once a year. There has been no marked change in the limit of the range westward in the last five years, but the columns have been thinned *fearfully*,—certainly one-half."

Influence of the Railroads upon the Decrease of the Buffalo.—Three railroads now enter or pass near the range of the Southern Herd. Their influence, though immense in respect to its decrease, seems not to have very greatly affected the extent of its range. The railroads, of course, primarily affect the buffalo by affording to the hunters easy access to its haunts, and by placing the hunters in communication with ready markets for the products of the chase. They also open up the country they traverse to permanent settlement, thus rendering the extirpation of the buffalo from the country bordering these avenues of travel not only speedy but permanent. Although the buffalo has no little fear of these iron highways and their thundering trains, this alone would not, for a long time at least, seriously influence its range; and the herds have not, except through the thinning of their ranks by the hunters who make these roads the bases of their operations, materially changed their range since the opening of the Union Pacific Railroad in 1869. The buffaloes still range northward to this road between Fort Kearney and the Forks of the Platte, but they appear to have of late rarely passed north of it. At this point the buffalo range is still within easy drive from the line of the road, and is often chosen by Eastern hunting-parties for their field of operations.

The Kansas Pacific Railway, traversing as it does one of the favorite and formerly most populous portions of the range of the great Southern Herd, has given opportunity, since it was opened in 1870, for the destruction of hundreds of thousands of buffaloes. After two or three years the results of this wholesale slaughter began to be apparent in the thinning of the herds and in their erratic movements and changed habits, especially in respect to their migrations.

During the summer of 1871 straggling bands occurred as far eastward in Northern Kansas as Fossil Creek, while the great herds were rarely met with east of the meridian of Fort Hays. In June of that year they blackened the prairies from the Saline River to the Republican Fork. In January, 1872, they had receded several hundred miles to the westward of their summer limit, ranging then over Eastern Colorado. Between the Union Pacific and Kansas Pacific Railroads they at this time migrated eastward in summer and westward in winter, passing with reluctance either of these great highways. At times, however, they swept across the Kansas Pacific Railway in immense herds, obliging the trains to await their passage.* In consequence of this eastward and westward migration they had already worn deep trails running in this direction, and at right angles to the older set

*General Meigs writes that a conductor of the Kansas Pacific Railway informed him in the winter of 1872–73, that "while he had been several times delayed by the crossing of immense herds going south he had never seen any buffalo returning."—*MS. Notes on the Buffalo.*

made when their migrations were mainly from the north southward in autumn and from the south northward in spring.* From the great persecution they had suffered from the hunters, who swarmed down upon them from all sides, their movements were already less regular than formerly.

The opening of the Atchison, Topeka, and Santa Fé Railroad has had a far greater influence upon the buffalo than either of the other roads, in consequence of the great number of hunters who seized upon it as a favorable basis for the prosecution of their terrible work of destruction. The story of this destruction and the fatal results attending the encroachment of the settlements upon the range of the buffalo is well told in the subjoined letter from Dr. W. S. Tremaine, U. S. A., kindly written in answer to my inquiries respecting this subject, and dated Fort Dodge, Kansas, July 16, 1875: "In regard to the buffalo, I would say that when I first came to this post, in 1869, the buffaloes ranged in almost countless herds from about where the town of Great Bend, on the Atchison, Topeka, and Santa Fé Railroad, now is, to Fort Lyon, Colorado, and from the Platte River to the Red River of Texas. Throughout this range you might travel for days and scarcely ever be out of sight of buffaloes. This condition remained up to the summer and autumn of 1873, when the Atchison, Topeka, and Santa Fé was completed to this point. Buffalo-hunting for their hides then became quite an industry in this neighborhood, and hundreds of thousands were slaughtered in this vicinity, so that at the present time a buffalo is a rare sight within two hundred miles of Fort Dodge." Dr. Tremaine gives the principal range of the Southern Herd of buffaloes as being now south of the Kansas line, between the North Fork of the Canadian and the Red River of Texas, and from about the 100th meridian to the eastern border of New Mexico. "A few small herds," he says, wander northward from the main body as far as the Platte country, passing along near the eastern boundary of Colorado. Some are also found further to the southward between the Red and Pecos Rivers. He speaks of the herds as having become very much restricted in range and as very much "thinned out." He says: "As regards their present numbers, I was told by an officer of cavalry who had scouted last summer and winter through the region I have indicated, that during his wanderings through this part of the country, which is now considered the principal habitat of the Southern Herd, he saw fewer buffaloes than he had seen in a trip from Fort Hays to Fort Dodge (eighty-six miles) in 1872."

Recent reports from Kansas and Colorado agree in respect to the enormous destruction of buffaloes throughout Kansas, incidentally referred to above by Dr. Tremaine. While the range seems not to have been as yet very materially circumscribed during the last four or five years, the reduction in numbers has been immense, and the vast herds existing there five years since are now represented by only scattered remnants, so fearfully have their ranks been depleted.

The incessant persecution of the buffalo along the lines of the two great Kansas railways has had the effect to crowd them southward and southwestward into Western Texas. In this Indian-infested region, too remote from railroads to render it feasible for the hunter to follow them for their hides and meat, the herd is now mainly concentrated where it is temporarily less exposed to persecution than on the more accessible plains of Kansas. The range of the herd thus not only changes with

* See Bulletin Essex Institute, Vol. VI, pp. 46, 47.

the seasons of the year, but also from year to year, in consequence of attacks upon them at new localities. Unless legal interference, either by the States of Kansas, Colorado, and Texas, or by the General Government, be speedily made, and rigorous restrictions most thoroughly enforced, the fate of the buffalo south of the Platte will be a repetition of its history east of the Mississippi River, namely, speedy extermination.

Area now occupied by the Southern Herd.—The region south of the Platte inhabited by the buffalo is already reduced to a very limited area. At the northward their range extends over only the head-waters of the Republican, and thence westward to the South Platte, to the northward of which river they still sometimes appear, their range thus including the small portion of Southwestern Nebraska that lies south of the Union Pacific Railway. They range thence southward throughout Western Kansas and Eastern Colorado, the extreme western part of the Indian Territory, Northern and Western Texas, extending in the latter State southward to the 30th parallel, and from the 98th meridian westward over the northern portion of the Staked Plains nearly to the eastern boundary of New Mexico. In 1873 they ranged to within a hundred miles of Santa Fé.*

Region between the Platte River and Parallel of 49°.—Passing to the northward of the Platte River, we will consider first the region situated between the Platte River and the United States and British boundary, or the 49th parallel. The buffalo, as is well known, formerly ranged over the whole country drained by the Missouri and its tributaries, as well as over the plains of the Red River of the North, and those of the Assinniboine and the Saskatchewan. The plains of the Red River, in Northern Minnesota and Dakota, formerly connected the great buffalo range of the Upper Missouri region with that of the Saskatchewan, whilst the Grand Coteau des Prairies was for a long time one of the regions of their greatest abundance. Beginning with Eastern Dakota, or that portion of the Territory east of the Missouri River, embracing the Grand Coteau des Prairies, we shall pass thence to the region between the Missouri River and the 49th parallel, and, lastly, trace their extermination over the vast triangular area bounded by the Missouri and Platte Rivers and the Rocky Mountains.

Extermination in Eastern Dakota.—As late as 1850 General John Pope stated that the buffalo ranged "in immense herds between the Pembina and Shayenne Rivers," and were "found in great numbers, winter and summer, along the Red River," being "frequently killed in the immediate vicinity of the settlements at Pembina.† Mr. Henry M. Rice also states that in the spring of 1847 a party of Red River hunters, numbering twelve hundred carts, went in a body south to Devil's Lake, in Minnesota (now Dakota); ‡ while Mr. J. E. Fletcher states that twenty thousand buffaloes were at this time annually killed in the country of the Sioux and Chippewa Indians, south of the United States and British boundary, § mostly within the present Territory of Dakota. The Hon. H. H. Sibley has given an interesting account of a buffalo-hunt in Eastern Dakota (then a part of Minnesota Territory) in Schoolcraft's great work on the Indian Tribes of the United States, || and incorporates

* H. W. Henshaw, in a letter to the writer, dated March 6, 1875.

† Report of an Exploration of the Territory of Minnesota. (Congressional Reports, 31st Congr., 1st Session, Senate Doc. No. 42, p. 27.)

‡ Congress. Rep., 31st Congr., 1st Sess., House Ex. Doc., Vol. VIII, No. 51, p. 8.

§ Ibid., p. 41.

|| Schoolcraft's History, Condition, and Prospects of the Indian Tribes of the United States, Vol. IV, pp. 101–110.

therewith a detailed account, furnished him by the Rev. Mr. Belcourt,* of the chase of the buffalo on the Pembina Plains. It contains not only much valuable information respecting the peculiar modes of hunting pursued by the Red River hunters, but also important statistics respecting the rate of their destruction at the date of writing (1853).

Mr. A. W. Tinkham, in the "Itinerary" of his route from St. Paul to Fort Union, in June and July, 1853, speaks of using the *bois de vache* for fuel on Maple River, and reports killing his first buffalo on the Shayenne, one of the chief tributaries of the Red River. At this time, he says, large herds roamed over the prairies of the Shayenne River, and extended as far south as the South Fork of the Shayenne. He also met with recent indications of the buffalo on the White Earth River.†

Governor Stevens, in speaking of the abundance of the buffalo on the Shayenne River, near Lake Zisne, the same year, says: "About five miles from camp, we ascended to the top of a high hill, and for a great distance ahead every square mile seemed to have a herd of buffalo upon it. Their number was variously estimated by the members of the party, some as high as half a million. I do not think it is any exaggeration to set it down at 200,000. I had heard of the myriads of these animals inhabiting these plains, but I could not realize the truth of these accounts till to-day, when they surpass everything I could have imagined from the accounts which I had received."‡

According to Assistant Surgeon Asa Wall, buffaloes were still common about Fort Abercrombie, on the Red River, at late as 1858.§

Mr. W. H. Illingworth, the well-known photographer of St. Paul, informs me that in 1866, when he made a journey from St. Cloud westward to the Yellowstone, he met with immense herds for two days in passing the Coteau des Prairies, west of the James River. They seem to have wholly disappeared east of the Missouri soon after this date, surviving in Southern Dakota, however, between the James and Missouri Rivers, for some years after their extermination over the plains of the Red River. As already stated, they were exterminated east of the Red River as early as about the year 1850, and, being at that time rapidly pressed westward by the Red River hunters, were wholly exterminated during the few years next following throughout the whole basin of the Red River, and even throughout the whole of the northern half of Dakota. In Southern Dakota, between the James and the Missouri, they lingered for some years later, but wholly disappeared east of the Missouri prior to the year 1870.

Region between the Upper Missouri and Forty-ninth Parallel.—The former existence of the buffalo over the whole of the region drained by the Upper Missouri is well substantiated by the evidences they themselves have left, and which exist in the form of well-defined trails and osseous remains. When Lewis and Clarke ascended the Missouri in 1804, they met with them at frequent points along almost its whole course, from the mouth of the Big Sioux to the Forks,|| and subsequent explorers found them on its remotest sources. As late as 1856 this

* The account given by Mr. Sibley as that furnished by Mr. Belcourt seems to be merely a translation of Mr. Belcourt's account of buffalo-hunting by the Red River half-breeds originally contained in a letter addressed by Mr. Belcourt to Major S. Woods, and dated "St. Paul, November 25, 1845." This document was published by Major Woods in his Report of his Expedition to the Pembina Settlement in 1849 (Congressional Documents of the 31st Congress, 1st Session, House Doc. No. 51, pp. 44–52).

† Pacific R. R. Expl. and Sur., Vol. I, Governor Stevens's Report, pp. 252–258.

‡ Pacific R. R. Rep. of Expl. and Surveys, Vol. XI, pt. 1, p. 59.

§ Med. Statistics U. S. Army, 1855–1860, p. 34.

|| Expedition, etc., Vol. I, pp. 67, 75, 77, et seq.

whole region was occupied, at least temporarily, by roving bands. Lambert, in his general report respecting the topography of this region, speaks of the extensive plains between the meridian of Fort Union and the Rocky Mountains as being the "pasture-grounds of unfailing millions of the uncouth and ponderous buffalo."* Lieutenant Saxon, in his report of a journey down the Missouri, from Fort Benton to Fort Union, made in 1853, says that during the last few days of their journey, as they approached Fort Union, they saw innumerable herds of buffalo-cows, in many places extending in every direction as far as the eye could reach.† Lieutenant Groger, the same year (October, 1853), also found large bands on the Missouri from the Musselshell to the Milk River,‡ and small bands were also seen by Tinkham west of the Great Falls, on the Sun River,§ where herds were also observed in January, 1854, by Lieutenant Groger.|| In December, 1853, they occurred in great numbers on Big Hole Prairie, on the head of the Jefferson Fork.¶ They were also reported as occurring on the Milk River, near Camp Atchison, and also on other of the neighboring northern tributaries of the Missouri.

Dr. Cooper states that in 1860 "the buffalo herd of the Upper Missouri was spread from the Rocky Mountains, near latitude 49°, south-east," and says that he "found them along the Missouri, from its upper Great Bend west to about fifty miles above Milk River, but nowhere in great numbers. Remains of their skeletons, left about five years since, were abundant west of Fort Benton, and," he adds, "I saw one or more old skulls daily in the valley of the Little Blackfoot and Hell Gate Rivers (west of the mountains), quite down to the junction with the Bitter Root."**

Lieutenant M. E. Hogan, 22d United States Infantry, who for some years previous had been in the United States military service in the Department of Dakota, informed me in 1873 that the buffaloes had recently crossed the Marias and Teton Rivers, in Northwestern Montana, from the northward, and were abundant throughout the region about Fort Shaw, and that there were "millions of buffaloes" on Milk River.

Respecting the present range of the buffalo between the Missouri River and the 49th parallel, and the evidences of their recent occupation of this whole belt of country, I am indebted to Dr. Elliott Coues for the subjoined important communication. Two seasons spent in this region as naturalist of the United States Northern Boundary Survey have given him opportunities for collecting much important information respecting this region. The communication, dated "Washington, March 2, 1875," is as follows:

"The time when the buffalo ranged in this latitude [parallel of 49°] eastward of the Red River of the North passed so long since that the traces of their former presence have become effaced. The present generation of hunters in Manitoba and adjacent portions of the United States trail to the westward, by several well-known routes, in pursuit of robes and meat. In travelling from the river I saw no sign whatever until in the vicinity of Turtle Mountain, where an occasional weather-worn skull or limb-bone may be observed. Thence westward to the Mouse River, the bony remains multiply with each day's journey, until they

* Pacific R. R. Rep. of Expl. and Surveys, Vol. I, Governor Stevens's Rep., p. 167.
† Ibid., p. 264.
‡ Ibid., p. 494.
§ Ibid., p. 369.
|| Ibid., p. 500.
¶ Ibid., p. 167.
** American Naturalist, Vol. I, p. 538.

become common objects; still, no horn, hoof, or patch of hide. In the space intervening between this river and the point where the Coteau de Missouri crosses the parallel of 49°, quite recent remains, as skulls still showing horns, nose-gristle, or hair, and portions of skeletons still ligamentously attached, are very frequent. At La Rivière de Lac, a day's march west of the Mouse River, there was a grand battue a few years since, as evidenced by the numbers of bones, the innumerable deserted badger-holes, and the circles of stones denoting where Indian lodges stood. Within the Coteau the most recent remains are the rule; and a hundred miles from such edge (nearly north of the mouth of the Yellowstone) living animals were seen in the summer of 1873.

"Thus comparing the two great basins of the Red River and of the Missouri respectively, it will be seen that the animal left the whole United States portion of the former before it was driven from parts of the Missouri basin equally far east, or even further eastward. This is borne out by observations made on my journey from the Mouse River due south to Fort Stevenson, on the Missouri. There were few skulls (about as many as between Mouse River and Turtle Mountain) until I struck the Coteau, within which they at once multiplied.

"In the western portion of the Red River basin numberless buffalo-*trails* still score the ground, with a general north-south trend.

"In the summer of 1874 I approached the parallel of 49° in a north-westerly course from the mouth of the Yellowstone. The whole country offered a fair amount of skeletal remains, in many cases ligamentously cohering, and was furrowed with trails. But there were no living animals in the region eastward of Frenchman's River, which is one of the first of many north-south tributaries of Milk River. A day's march west of this river brought us to the edge of the 'Yellowstone Herd,' as the northerly division of the buffalo is termed, where the first buffalo were seen and killed. Small straggling droves, or single animals, were observed every day thence to the vicinity of the Sweet Grass Hills (or Three Buttes, as they are called on the map), where they become very abundant. In this city many thousands, if not some hundreds of thousands, passed the season. During the latter part of August we travelled for several days in continual sight of droves on every side on the road between the Sweet Grass Hills and Fort Benton; one day the plain was uniformly dotted, as far as the eye could reach, in at least a quadrant of a circle.

"In the comparatively short distance between the Sweet Grass Hills and the Rocky Mountains we encountered no buffalo, but this was a mere fortuitous circumstance for the particular days; the 'chips' were everywhere. They were traced, however, by their remains into the very heart of the Rocky Mountains, at an altitude of at least 5,000 feet; and I was informed that the various glades were a winter resort of some of the animals that pass that season in this latitude. But I could obtain no indication that the buffalo ever [here] crossed the mountains. Hunters and guides familiar with the region for years agree that this barrier is not surmounted, and had never been passed, either within their memory or according to tradition; indeed, the Kootanie Pass has been always known as the point where Indians from the westward have come annually to hunt on the opposite side.

"It is sufficiently attested that buffaloes pass the winter in this region, or at least have very recently done so. In exploring the Sweet Grass Hills, I followed up one gorge where for a mile or so skulls and skeletons lay almost touching each other in the cul-de-sac. Here was evident indication that a drove, in attempting to cross from the hog-back on one side to the other, had sunk in the snow which filled the ravine, and lost many of their number. The buffaloes are more expert and venturesome climbers than their unwieldy forms would indicate. Upon the summits of the Sweet Grass Hills, inaccessible on horseback, and where a man can only go about by scrambling, their dung and bones are found, with those of the mountain sheep. The hillsides here, and the equally steep banks in places along the heads of the Milk River and its tributaries, too declivous in their natural state to afford footing to a horse or mule, are cut by innumerable hoofs into a series of narrow terraces, each a buffalo trail.

"In the whole region just north of the Milk River, absolutely treeless excepting along a part of the stream, and on the Sweet Grass Hills, buffalo chips are everywhere at hand for fuel.

"In descending the Missouri River from Fort Benton, buffalo were seen almost daily during that part of the voyage which embraced the rapid portion of the river flowing between the bluffs of the Bad Lands. Small droves were seen surmounting peaks which, it would seem, only a mountain sheep could scale; and in one instance, indeed, the attempt was a failure, and the animal rolled down hill in a cloud of dust. No more were seen below the mouth of the Musselshell, where the Missouri widens and enters a flatter country. The limit on the Missouri corresponds in longitude, in a general way, with that above noted on the parallel of 49°."

It thus appears that twenty years ago buffaloes were accustomed to frequent the whole region between the Missouri River and the 49th parallel, from the western boundary of Dakota, or the 104th meridian, westward to the Rocky Mountains, occurring even throughout the foot-hills of the latter as well as over the head-waters of the Bitter Root, or St. Mary's River, one of the sources of Clarke's Fork of the Columbia, but that they are now restricted to the region between Frenchman's Creek, near the 107th meridian, and the Rocky Mountains, over much of which area their occurrence is merely irregular and more or less fortuitous, their main range being between the 110th and the 112th meridians.

Region between the Upper Missouri and Platte Rivers.—It is so well known that the buffalo formerly ranged throughout this region, that there is little need of presenting further evidence of the fact than will be given incidentally in tracing the boundaries of their present range, and in sketching the history of their extirpation over the greater part of this extensive territory. Beginning at the eastward, we find that Bradbury in 1810, in crossing from the Platte River northward to the Mandan Villages, met with a few buffaloes in what is now Eastern Nebraska, on the Elk Horn River, and that they were then plentiful on the Canon Ball and Heart Rivers, in what is now Southwestern Dakota.* They lingered in Southwestern Dakota till within a very short time. The last buffalo killed near Fort Rice was taken in 1869, when three were killed from a herd of ten old bulls that had wandered considerably to the eastward of the main herds. According to Dr. W. J. Hoffman, to whom I am indebted for other interesting facts relating to the subject of the present paper, the buffaloes disappeared from the region between the Cheyenne and Grand River Agencies at about the same time (1869), although occasional stragglers frequented the plains toward the Black Hills till somewhat later. He states that fresh hides were brought into the Grand River Agency in 1872, that were obtained about one

* Bradbury (John), Travels in the Interior of North America in the years 1809, 1810, and 1811, pp. 53, 134.

hundred miles to the westward of that place.* Dr. Hayden also informs me that a few were found until a few years since south of the Black Hills, on the sources of the Niobrara and Cheyenne Rivers, from which localities they have, however, been since exterminated.

As already stated, they were abundant about Fort Union at the mouth of the Yellowstone, in 1853, and for some distance below this point west of the Missouri, where they remained for some years later. Dr. Hayden informs me that they were abundant there as late as 1859, and that even as late as 1866 they occupied much of the country between Fort Union and Fort Pierre. In 1861 Dr. Hayden published the following general statement in relation to the range of the buffalo at that time on the Upper Missouri. "They occur," he says, "in large bands in the valley of the Yellowstone River, and in the Blackfoot country, but their numbers are annually decreasing at a rapid rate. Descending the Yellowstone in the summer of 1854, from the Crow country, we were not out of sight of large herds for a distance of 400 miles. . . . . In 1850 they were seen as low down on the Missouri River as the Vermilion, and in 1854 a few were killed near Fort Pierre. But at the present time (1861) they seldom pass below the 47th parallel on the Missouri. Every year, as we ascend the river, we can observe that they are retiring nearer and nearer to the mountainous portions."†

General W. F. Raynolds, in passing from Fort Pierre westward in July, 1859, says that the whole country, for one hundred and forty miles, was a dry, desolate tract, a few antelopes forming the only living things met with; "but buffaloes," he says, "have evidently been here, and may return at more favorable seasons of the year. Six bulls were seen to-day in the distance, as we drove into camp, being our first sight of the famous 'lords of the prairie.' We are now approaching the Black Hills, however, and will soon have them around us in abundance."‡ This locality was on the head-waters of the Cheyenne. Again, in speaking of the valley of the Yellowstone, he says: "This valley has long been the home of countless herds of buffalo. . . . . When my party first reached the bluff overlooking the Yellowstone the sight was one which in a few years will have passed away forever. I estimated that about fifteen miles in length of the wide valley was in view. The entire tract of forty or fifty square miles was covered with buffalo as thickly as in former days in the West (when cattle were driven to an Eastern market) a pasture-field would be which was intended only to furnish subsistence to a large drove for a single night. I will not venture an estimate of their probable numbers."§

In 1873 I made a journey from Fort Rice, on the Missouri, to the Yellowstone and Musselshell Rivers, accompanying the "Yellowstone Expedition" of that year (General D. S. Stanley commanding) as naturalist of the expedition. From my report on the collections made I quote the following: "Recent signs of the buffalo were first met with in the valley of the Yellowstone, near the mouth of the Rosebud,—tracks of single old bulls that had passed down to the river for water within a period of a few weeks. Above this point considerable numbers seemed to have frequented the river valley during the early part of the season (1873), and tracks but a few days old were frequent for the last ten miles before reaching Pompey's Pillar. The first buffalo *seen* was observed about twelve miles west of Pompey's Pillar. Eight miles further west, on the divide between the Yellowstone and the Mussel-

* In a letter dated April 16, 1875.
† Transact. Amer. Phil. Soc., Vol. XII, 2d Series, p. 150.
‡ Exploration of the Yellowstone, p. 27.
§ Ibid., p. 11.

shell, we found large herds had grazed but a day or two before our arrival, and fresh tracks of cows and calves, as well as of bulls, were abundant. From this point to the Musselshell we were frequently in sight of large bands, and quite a number of individuals were killed. They moved off rapidly, however, as we approached, and at no time were more than a few hundred in sight at once. We found later that the valley of the Musselshell and its adjoining prairies had been the recent feeding-ground of large herds, immense numbers having evidently spent the early part of the season there. They seemed not, however, to have visited the valley in large numbers before for many years, as all the trails and other signs had evidently been made within the few weeks immediately preceding our arrival. Traces of ancient trails remained, but they were few and insignificant as compared with those of the present year. The herds seemed to have occupied the whole valley as far as we followed it (from the 109th meridian to the Big Bend), as well as the plains on either side. Considerable bands had also ranged over the divide between the Musselshell and the Yellowstone, particularly along the two Porcupine Creeks. General Custer met with small herds still further to the eastward, and the main expedition came in sight of a few near the mouth of Custer's Creek, where several were killed by the scouts. On our return we found that during our absence small bands had visited the valley of the Yellowstone itself, and had ranged as far down as Powder River, while quite large herds had recently passed up Custer's Creek.

"Occasional skeletons and buffalo chips in a good state of preservation occur eastward nearly to the Missouri, but the only very recent signs observed this year east of the Yellowstone were the tracks of a few old straggling bulls a few miles east of the river."* I was also informed by credible authorities that they then wintered in great numbers on the head-waters of the Big-Horn, Tongue, and Powder Rivers, passing northward in spring to the Yellowstone and Musselshell. Mr. Reynolds, a hunter and scout of great experience, and an unquestionable authority, informed me that the buffalo range of the Upper Missouri embraced the regions of the Powder, Tongue, Big-Horn, and Upper Yellowstone Rivers, and thence northward over the Musselshell, Teton, and Marias Rivers, to the Milk River.

The recent rapid extermination of the buffalo over Southwestern Dakota and the adjoining portions of Wyoming has been undoubtedly effected mainly by the Sioux Indians, who have of late ranged over this region. This at least is the view taken by Colonel Dodge, and apparently with good reason. He refers to the subject as follows: "The great composite tribe of Sioux, driven by encroaching civilization from their homes in Iowa, Wisconsin, and Minnesota, had crossed the Missouri and thrust themselves between the Pawnees on the east and the Crows on the north and west. A long-continued war between the tribes taught at least mutual respect, and an immense area, embracing the Black Hills and the vast plains watered by the Niobrara and White Rivers, became a debatable ground, into which none but war parties ever penetrated. Hunted more or less by the surrounding tribes, immense numbers of buffalo took refuge in this debatable land, where they were comparatively unmolested, remaining there summer and winter in security. When the Pawnees were finally overthrown and forced on to a reservation, the Sioux poured into this country, just suited to their tastes, and, finding buffalo very plenteous and a ready sale for their robes, made such a furious onslaught upon the poor beasts that in a few years scarce a buffalo could be found in the extensive tract of

* Proc. Boston Soc. Nat. Hist., Vol. XVII, pp. 39, 40, 1874.

country south of the Cheyenne and north and east of the North Platte River. This area, in which the buffalo had thus become practically extinct, joined on the southwest the Laramie Plains country, and there resulted a broad east-and-west belt from the Missouri to Montana, which contained no buffalo."*

I learn from General F. H. Bradley (United States Infantry) that in 1868, when Forts Smith, Reno, and other military posts in the Black Hills region were abandoned, buffaloes were very abundant in all the so-called Big Horn country, and that in one day they killed fifty tons of meat for garrison use.

During the period of the government surveys for a railroad route from the Mississippi River to the Pacific Ocean, during 1853 to 1856, buffaloes were met with in great abundance on the southern tributaries of the Missouri, between the Great Falls of the Missouri and the mouth of the Yellowstone. In passing from Fort Benton southeast to the Musselshell River, Lieutenant Mullan reports meeting with three lean old bulls on Arrow River, large herds on the head of the Judith River, between the Girdle and Judith Mountains, and a considerable number along the Musselshell.†

In 1871 no buffaloes occurred in Eastern Wyoming south of the Black Hills, and they had also already been long extinct over the Laramie Plains, and in the valley of the North Platte in Western Wyoming, which region they probably have not regularly frequented since they were dispersed, about 1849–50, by the great overland emigration to California. I was informed that none then existed in the territory south of the Sweetwater Mountains and the Black Hills. Frémont, in 1842, constantly met with large herds as far west as the Laramie River, but none were seen on the North Platte above the junction of the Laramie until he reached the mouth of the Sweet Water, the grasshoppers and the dry weather having destroyed the grass over the Laramie Plains. An explanation of their final disappearance from the Laramie Plains has been offered by Colonel Richard I. Dodge, which is at least probable. He says that according to hunters' traditions the Laramie Plains were visited in the winter of 1844–45 "by a most extraordinary snow-storm. Contrary to all precedent, there was no wind, and the snow covered the surface evenly to the depth of nearly four feet. Immediately after the storm a bright sun softened the surface, which at night froze into a crust so firm that it was weeks before any heavy animal could make any headway over it. The Laramie Plains, being entirely surrounded by mountains, had always been a favorite wintering-place for the buffaloes. Thousands were caught in this storm, and perished miserably by starvation. Since that time not a single buffalo has ever visited the Laramie Plains. When I first crossed these plains, in 1868, the whole country was dotted with skulls of buffaloes, all in the last stages of decomposition and all apparently of the same age [or period of exposure], giving some foundation for the tradition. Indeed, it was in answer to my request for an explanation of the numbers, appearance, and identity of age [condition] of these skulls, that the tradition was related to me by an old hunter, who, however, could not himself vouch for the facts."‡

Chicago Inter-Ocean, August 5, 1875.

† Pacific R. R. Rep. of Expl. and Surveys, Vol. XI, pt. i, p. 59.

‡ *Chicago Inter-Ocean*, August 5, 1875. This and the previous extracts from the Inter-Ocean newspaper were sent to this paper by a reporter accompanying the Black Hills Expedition of 1875, of which Colonel Dodge was in command, as a portion of an "advance chapter" from a forthcoming book on the West by Colonel Dodge. This book, "based on personal experience," has recently appeared, with maps and illustrations, under the title of "The Hunting Grounds of the Great West." (New York, Messrs. G. P. Putnam's Sons; London, Chatto and Windus).

That this may have been the case seems very probable from the fact that I found, in returning over these plains in December, 1871, the snow so deep and so heavily encrusted that the herds of domestic stock were dying from starvation whenever it happened that their owners had not provided for such an emergency by laying in a good supply of hay. Many animals perished from lack of food and shelter, the occurrence of such conditions as a deep snow heavily encrusted being wholly unlooked for; and had buffaloes been then living on these plains they could hardly have survived the long period during which the ground was inaccessible to grazing animals.

The buffalo has also become exterminated over a large portion of the country to the northward of the Sweet Water along the eastern base of the Rocky Mountains, extending northward, in fact, over the head-waters of the Yellowstone and Missouri Rivers. Dr. Hayden informs me that but few were found in 1871 and 1872 on the Upper Yellowstone, and that they are now rarely seen above Shield's River, although they occurred in the Wind River Valley in 1860. He says, moreover, that very few are found on the Three Forks of the Missouri, where they have been nearly all destroyed or driven out by the miners. Those that remain are chiefly old bulls, the scattered survivors of the former large herds, and which of course will not long remain. He also says that a few were met with in the valley of the Gros Ventres as late as 1860, and in the valley of the upper part of the Snake River Valley in 1870,—the two latter localities of course being on the western slope of the Rocky Mountains.

It thus appears that the present range of the buffalo between the Platte and the Missouri is confined to the comparatively small area drained by the principal southern tributaries of the Yellowstone, namely, the Powder, the Tongue, and the Big Horn Rivers, from which they range northward over the middle portions of the Yellowstone and the Musselshell Rivers to the Missouri.

FORMER BOUNDARIES OF THE RANGE OF THE BUFFALO WITHIN THE BRITISH POSSESSIONS, AND ITS PRESENT DISTRIBUTION WITHIN THAT AREA.

The range of the buffalo, as previously remarked, formerly extended continuously from the plains of the United States northward to Great Slave Lake, in latitude 62° to 64° north, being apparently almost as numerous over the plains of the Red River, the Assinniboine, Qu'appelle, both branches of the Saskatchewan, and the Peace River, as over the plains of the Missouri. Franklin, in 1820, met with a few at Slave Point, on the north side of Great Slave Lake,* and Dr. Richardson states that in 1829 they had recently, according to the testimony of the natives, wandered to the vicinity of Great Marten Lake, in latitude 63° or 64°.† In respect to the distribution of the buffalo in the "Fur Countries," Dr. Richardson speaks as follows: "As far as I have been able to ascertain, the limestone and sandstone formations lying between the great Rocky Mountain ridge and the lower eastern chain of primitive rocks, are the only districts in the fur countries that are frequented by the bison. In these comparatively level tracts there is much prairie-land, on which

* "A few frequent Slave Point, on the north side of the lake, but this is the most northern situation in which they were observed by Captain Franklin's party."—SABINE, *Zoölogical Appendix* to *Franklin's Journey*, p. 668.

† Fauna Boreali-Americana, Vol. I, p. 279. See also Zoölogical Appendix to Parry's Second Voyage, p. 332.

they find good grass in the summer; and also many marshes overgrown with bulrushes and carices, which supply them with winter food. Salt springs and lakes also abound on the confines of the limestone, and there are several well-known salt-licks, where bison are sure to be found at all seasons of the year. They do not frequent any of the districts formed of primitive rocks, and the limits of their range to the eastward within the Hudson Bay Company's territories may be correctly marked on the map by a line commencing in longitude 97° on the Red River which flows into the south end of Lake Winipeg, crossing the Saskatchewan to the westward of the Basquian hill, and running thence by the Athapescow to the east end of Great Slave Lake. Their migrations to the westward were formerly limited by the Rocky Mountain range, and they are still unknown in New Caledonia and on the shores of the Pacific to the north of the Columbia River; but of late years they have found out a passage across the mountains near the sources of the Saskatchewan, and their numbers to the westward are said to be annually increasing."* The range of the buffalo in British America was hence co-extensive with the prairies, meeting the range of the musk-ox on the north, and the prairies and plains of the United States on the south. It was not, however, exclusively confined to the plains, and apparently less so at the northward than toward the south. Besides positively forsaking the more exposed portions of the northern plains and seeking refuge in the woods during the severer periods of cold in winter, they are said to frequent, at all seasons, the timber adjoining the prairie districts. In a later work Dr. Richardson refers to the range of this animal as follows: "The bison, though inhabiting the prairies in vast bands, frequents also the wooded country, and once, I believe, almost all parts of it down to the coasts of the Atlantic; but it had not until lately crossed the Rocky Mountain range, nor is it now known on the Pacific Slope, except in a very few places. Its most northern limit is the Horn Mountain [in latitude 62]."† To the northward of the Saskatchewan, the prairie country is confined to limited areas, and there buffaloes range extensively through the open woods.‡ The habitat of the bison north of the United States, at the beginning of the present century, hence embraced a triangular area, extending through about seventeen degrees of longitude (from 96° to 113°) on the northern boundary of the United States, decreasing in breadth northward to a narrow point at Great Slave Lake. At present, however, they are confined within much narrower limits than formerly, and are quite absent over large areas that once were among their favorite resorts.§

*Fauna Boreali-Americana, Vol. I, pp. 279, 280.

† Arctic Searching Expedition: A Journal of a Boat-Voyage through Rupert's Land and the Arctic Sea, American ed., p. 99, 1852.

‡ Hind believes that the so-called "prairie" buffalo, as distinguished by the hunters from the "wood" buffalo, formerly "ranged through open woods, almost as much as he now does through the prairies."—*Assinniboine and Saskatchewan Expedition*, Vol. II, p. 106.

§According to the observations of Mr. W. H. Dall, and others, a near ally of the buffalo (the *Bison antiquus* Leidy = *B. crassicornis* Richardson) formerly existed considerably to the northwestward of the former range of the living species, extending throughout probably nearly the whole of Alaska. The evidences of this consist in the occurrence of their fossil remains at different localities in the valley of the Yukon and elsewhere. In answer to inquiries of mine, Mr. Dall wrote me, under date of San Francisco, Cal., January 23, 1871, as follows, respecting the distribution of these remains: "Your letter is at hand, and in reply I can only say that the bones of the bison are found on the Upper Yukon, from the Ramparts eastward and northward, and also at Kotzebue Sound. They are found, like all the remains of tertiary mammals in that region, on or very near the surface, and are especially abundant on the Kotlo River, which falls into the Yukon above Fort Yukon [latitude 66°, longitude 141°,—just west

The following abstracts and quotations embrace the more important references to the range and extermination of the buffalo in British North America, and are arranged nearly in a chronological order. In 1790 Mackenzie found buffaloes in considerable numbers on Peace River, along which they extended westward to the base of the Rocky Mountains.* At this time they abounded also on the plains between the Assinniboine, Red, and Missouri Rivers, as well as on both branches of the Saskatchewan and their tributaries.†

Ross Coxe, in June, 1812, also found the buffalo in small numbers on the head-waters of the Assinniboine River and its tributaries,‡ but from all this region they have now nearly or quite disappeared. Hind reports finding bones and horns of buffaloes on the Assinniboine River, between Fort Garry and Prairie Portage, in 1857, but makes no mention of the occurrence of the animals themselves there at that date, but says they were still found on the sage plains further north. The Red River hunters at this time, he says, went part to the plains of the Saskatchewan, and part to the Yellowstone and Coteau de Missouri for their buffaloes.§ Alexander Ross, writing at about the same date, also says, "Formerly all this part of the country [Red River Plains] was overrun by wild buffalo, even as late as 1810"; but adds, "Of late years the field of chase has been far distant from the Pembina Plains."‖

Simpson reports that buffaloes were abundant on the plains south of the Saskatchewan in the winter of 1836, and that the country about Carlton House was completely intersected with their deeply-worn trails, and strewed with their skeletons; from this region they had been temporarily driven by the autumnal fires. He also met with a few buffaloes on the Clear Water River, a little above its junction with the Athabasca. In January, 1840, they were also extremely abundant about Carlton House.¶

Respecting the range and the migrations of the buffalo within the British Possessions about the year 1858, Hind observes as follows: "Red River hunters recognize two grand divisions of buffalo, those of the Grand Coteau and Red River, and those of the Saskatchewan. .... The

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of the United States and British boundary]. The remains I have seen, with those of the elephant (in similar situations), are black and fossilized. The bones of the musk ox and mountain goat, on the contrary, are white, and look very recent. The latter animal is still rarely found living on the mountains near the Upper Yukon. The bison remains which I have seen have been principally horn-cores and the remains of the cranium and lower jaws. The indications are that the *Elephas primigenius* and the fossil bison were contemporaries, but that the musk ox was a later comer. However, this idea rests merely on the appearance of the bones, as the bones of all (as well as the remains of fossil horses) are found together in a bed of blue clay, near the surface, at Kotzebue Sound, and (barring the horses) all over the Upper Yukon Valley, in similar positions, irregularly scattered on the ground. I found the cranium of an elephant in the grass at the mouth of the Yukon, skulls of musk oxen and bisons on the surface in little valleys in the Ramparts, and on the alluvial plain near Fort Yukon."

In addition to the above, I have since been informed by Mr. Dall that he obtained a complete skull, except the lower jaw, on the Sitzikunten River, just below the Ramparts of the Yukon, in about latitude 65° and longitude 151°, and other fragments about fifty miles lower down the Yukon. The skull was unfortunately lost during the subsequent journey down the river. [The above should have been inserted in connection with the history of *Bison antiquus*, but was accidentally omitted.]

* Mackenzie (Sir Alexander), Travels to the Polar Sea and to the Pacific Ocean in the years 1789–91, Vol. II, pp. 147, 155, 156, 377.

† Ibid., pp. lxi, lxii, lxv, lxix.

‡ Adventures on the Columbia River, p. 259.

§ Hind (H. Y.), Canadian, Red River, Assinniboine, and Saskatchewan Exploring Expeditions, Vol. II, p. 272.

‖ The Red River Settlement: Its Rise, Progress, and Present State, p. 15.

¶ Simpson (Thomas), Narrative of the Discovery of the North Coast of America, London, 1843, pp. 40, 45, 46, 60, 402, 404.

northwestern buffalo ranges are as follow: The bands belonging to the Red River Range winter on the Little Souris, and southeasterly toward and beyond Devil's Lake, and thence on to Red River and the Shayenne. Here, too, they are found in the spring. Their course then lies west towards the Grand Coteau de Missouri until the month of June, when they turn north, and revisit the Little Souris from the west, winding round the flank of Turtle Mountain to Devil's Lake, and by the main river (Red River), to the Shayenne again. In the memory of many Red River hunters the buffalo were accustomed to visit the prairies of the Assinniboine as far as Lake Manitobah, where in fact their skulls and bones are now to be seen; their skulls are also seen on the east side of the Red River of the North, in Minnesota, but the living animal is very rarely to be met with. A few years ago they were accustomed to pass on the east side of Turtle Mountain, through the Blue Hills of the Souris, but of late years their wanderings in this direction have ceased; experience teaching them that their enemies, the half-breeds, have approached too near their haunts in that direction.

"The country about the west side of Turtle Mountain, in June, 1858, was scored with their tracks at one of the crossing places on the Little Souris, as if deep parallel ruts had been artificially cut down the hill-sides. These ruts, often one foot deep and sixteen inches broad, would converge from the prairie for many miles to a favorite crossing or drinking place; and they are often seen in regions in which the buffalo is no longer a visitor.

"The great western herds winter between the south and north branches of the Saskatchewan, south of the Touchwood Hills, and beyond the north Saskatchewan in the valley of the Athabasca; they cross the South Branch in June and July, visit the prairies on the south side of the Touchwood Hill range, and cross the Qu'appelle valley anywhere between the Elbow of the South Branch and a few miles west of Fort Ellice, on the Assinniboine. They then strike for the Grand Coteau de Missouri, and their eastern flank often approaches the Red River herds coming north from the Grand Coteau. They then proceed across the Missouri up the Yellow Stone, and return to the Saskatchewan and Athabaska as winter approaches, by the flanks of the Rocky Mountains. We saw many small herds, belonging to the western bands, cross the Qu'appelle valley and proceed in single file towards the Grand Coteau de Missouri in July, 1858. The eastern bands, which we had expected to find on the Little Souris, were on the main river (Red River is so termed by the half-breeds hunting in this quarter). They had proceeded early thither, far to the south of their usual track, in consequence of the devastating fires which swept the plains from the Rocky Mountains to Red River in the autumn of 1857. We met bulls all moving south, when approaching Fort Ellice; they had come from their winter quarters near the Touchwood Hill range. As a general rule the Saskatchewan bands of buffalo go north during the autumn and south during the summer. The Little Souris and main river bands go north-west in summer and southeast in autumn."* Hind also states that the buffaloes still frequented the eastern flank of the Rocky Mountains.†

The Earl of Southesk, in his recently published narrative of his sporting adventures in British North America in 1859,‡ makes but

* Hind (H. Y.), Narrative of the Canadian Red River Expedition of 1857, and of the Assinniboine and Saskatchewan Exploring Expeditions of 1858, Vol. II, pp. 107-109 See also Vol. I, pp. 295, 306, 336, 342, 356.

† Ibid, Vol. II, p. 106.

‡ Saskatchewan and the Rocky Mountains, 1875.

few references to the buffalo, and adds nothing of much importance to our knowledge of its distribution. He speaks, however, of their occurrence on the plains west of Fort Ellice, and of meeting with large herds between the north and south branches of the Saskatchewan. He also met with their recent remains near Old Bow Fort, on the South Saskatchewan, at the base of the Rocky Mountains. "The plains," he says, "are all strewn with skulls and other vestiges of the buffalo, which came up this river last year in great numbers. They were once common in the mountains. At the Kootanie Plain I observed some of their wallowing places, and even so high as a secluded little lake near where the horses were taken up to the ice bank I saw traces of them. They are now rapidly disappearing everywhere." A few were also seen near the Touchwood Hills, west of Fort Pelly, in November, which was about the most easterly point at which they were seen.*

Mr. B. R. Ross, in speaking of the range of the buffalo in the far north in 1861, says that the "strong wood variety comes so far north and east as about twenty miles from the mouth of Little Buffalo River, near Fort Resolution, Great Slave Lake." He adds that it is found "most numerously in the vicinity of the salt plains of Salt River. It is unknown throughout the country inhabited by any of the Sclave tribes, and the point mentioned above may be considered as its farthest limits. It is of larger size than the plain variety, of darker color, and more thickly furred. The Chipewyans eat its flesh, and make robes and parchment from the hides." From its scarcity, however, he adds that it does not contribute materially to their needs.†

Captain W. F. Butler, writing in 1872, thus speaks of the region of the Touchwood Hills: "This region bears the name of the Touchwood Hills. Around it, far into endless space, stretch immense plains of bare and scanty vegetation, plains scored with the tracks of countless buffalo, which, until a few years ago, were wont to roam in vast herds between the Assinniboine and the Saskatchewan. Upon whatever side the eye turns when crossing these great expanses, the same wrecks of the monarch of the prairie lie thickly strewn over the surface. Hundreds of thousands of skeletons dot the short, scant grass; and when fire has laid barer still the level surface the bleached ribs and skulls of long-killed bison whiten far and near the dark burnt prairie."‡

Captain Butler crossed the plains from Fort Ellice in a northwest direction to Fort Carlton (Carlton House), and journeyed thence up the North Saskatchewan River to the base of the Rocky Mountains; but he seems not to have met with any living buffalo throughout his journey. He again refers to the vast diminution the buffalo has undergone, and mentions the wholesale slaughter formerly practised by the Cree Indians on the plains of the Saskatchewan, and describes a hunt he himself participated in on the plains of Nebraska. Referring to the rapidity with which the buffalo is vanishing from the "great central prairie land," he says: "Far in the northern forests of the Athabasca a few buffaloes may for a time bid defiance to man, but they, too, must disappear, and nothing be left of this giant beast save the bones that for many an age will whiten the prairies over which the great herds roamed at will in times before the white man came."§

Captain Butler, in a later work, refers to the existence of buffaloes

* Ibid., pp. 52, 254, 306.

† "An account of the Animals useful, in an economic point of view, to the various Chipewyan Tribes." Can. Nat. and Geol., Vol. VI, Dec., 1861, p. 440.

‡ The Great Lone Land, p. 217, 1863.

§ The Great Lone Land, pp. 315, 320.

near the forks of the Athabasca River, and thence northward to the eastern end of Athabasca Lake. At Fort Chipewyan Captain Butler, on inquiry as to the amount of game destroyed by a good hunter in a season, was informed that an Indian named Chripo had killed, among other game, ten wood buffalo during the previous winter, showing the buffalo to be far from rare in the vicinity of Fort Chipewyan. "The wood buffalo and the moose," he further adds, "are yet numerous on the northwest and southwest shores" of Athabasca Lake, but are not found further to the eastward. They are, however, scarce, he affirms, in comparison with the numbers found there by Hearne. He also states that further westward their northward range extends to within a day's journey of Fort Vermilion, on the Peace River, and that "there are scattered herds, even now [1873], on the banks of the Liard River, as far as sixty-one degrees of north latitude."*

Mr. Huyshe, writing in 1871 of the region about Fort Garry, says: "Buffalo are no longer found nearer than three hundred miles west of Fort Garry, and are gradually being driven further and further west by the advancing stream of civilization."†

In a valuable communication respecting the present and former range of the buffalo in the British Possessions, kindly sent me by Mr. J. W. Taylor, U. S. consul at Winnipeg, Mr. Taylor, under date of "United States Consulate, Winnipeg, B. N. A., April 26, 1873," writes as follows: "In preparing this reply to your note requesting information respecting the comparative numbers and present range of the buffalo, I have consulted Mr. Andrew McDermott, an old and intelligent resident of Selkirk Settlement, now known as the province of Manitoba. This gentleman, when a very young man, was in the service of the Hudson Bay Company,—from 1812 to 1821,—and has since been a successful trader. His position in the country is attested by his recent appointment as the Manitoba director of the Canada Pacific Railway Company.

"My informant, in 1818, was in the midst of a large herd, only two miles west of Fort Garry, where I am writing. His party stood for an hour in the midst of the black moving mass, with difficulty preventing themselves, by the constant discharge of fire-arms, from being trampled to death. Now, in 1873, the nearest point where the animal is found is at Woody Hills, upon the International frontier, three hundred miles southwestwardly, while you must go five hundred miles west to meet large bands. Formerly a variety called the wood buffalo was very numerous in the forests surrounding Lakes Winnipeg and Manitoba, the last survivor having been killed only two years ago, on Sturgeon Creek, ten miles west of Fort Garry. The wood buffalo is smaller than its congener of the plains, with finer and darker wool, and a superior quality of flesh. It more resembles the 'bison' of naturalists.

"The Saskatchewan plains near the Rocky Mountains, have always been a great resort of the buffalo, and although the traditions of their immense multitudes fifty years ago have hardly been sustained of late, yet I am inclined to the opinion that the extension of settlements in Dakota and Montana, the navigation of the Missouri by steamers, and the construction of the Northern Pacific Railroad are concentrating the herds which had previously retreated northward from the great overland route now traversed by the Union Pacific Railroad upon the tributaries of the Saskatchewan. Quite recently, a party of hunters in the district adjoining the country of the Blackfoot Indians, in longitude

* The Wild North Land, pp. 122, 130, 131, 139, 142, 167, 211.

† Huyshe (G. L.), The Red River Expedition, p. 230, 1871.

110°, latitude 51°, was seven days in passing through a herd. The Saskatchewan district sent 17,930 buffalo-robes through Minnesota to market during the year ending September 30, 1872, while an equal number was either consumed in the country or despatched to Europe by vessels from York Factory, on Hudson's Bay."*

During the summer of 1873, Mr. A. R. C. Selwyn made a journey from Manitoba to Rocky Mountain House, in describing which he says not a single buffalo was met with on the whole journey, although the region he traversed was "swarming" with them not many years before. He saw only their "skulls whitening on the plains, and their deep-worn and grass-grown tracks"—evidences of their former recent existence.†

Respecting the present range of the buffalo in that portion of the British Possessions immediately north of the United States line, I have been favored, through Principal J. W. Dawson of McGill College, Montreal, with the following important communication from Professor George M. Dawson, Geologist of the British and United States Boundary Survey, dated McGill College, Montreal, June 3, 1875: "Understanding from Principal Dawson that you wish to collect information as to the range of the buffalo in British North America, I have marked on the inclosed portion of a map the range of the animal on the forty-ninth parallel, of which alone I can speak from personal knowledge. During the last sixteen years it would appear that the buffaloes have been driven back over two hundred miles on the forty-ninth parallel, and now do not extend in any force beyond White Mud River, or Frenchman's Creek (longitude 107° 30′). They reached this point when we arrived there late in June of last summer, and were going north in great herds, followed by the Sioux Indians. This migration seems to have ceased before about the 20th of July, when they were confined to the limits stated on the map,‡ and remained so till we left the country, in September. The Sweet Grass Hills form their centre in the vicinity of the Line. The pasture is good, and the region is besides a sort of neutral ground among the Indian tribes. We saw abundant traces of the passage of great herds in spring on the upper branches of Milk River, and they come in to the foot of the Rocky Mountains. I do not think they ever cross the mountains in the vicinity of the forty-ninth parallel, though I have seen their bones as far up the South Kootanie Pass as the last grassy meadow."

On the map referred to in the above-given letter, a line drawn along Frenchman's Creek or White Mud River is given as the eastern limit of the present range of the buffalo, while the region a little to the west of this line is marked as the district where "great herds" were seen "going north in June." The line drawn parallel to the Little Souris River, and about forty miles to the westward of it, following the Coteau de Missouri, is given as the "approximate eastern limit of 'buffalo chips.'"

In addition to the information contained in Professor Dawson's letter, I find the following in his recent "Report on the Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel," etc.: "From what I could learn," says Professor Dawson, "I believe that, at the

* Captain Butler states that in 1872 "not less than 30,000 robes" found their way to the Red River, and that "fully as many more in skins of parchment or in leather had been traded or consumed in the thousand wants of savage life." The Blackfoot tribes alone are said to kill twelve thousand annually.—*Wild North Land*, p. 62.

† Canadian Naturalist, second series, Vol. VII, 1875, p. 199.

‡ A belt about seventy-five miles wide, situated on both sides of the 111th meridian, but lying mainly between the 111th and 112th meridians, and stretching northward toward the South Saskatchewan.

present rate of extermination, twelve to fourteen years will see the destruction of what now remains of the great northern band of buffalo, and the termination of the trade in robes and pemican, in so far as regards the country north of the Missouri River."*

Several western newspapers have recently given accounts of "buffaloes moving eastward." The following, in substance (here copied from the New York *Daily Graphic*, of October, 1876), has been often republished by the daily press: "The Winnepeg *Free Press* notices the arrival of immense herds of buffaloes within eighty miles of Red River, after ten years of total absence. From all accounts the herds are migrating eastward. The Sioux Indians, residing at Devil's Lake, in Dakota, have already been on a great hunt, and have returned to their homes with an abundance of buffalo-meat and numbers of robes. Travellers from the northwest, who lately came into Winnepeg, report very large numbers of buffalo very much further east than heretofore, and the Free Press urges the importance of legislation to prevent their wanton extermination."

Present Range of the Northern Herd.—From the foregoing it appears that what may be termed the great *Northern Herd* of buffaloes ranges from the principal southern tributaries of the Yellowstone northward over a large part of Montana, far into British North America, extending northward to the wooded region of the Liard, Athabasca, and Peace Rivers. To the westward, north of the United States, buffaloes still range to the base of the Rocky Mountains, though doubtless somewhat irregularly, and usually only in small numbers; while their eastern limit does not appear to extend beyond the longitude of Carlton House, or to the eastward of the one hundred and sixth meridian. They have thus, within the last thirty years, become exterminated over more than half of the more fertile portion of the region north of the United States formerly occupied by them, including the whole of the vast prairie region drained by the Assinniboine and Qu'appelle Rivers, and are now confined principally to the arid plains between the two forks of the Saskatchewan, where, as Professor Dawson believes, they cannot survive for many years longer. The extent of their range north of the North Saskatchewan seems not to have become greatly restricted since Richardson, Hearne, and Franklin visited this region; but they doubtless occur there in far smaller numbers than formerly.

GENERAL REMARKS RESPECTING THE RAPID DIMINUTION OF THE BUFFALO, AND ITS EVIDENT DESTINY OF SPEEDY TOTAL EXTERMINATION.

It thus appears that the buffalo has become so reduced in numbers, and so circumscribed in its range, that, instead of roaming over nearly half of the continent, as formerly, it is restricted to two small widely-separated areas, the southern of which embraces portions of Texas, Colorado, and Kansas, scarcely exceeding in area the smaller of these States, while the northern embraces only a larger portion of the Territory of Montana and an adjoining area to the northward of nearly equal extent. Even as late as the beginning of the present century the buffalo occupied the whole of the region between the Mississippi and the Rocky Mountains, and extended from the Rio Grande on the South to Great Slave Lake on the north, and also over a considerable area west of the Rocky Mountains, or through thirty-five degrees of latitude and

*Report on the Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel, etc., 1875, p. 296.

about twenty degrees of longitude. This immense habitat of almost a third of the continent has been reduced in three-fourths of a century to a region not larger in the aggregate than the present territories of Dakota and Montana. Over a large part of the former vast region they inhabited they were as numerous as they now are in Western Kansas or Northern Texas, and ranged at different seasons over the whole. Particular portions of this area have ever formed their favorite places of resort, where they were sure to be found at almost any season of the year. There is, for instance, abundant historic evidence that over the plains of Kansas, especially near the forks of the Platte, along the Republican, the Pawnee, the Canadian, and other tributaries of the Arkansas, they were as numerous when these parts were first visited by the early explorers as they have ever been since, and that subsequent travellers have always found them in immense numbers at all these points, the plains there literally swarming with them.

In this connection two questions naturally arise, especially in the minds of those not fully conversant with the subject: Have the buffalo really decreased to the extent these statements imply? or have they simply been driven in by the "encroachments of civilization" and concentrated upon a smaller area? Not a few otherwise intelligent persons, on visiting Western Kansas or Northern Texas and seeing the herds which there recently literally blackened the plains, at once adopt the latter hypothesis, and proclaim that this vast amount of talk about the decrease of the buffalo is all "nonsense"; that they are just as numerous as ever, and are not at all decreasing; that the extermination of the wolves and the Indians more than compensates for the slaughter made by the professional hunters and by the numerous sporting parties from the East.* The hunters often adopt the same theory, from the most evident reason of self-interest, fearing that some restrictions, which will act unfavorably upon their business, may be placed upon the wholesale and indiscriminate slaughter now carried on; yet the more candid are willing to admit that, at the present rate of destruction, the buffalo can last but a few years longer. That such is the truth is evident on a moment's reflection, when one has a full knowledge of the facts. Less than fifty years ago the buffaloes swarmed in as great—or certainly in very nearly as great—numbers as at the present time, *not only* over the regions they now frequent, but *at the same time* over the Laramie Plains, over much of the Green River Plateau, over the headwaters of the Colorado and Columbia Rivers, over the plains of the Yellowstone, and especially over the vast plains of the Red River of the North and the Grand Coteau de Missouri; throughout all of which region they have been gradually exterminated, leaving nothing to mark their former presence but their rapidly-crumbling skeletal remains and their well-worn trails. Over much of this region they have been not merely *driven out* and pressed on to some more secure retreat, but actually *exterminated*, the vast majority *being killed on the spot*, as we have seen was the case east of the Mississippi during the last quarter of the eighteenth century.

* In General Meigs's MS. notes on the buffalo, already quoted, he says: "It is a question whether the buffalo west of the Mississippi have diminished or increased in numbers to this time," and quotes General Sheridan's opinion in confirmation of this view. He says: "General Sheridan, the year after the Grand Duke of Russia hunted with him on the Kansas Pacific, told me that he thought there were probably *more buffalo that year than there had ever been before.* He had travelled through seventy miles of buffalo. He thought the killing by strychnine of wolves for the hides had saved many buffalo-calves, and the hostilities with Indians had prevented them from hunting as freely as usual for some years.

This shows with the utmost certainty what is to be the destiny of this former "monarch of the prairies," unless rigidly protected by legal restrictions, defining not only the seasons at which the animals may be killed, but also protecting the young and the bearing females. At the present time, as well as heretofore, those animals are most sought after on which the perpetuation of the race depends,—the young animals of both sexes and the cows. The older bulls are alike generally useless both to the Indian and the white hunter. The skins of cows are alone used by the Indians in furnishing themselves with robes; the young and middle-aged cows are regarded as especially desirable by the white hunters, since they afford the best meat for the market, although along with them are killed yearlings, and two- and three-year-olds of both sexes; but bulls older than five or six years are not generally desired, though many have of late years been killed merely for their hides. The hunting season being chiefly in the fall and winter, the cows are then with young, and thus two animals are killed in securing one.

Recent Destruction of the Buffalo in Kansas.—Some idea of the havoc recently made with the buffalo in Kansas can be formed from the following well-attested statements. At the time of the completion of the Atchison, Topeka, and Santa Fé Railroad to Dodge City, which occurred September 23, 1872, the principal trade of the town consisted in the "outfitting of hunters, and exchange for their game." The number of hides shipped during a period of three months, beginning with this date (September 23), is reported to have been 43,029, and the shipment of meat for the same time 1,436,290 pounds.* The forty-three thousand hides of course represent forty-three thousand dead buffaloes, and the one million and a half pounds of meat—the saddles only being saved—represent at least six or seven thousand more, making a total of at least fifty thousand killed in three months. The same authority states that the returns for the January following exceeded those of the preceding months by over *one hundred and fifty per cent.*, thus making the number of buffaloes killed merely "around Fort Dodge and the neighborhood," for this period of four months, exceed one hundred thousand! This, too, is aside from those killed in "wanton cruelty, miscalled sport, and for food for the frontier residents."

Another report of about the same date, referring to a locality about one hundred miles southeast of Fort Dodge, says: "Thousands upon thousands of buffalo hides are being brought here [Wichita, Kansas] by hunters. In places whole acres of ground are covered with their hides, spread out, with their fleshy side up, to dry. It is estimated that there are, south of the Arkansas and west of Wichita, from one to two thousand men shooting buffalo for their hides alone."† Another account‡ states that during the season of 1872–73 not less than *two hundred thousand* buffaloes were killed in Kansas merely for their hides.§ It is also stated that in 1874, on "the south fork of the Republican, upon one spot, were to be counted six thousand five hundred carcasses of buffaloes, from which the hides only had been stripped. The meat was not touched, but left to rot on the plains. At a short distance hundreds more of carcasses were discovered, and, in fact, the whole plains were dotted with the putrefying remains of buffaloes. It was estimated

***Forest and Stream*, February, 1873.

† *Wichita* (Kansas) *Eagle*.

‡ *Forest and Stream*, Oct. 15, 1873.

§ General M. C. Meigs in his MS. notes says that one hundred and eighty thousand hides are reported to have passed over the Atchison, Topeka, and Santa Fé road alone in a single season.

that there were at least two thousand hunters encamped along the plains hunting the buffalo. One party of sixteen stated that they had killed twenty-eight hundred during the past summer, the hides only being utilized." The same account says that the extent of the slaughter of the buffalo for their hides was so great that the market for them became glutted to such a degree that whereas a few years before they were worth three dollars apiece at the railroad stations, skins of bulls would now bring only a dollar, and those of cows and calves sixty and forty cents respectively.* While on the plains in 1871, I had an opportunity of witnessing some of the evidences of the wholesale slaughter of buffaloes for their hides, as practised at that time along the line of the Kansas Pacific Railway in Northwestern Kansas, where sometimes several scores and even hundreds of decaying carcasses, from which nothing but the hides had been taken, could be seen from a single point of view. During the season of 1871 meat and hides representing over twenty thousand individuals were shipped over the Kansas Pacific Railway.

Mr. W. N. Byers, editor of the "Rocky Mountain News," in referring to this wholesale slaughter (in the letter previously quoted), characterizes it as "simply inhuman and outrageous." He adds: "The slaughter-ground is mainly Kansas, reaching only into the edge of Colorado. Practised hunters follow the herds day after day, and shoot themdown by scores. Sixty, seventy, eighty or more a day is no unusual number. A good shooter will keep five or six 'skinners' at work. I heard a young man say within a week past that during the winter of 1873–74 he killed over three thousand buffaloes,—in one day eighty-five, in another sixty-four," etc.

Another writer thus refers to the same subject: "The butchery still [summer of 1875] goes on. Comparatively few buffalo are now killed, for there are comparatively few to kill. I was, in October of 1874, on a short trip to the buffalo region south of Sidney Barracks. A few buffalo were encountered, but there seemed to be more hunters than buffaloes. The country south of the South Platte is without water for many miles, and the buffaloes must satisfy their thirst at the river. The south bank was lined with hunters. Every approach of the buffaloes to water was met by rifle bullets, and one or more bit the dust. Care was taken not to permit the others to drink, for then they would not return. Tortured with thirst, the poor brutes approach again and again, always to be met by bullets, always to lose some of their number. But for the favoring protection of night the race would before now have been exterminated. In places favorable to such action, as the south bank of the Platte, a herd of buffalo has, by shooting at it by day and by lighting fires and firing guns at night, been kept from water for four days, or until it has been entirely destroyed. In many places the valley was offensive from the stench of putrefying carcasses. At the present time the southern buffalo can hardly be said to have a range. The term expresses a voluntary act, while the unfortunate animals have no volition left. They are driven from one water-hole to meet death at another. No sooner do they stop to feed than the sharp crack of a rifle warns them to change position. Every drink of water, every mouthful of grass, is at the expense of life, and the miserable animals, continually harassed, are driven into localities far from their natural haunts,—anywhere to avoid the unceasing pursuit. A few, probably some thousands, still linger about their beloved pastures in the Republican country. A few still hide in the deep cañons of the Cimarron country, but

* Baird's Annual Record of Science and Industry for 1874, p. 304.

the mass of southern buffalo now living are to be found far away from the dreaded hunter, on a belt of country extending southwest across the upper tributaries of the Canadian, across the northern end of the Staked Plain to the Pecos River. The difficulty of getting the hides to market from these remote and Indian-infested regions is some guaranty that the buffalo will not be extinct for a few years."*

These facts are sufficient to show that the present decrease of the buffalo is extremely rapid, and indicate most clearly that the period of his extinction will soon be reached, unless some strong arm is interposed in his behalf. As yet no adequate game-laws for the protection of the buffalo, either by the different States and Territories included within its range, or by the General Government, have been enacted. In a country so sparsely populated as is that ranged over by the buffalo, it might be difficult to enforce a proper law, yet the parties who prosecute the business of buffalo-hunting professionally are so well known that it would not be difficult to intercept them and bring them to justice, if found unlawfully destroying the buffalo. It is evident that restrictions should be made, not only in respect to season, but the young and the bearing females should be protected at all seasons. The Government might even set apart certain districts within which the buffalo should be constantly exempt from persecution.†

Since this memoir was originally published, the following has appeared from the pen of Mr. William Blackmore, of London, England, communicated to the London Field, Farm, and Garden, under date of October 23, 1876. Mr. Blackmore writes from ample experience in the "Buffalo country," and puts the case none too strongly. I give his communication almost entire, suppressing merely matter based on the statements of Colonel Dodge, already published in the present memoir:

EXTERMINATION OF THE BUFFALO OR AMERICAN BISON.

SIR: The interesting account of the threatened extermination of the buffalo on the North American continent contained in your last number induces me to give some further details, and to add my testimony to that of Mr. Allen as to the wanton destruction of these animals for their hides during the last few years.

In a book by Col. R. J. Dodge, of the United States Army, called "The Hunting Grounds of the Great West," now in the press, and about to be published by Messrs. Chatto and Windus, a long account of the destruction of buffaloes by professional "buffalo skinners" is given, together with a map showing the buffalo range as it existed in 1830, and as it now exists. Colonel Dodge also gives a series of carefully prepared statistics, procured by him from the railroad returns, and other authentic sources, from which it appears that the total destruction of the "Black Cattle of Illinois," during the three years 1872, 1873, and 1874, amounted to upward of four millions and a half (not between three and four millions annually, as stated by Mr. Allen‡), out of which number upward of three millions were killed for the mere sake of their hides. When in the West in 1872, I satisfied myself by personal inquiries that the number of buffaloes then being slaughtered for their pelts was at least one million per annum. This estimate was considered excessive, but the recent statistics furnished by Colonel Dodge verify its accuracy.

* Colonel Richard I. Dodge.—See *Chicago Inter-Ocean* of August 5, 1875.

† Respecting this matter the following suggestions were made in Professor Baird's "Annual Record of Science and Industry" for 1874, p. 304: "As these animals range almost entirely within the Territories of the United States, it is within the province of Congress to enact laws prohibiting their destruction, but the difficulties lie in the matter of enforcing them. Possibly some provision for seizing and confiscating the green hides, along certain lines of railway or during certain seasons of the year, as a part of the penalty to be attached to the violation of the law on the subject, might accomplish the result; but, at any rate, the subject is one that demands the prompt attention of legislators, in view of the relationship of these animals to the welfare of the Indians, and the reaction which their destruction will produce upon the scattered white settlements in the vicinity of the range of both buffaloes and Indians."

‡ This estimate refers to the destruction of the buffalo throughout *its entire range*, not simply to its destruction in Kansas, as here represented.—J. A. A.

In the autumn of 1868, while crossing the plains on the Kansas Pacific Railroad, for a distance of upward of 120 miles, between Ellsworth and Sheridan, we passed through an almost unbroken herd of buffalo. The plains were blackened with them, and more than once the train had to stop to allow the unusually large herds to pass. Standing on the crest of a low hill near Monument Station at sunset, on a fine day in October, from whence I could see around me in all directions for a distance of from ten to twenty miles, there was nothing but herds of buffalo in sight; so far as I could see with a powerful opera-glass, nothing but Indian cattle were visible, quietly browsing in small groups of from twenty to fifty each. A few years afterward, when travelling over the same line of railroad, it was a rare sight to see a few herds of from ten to twenty buffalo. A like result took place still further southward, namely, between the Arkansas and Cimmaron Rivers. In 1872, while on a scout for about 100 miles south of Fort Dodge into the Indian Territory, we were never out of sight of buffalo. In the following autumn, on travelling over the same district, while the whole country was whitened with bleached and bleaching bones, we did not meet with buffalo until we were well into the Indian Territory, and then only in scanty bands. During this autumn, when riding for a distance of from thirty to forty miles along the north bank of the Arkansas River to the east of Fort Dodge, there was a continuous line of putrescent carcasses, so that the air was rendered pestilential and offensive to the last degree. The hunters had formed a line of camps along the banks of the river, and had shot down the buffalo night and morning as they came to drink. In order to give an idea of the number of these carcasses, it is only necessary to mention that I counted sixty-seven on one spot not covering four acres.

Colonel Dodge gives an instance of having himself counted 112 carcasses inside a semicircle of 200 yards radius, all of which were killed by one man from the same spot, and in less than three-quarters of an hour. The greatest number of buffalo killed from one stand by one man was 133. In a conversation I had at Dodge City with one of the leading buffalo-hunters, who was the proprietor of one of the best "skinning outfits" in Kansas, he told me that he usually killed only about eighty per day, as he found that his three men could not well skin more; and, in reply to my inquiry as to the largest number he had ever shot from one stand, he gave me the above figures, adding that he had frequently killed all that he wanted for the day's skinning from one stand.

This great loss of good and wholesome animal food, all of which, with a little judgment and foresight, and by imposing reasonable restrictions on the slaughter of this game, could have been utilized, will be better understood by reference to the statistics of cattle in other countries. On reference to the official agricultural returns of Great Britain, the United Kingdom, British Possessions, and foreign countries, it will be seen that the wanton and wasteful slaughter for the three years in question (and in making the comparison I am keeping to the illegitimate slaughter for hides, and not legitimate slaughter for food) swept away more buffaloes than there are cattle in Holland and Belgium, or three-fourths of the cattle in Ireland, or one-half of the cattle of Great Britain.

The result, therefore, would be the same as if a fearful murrain in one year had destroyed the whole of the cattle in Holland and Belgium, or in the same time if either three-fourths of the cattle of Ireland or one-half of those of Great Britain had been swept away by a plague as great as that of Egypt.

The citizens of the United States will better realize this great waste if they consider that this destruction amounted annually to nearly three times the number of the annual drives of cattle from Texas, which range from 350,000 to 500,000 head per annum, or that it would have been the same during the three years as if all the cattle in Canada or half of those in Texas had been carried off by some dire disease.

The mere loss of food, however, is not the only evil which has resulted from this wastefulness and wantonness. Many of the wild Indians of the plains, deprived of their ordinary sustenance, Government rations not being forthcoming, and driven to desperation, have taken to the war-path, so that during the present war many of the Cheyennes, and some of the young braves from the friendly Red Cloud and Spotted Tail agencies, have left their reservations and joined the hostile Sioux under Sitting Bull. The hardy settler and pioneer of the plains, who always looked to the buffalo for his winter supply of meat, has been deprived of this resource, and complains as bitterly as any of this slaughter for pelts.

In 1873, when the settlers in Kansas were suffering from the destruction of their crops by the ravages of the grasshoppers, troops were considerately sent by the Government to the Republican to kill meat for the starving families. When the soldiers arrived, however, at their hunting-grounds there was but little meat for them to kill, as the "buffalo-skinners" had anticipated them, and had slaughtered nearly every buffalo in the district.

The necessity, as suggested by Mr. Allen, for protection of the buffalo by legislation is self-apparent. With the great economy endeavored to be introduced into each department of the Government of the United States, it is difficult to understand how the

Executive, while they enforce a heavy tax upon each seal which may be killed in Alaska, has neglected to avail themselves of such a fruitful source of revenue as that which might be derived from buffalo pelts. A tax of $5 on each skin,* which could have been easily imposed and collected—under heavy penalties and forfeiture of all skins not having the Government dutys-tamp thereon—would realize not less than $1,000,000 per annum, even supposing that the number of buffaloes annually killed for their skins were only 200,000 in lieu of upward of a million. The number slaughtered for their skins, with a tax on each skin of $5, would, during the three years in question, have produced a gross revenue of $15,000,000, or nearly £3,000,000 sterling.

I suggested this remedy at the time, but, although referred to by the press, it was not attended to, and it is now almost too late. It is of little use to "lock the stable-door after the steed has been stolen."

The evils to the citizens of the United States arising from this wholesale and wanton destruction of buffalo during the three years referred to may be summarized as follows:

1. Loss of the good and nutritious meat of upward of 3,000,000 of buffalo.
2. Loss of revenue to the United States of $15,000,000, assuming that a reasonable tax of $5 had been imposed on each pelt.
3. Principal Indian tribes on the plains being deprived of their annual supply of food for the winter, and only receiving short rations on their reservations, driven on the war-path.
4. Cost of Indian wars in the lives of the citizens of the United States and money.
5. Pioneer settlers deprived of their supply of winter food. Prior to 1870 the western settlers, from Eastern Kansas to the base of the Rocky Mountains, looked to the buffalo as their winter store-house.

* * * * * * *

HISTORICAL AND STATISTICAL REMARKS RESPECTING THE DESTRUCTION AND RECKLESS WASTE OF THE BUFFALO.

In addition to the statistics already given relating to the recent destruction of the buffalo in Kansas, it seems fitting in this connection to here append such additional statistical data as can be conveniently gathered concerning its destruction at large, together with a few remarks in respect to the causes and motives that have led to such a waste of life, and the agencies that have effected it.

The excitement of the chase, as is well known, seems almost universally to beget a spirit of wanton destructiveness of animal life. Wherever civilized man has met with the larger mammalia in abundance, as has often happened in the experience of explorers and pioneer settlers of newly discovered countries, the temptation to slaughter for the mere sake of killing seems rarely to be resisted. In the case of the carnivorous species an exterminating persecution is often pardonable, and to some extent necessary. The fur-bearing species, even when hunted to excess, are seldom destroyed wantonly, though often imprudently, the trapper blindly considering only his immediate profits. In the case of the harmless herbivorous species, the ungulates especially, self-interest, it would seem, would prompt an economical treatment of the game in newly settled districts. But the history of America shows that no such principle has here been regarded, where other animals than the buffalo—as the elk, moose, deer, prong-horn, and mountain sheep—have been slaughtered with the utmost recklessness. When stress of weather, for instance, or other circumstances, have brought these animals within the hunter's power, scores and even hundreds have often been killed by single parties already so well supplied with the products of the chase that they had no need for and could make no use of the animals thus destroyed.

* This would, perhaps, be an advisable expedient, but would not result in an extensive revenue to the Government, as, if rigidly enforced, it would amount to practical prohibition, as the hides taken by the "skinners" rarely bring more than $3 each, and *net* them very much less. It would none the less afford thorough protection to the buffalo were the enforcement of such a provision practicable.—J. A. A.

The buffaloes, from their great numbers and the little tact required in their capture, have probably been the victims of indiscriminate, improvident, and wanton slaughter to a greater extent than any other North American animal. As already stated, thousands are still killed annually merely for so-called "sport," no use whatever being made of them; thousands of others of which only the tongue or other slight morsel is saved; hundreds of thousands of others for their hides, which yield the hunter but little more than enough to pay him for the trouble of taking and selling them; while many more, though escaping from their would-be captors, die of their wounds and yield no return whatever to their murderers.* Of the hundreds of thousands that for the last few years have annually been killed, probably less than a fourth have been to any great extent utilized. While this wanton and careless waste has ever characterized the contact of the white race with the sluggish and inoffensive bison of our plains and prairies, the Indians have likewise been improvident in their slaughter of this animal, often killing hundreds or thousands more during their grand annual hunts than they could possibly use, or from which they saved merely the tongues. The wolves were formerly also a great check upon the increase of the buffalo, but the hunters by means of poison have reduced their number much more rapidly than even that of the buffalo, so that the influence of the wolves in hastening the extirpation of the buffalo is now but slight. The Indians, too, have vanished before the western advance of the white man more rapidly even than the buffalo, so that the destruction of the buffalo by the Indians is now relatively far less than formerly. Hence the opinion, as stated in the preceding pages, has been advanced, and to some extent publicly advocated, that the present rate of the decrease of the buffalo is actually less than formerly, notwithstanding the vast numbers annually killed by white hunters, in consequence of the greatly reduced numbers of the wolves and the Indians. A slight glance at the history of the decline of the buffalo, however, is sufficient to at once indicate the fallacy of such an opinion; and none are better aware of this than the most active participators in their destruction,—the professional buffalo-hunters themselves,—many of whom are candid enough to admit that, through the almost utter extermination of the buffalo, their present occupation will soon pass away, unless the general or local governments enforce the most peremptory restrictions upon their slaughter.

The Indians, prior to the discovery of the continent by Europeans, appear not to have seriously affected the number of buffaloes, their natural increase equalling the number destroyed both by the Indians and the wolves. When the Jesuit missionaries penetrated the range of the buffalo east of the Mississippi, in the seventeenth century, they found this animal the main subsistence of the Indian tribes, as it doubtless had been for centuries, its flesh serving them for food, its skins for shields, clothing, and tents, and its hair, wool, horns, hoofs, and bones for various articles of ornament and use. No sooner, however, had Europeans made settlements within its range, than the buffaloes began to disappear, and were either wholly destroyed or driven from their favorite haunts in the short space of a very few years. The destruction increased with the increase of the white population till they

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* Professional buffalo-hunters of the Kansas plains repeatedly assured me that they believe that an average of not more than one in three of the buffaloes killed by them were secured and made use of. From extended observations, however, I felt convinced that this was quite too high an estimate of the proportion unrecovered of those killed. Yet the waste is actually enormous, even in the contingencies of hunting for legitimate purposes, namely, for frontier consumption and shipment to Eastern markets.

were totally exterminated east of the Mississippi (at least, south of the present State of Minnesota), as already shown, prior to the beginning of the nineteenth century. Even as late as fifty years ago they occupied a considerable area west of the Rocky Mountains, all the extensive parks and valleys within these mountains, and all the vast plains and prairies between them and the Mississippi River. The fur-hunters and trappers appear to have begun at this date to contribute appreciably toward their rapid diminution, but not until the establishment of the "overland trails," and the constant passing of large emigrant parties across the plains, did their numbers here become very greatly diminished. Steadily pressed back on their eastern boundary by advancing settlements, they were at the same time rapidly thinned along the line of the great emigrant routes. These thoroughfares becoming from year to year more numerously travelled, especially the more northern route by way of the South Pass, the buffaloes were driven to the right and left of the line of travel, till finally by this intersection their range was divided into two essentially distinct regions. The construction of the Union Pacific Railroad completely severed the northern from the southern herds, while the Kansas Pacific and the Atchison, Topeka, and Santa Fé Roads opened up new highways to their most populous holds. In the mean time adventurers and miners either gradually exterminated them in the parks and valleys of the mountains, or drove them eastward into the plains, while they were at the same time preyed upon by the great buffalo-hunting parties from the Red River Settlements and the United States, until they have dwindled to a few hard-pressed bands lingering chiefly in the least-frequented parts of their formerly almost undisturbed haunts.

A century ago the rapid extermination of the buffalo had begun to attract the attention of travellers, Romans, as early as 1776, alluding to the wanton destruction of "this excellent beast, *for the sake of perhaps his tongue only*."* As early as 1820 Major Long thought it highly desirable that some law should be enforced for the preservation of the bison from wanton destruction by the white hunters, who, he said, were accustomed to attack large herds, and from *mere wantonness* slaughter as many as they were able and leave the carcasses to be devoured by the wolves and birds of prey.†

Gregg, in 1835, also alludes to the wanton slaughter of these animals by travellers and hunters, and the still greater havoc made among them by the Indians, who often kill them merely for their skins and tongues. Their total annihilation he regarded as only a question of time, although he believed that if they were only killed for food, their natural increase would perhaps replenish the loss.‡ Almost every intelligent traveller who has crossed the plains or spent much time in the buffalo country has also called attention to this exterminating slaughter, and predicted their complete annihilation at no very distant date. Some writers believed twenty or thirty years ago that they would hardly survive to the present time unless protected by the government.

Dr. Leidy, in 1852, says: "The day is not far distant when it [the buffalo] will become quite extinct, unless protected by a munificent republic, as has been done by the Emperor of Russia in the case of the aurochs, or European bison."§ Professor Baird, writing at about the same time, says: "Still, vast as these herds are, their numbers are much

* Natural History of Florida, p. 174.
† Long's Expedition, Vol. I, p. 482.
‡ Commerce of the Prairies, Vol. II, p. 213.
§ Mem. Extinct Species of American Ox, p. 4 (Smith. Contrib., Vol. V, Art. iii.)

less than in earlier times, and they are diminishing with fearful rapidity. Every year sees more or less change in this respect, as well as alterations of their great line of travel. . . . . If it were possible to enforce game-laws, or any other laws on the prairies, it would be well to attach the most stringent penalties against the barbarous practice of killing buffalo merely for the sport, or perhaps for the tongues alone. Thousands are killed every year in this way. After all, however, it is perhaps the Indian himself who commits the mischief most wantonly."*

General W. F. Raynolds, in his report of his Exploration of the Yellowstone in 1859 and 1860, thus refers to this matter:† "And here I would remark, that the wholesale destruction of the buffalo is a matter that should receive the attention of the proper authorities. It is due to the fact that the skin of the *female* is alone valuable for robes. The skin of the male over three years old is never used for that purpose, the hair on the hind quarters being not longer than that on a horse, while on the fore quarters it has a length of from four to six inches. The skin is also too thick and heavy to be used for anything but lodge coverings, while the flesh is coarse and unpalatable, and is never used for food when any other can be had. The result is that the females are always singled out by the hunter, and consequently the males in a herd always exceed the females, in the proportion of ten to one. Another, but far less important cause of their extinction is the immense number of wolves in the country, which destroy the young. The only remedy that would have the slightest effect in the case would be a prohibition of the trade of buffalo-robes, and a premium upon wolf-skins. I fear it is too late for even this remedy, and notwithstanding the immense herds that are yet to be found, I think it is more than probable that another generation will witness almost the entire extinction of this noble animal."

During the fifteen years that have passed since this was written, the wolves have in a great measure been exterminated over much of the buffalo range, but something far more fatal to the buffalo than anything then known—the railroad—has penetrated its range, and while the females and the young are still slaughtered with the same recklessness as before, the old bulls have of late been hunted with almost equal eagerness.

Statistics relating to the Destruction of the Buffalo, based principally on the Trade in Robes.—Frémont, in 1845, published some statistics furnished him by Mr. Sanford, a partner of the American Fur Company, respecting the number of robes annually obtained from the Indians by the different fur companies. The average return for the preceding eight or ten years is given as ninety thousand annually. "In the Northwest," says Mr. Sanford, "the Hudson's Bay Company purchase from the Indians but a very small number—their market being Canada, to which the cost of transportation nearly equals the produce of the furs; and it is only within a very recent period that they have received buffalo-robes in trade; and out of the great number of buffalo annually killed throughout the extensive regions inhabited by the Camanches and other kindred tribes [Texas, the Indian Territory, and Kansas] no robes whatever are furnished for trade. During only four months of the year (from November until March) the skins are good for dressing; those obtained in the remaining eight months being valueless to traders; and the hides of bulls are never taken off or dressed as robes at any season. Probably not more than one-third of the skins are taken from the animals killed, even when they are in good season, the labor of preparing and

* Pat. Off. Rep., Agricult., 1851-'52, Part II, p. 125.
† Exploration of the Yellowstone, p. 11, published in 1868.

dressing the robes being very great; and it is seldom that a lodge trades more than twenty skins in a year. It is during the summer months, and in the early part of autumn, that the greatest number of buffalo are killed, and yet at this time a skin is never taken for the purpose of trade."*

Besides the number of robes traded by the Indians, as many or a greater number were at this time annually used by the Indians themselves. This would make, at a moderate estimate, the annual number of about two hundred thousand robes, which represent, according to the competent authority above cited, only *one-third* of the buffaloes killed during about *one-third of the year*, and during that part of the year, too, when the smallest number are destroyed. Taking the above data as a basis for an estimate, the whole number killed annually by the Indians must have equalled eighteen hundred thousand (1,800,000). Allowing a slight addition for the relatively greater number killed during the warmer parts of the year, we have, in round numbers, the startling total of about two millions as the average annual number destroyed by only those tribes of Indians who were accustomed to collect robes for the market. These embraced only a small portion of the tribes living within or on the borders of the great buffalo range; so that probably two millions a year is much less than half the number killed at this time by the Indians alone. Besides this, travellers and white hunters killed annually hundreds of thousands more. When we consider that this enormous destruction continued for several decades, we need no longer be surprised at the rapid numerical decrease of the buffalo that has marked the last forty or fifty years of his history.

In 1852 Professor Baird wrote: "Mr. Picotte, an experienced partner of the American Fur Company, estimated the number of buffalo-robes sent to Saint Louis in 1850 at one hundred thousand. Supposing each of the sixty thousand Indians on the Missouri to use ten robes for his wearing apparel every year, beside those for new lodges and other purposes, by the calculation of Mr. Picotte, we shall have an aggregate of four hundred thousand [*sic*] robes [seven hundred thousand?]. We may suppose one hundred thousand as the number killed wantonly or destroyed by fire or other casualties, and we will have the grand total of half a million [eight hundred thousand?] of buffalo destroyed every year. This, too, does not include the numbers slaughtered on Red River and other gathering points." † In this estimate the important fact is overlooked that the robes are all taken during three months of the year, at a season, too, when the smallest number are killed, and that only about one-third of those killed during these three months are utilized for robes. If this number should be multiplied by nine, as it evidently must be from the above-quoted statements of Mr. Sanford, and which from general considerations also seems probable, we should have the immense total of from five to seven millions as the number killed yearly by the Indians who furnished the one hundred thousand robes for the Saint Louis market! Ten robes, however, seems to be a large number to be used annually by each person. If we reduce the number to three, we shall still have an annual aggregate of nearly three and a half millions as the number destroyed by the Upper Missouri tribes alone. South of this region there were at this time upward of forty thousand Indians belonging to other tribes living within the range of the buffalo, beside the numerous populous tribes inhabiting the buffalo range north of the United States. The number that must have been

* Frémont's First and Second Expeditions, p. 145.
† Pat. Off. Rep., Agricult., 1851-52, Part II, p. 125.

killed each year by all these tribes together is a startling sum to contemplate.

In 1854 the Hon. H. H. Sibley, in his paper on the buffalo contained in Schoolcraft's "History, Condition, and Prospects of the Indian Tribes of the United States," gives a later estimate of their annual destruction in the Missouri region. He says: "From data which, although not mathematically correct, are sufficiently so to enable us to arrive at conclusions approximating the truth, it has been estimated that for each buffalo-robe transported from the Indian country, at least five animals* are destroyed. If it be borne in mind that very few robes are manufactured of the hides of buffalo except such as, in hunters' parlance, are killed when they are in season, that is during the months of November, December, and January, and that even of these a large proportion are not used for that purpose, and also that the skins of the cows are principally converted into robes, those of the males being too thick and heavy to be easily reduced by the ordinary process of scraping, together with the fact that many thousands are annually destroyed through sheer wantonness, by civilized as well as savage men, it will be found that the foregoing estimate is a moderate one. From the Missouri region the number of robes received varies from forty thousand to one hundred thousand, so that from a quarter to half a million of buffaloes are destroyed in the period of each twelvemonth."†

From the preceding remarks it is evident that Mr. Sibley's estimate is far below the truth. Since as many robes are doubtless used by the Indians themselves as they sell, this number must include not more than half of the robes taken during only three or four months of the year. Hence instead of one-fourth to half a million representing the number annually killed at this date in the Missouri region, probably a million to a million and a half would be a much nearer estimate.

In June, 1873, I met at Fort Abraham Lincoln, Dakota Territory, Mr. F. F. Gerard, the well-known Cree interpreter, whose twenty-five years' experience in the Upper Missouri country, nearly every part of which he had visited, together with his having been formerly an agent of the American Fur Company, had given him much valuable information respecting not only the fur trade but the former range and the recent great decrease in numbers of many of the larger mammals of that region. From him I learned that in 1857 the trade in buffalo-robes at the principal posts on the Upper Missouri was about as follows: At Fort Benton, the number received amounted to 3,600 bales, or 36,000 robes; at Fort Union, 2,700 to 3,000 bales, or about 30,000 robes. At Forts Clarke and Berthoud, 500 bales at each post, or about 10,000 robes; at Fort Pierre, 1,900 bales, or 19,000 robes; giving a total for one year of about 75,000 robes, which he informed me was about the annual average at that period. Allowing that the Indians retained only as many more for their own use, and estimating as before that one robe represents the destruction of three buffaloes, gives four hundred and fifty thousand as the number killed by a portion only of the Upper Missouri Indians in one-third of a year, or over a million and a third annually. To this number, as already noticed, must be added the number killed by the Indians to the northward and southward of this region, as well as the great numbers destroyed by the Red River half-breeds and by white men.

Respecting the number killed by the Red River hunters, I have met

* Evidently quite too low an estimate.

† Schoolcraft's History, Condition, and Prospects of the Indian Tribes of the United States, Vol. IV, p. 94.

with no satisfactory statistics, but that it must have been immense is evident from the number of persons engaged in their hunting expeditions. Mr. Ross, in his history of the Red River Settlement, states that the number of carts assembled for the first trip in 1820 was five hundred and forty. Subsequently the number regularly increased to one thousand two hundred and ten in 1840. In his description of the hunt of this year, he states that the number of hunters engaged was six hundred and twenty for two months, who were accompanied by six hundred and fifty women, and three hundred and sixty boys and girls, the party numbering altogether sixteen hundred and thirty souls. The party was armed with seven hundred and forty guns, and had with them eleven hundred and fifty-eight horses and five hundred and eighty-six draught oxen, with other equipments in proportion. During the first day of the hunt no less than thirteen hundred and seventy-five buffalo-tongues were brought into camp, and during the first two races not less than twenty-five hundred animals were killed. Of these he estimates that less than one-third were properly utilized, as he considers that seven hundred and fifty animals, making all due allowance for waste, would have been ample for the amount of pemmican and dried meat saved from them. The rest, he says, was wasted; "and this," he adds, "is only a fair example of the manner in which the plain business is carried on under the present system. Scarcely one-third in number of the animals killed are turned to account."*

Dr. Hayden, in 1861, says that as near as he could determine, about one hundred thousand robes were then annually made by the Indians of the Upper Missouri country.† Dr. Hayden also states that at this period the bulls outnumbered the cows ten to one; which personal experience led me to think was a fair estimate of the proportion of the sexes in 1871 on the plains of Kansas.

Through the kindness of E. T. Bowen, Esq., General Superintendent of the Kansas Pacific Railway, I have obtained a statement of the "estimated shipments of buffalo products over the Kansas Pacific Railway during the year 1871." This estimate, carefully prepared by the Auditor of the Company, is as follows: Dry hides, three hundred and forty-one thousand one hundred and fifty-one (341,151) pounds, estimated at twenty-five pounds per hide, and thus representing thirteen thousand six hundred and forty-six (13,646) buffaloes; eleven hundred and sixty-one thousand four hundred and nineteen (1,161,419) pounds of meat, estimated at two hundred pounds per saddle, and thus representing five thousand eight hundred and seven (5,807) buffaloes. No return is here made of the large amount of salted and cured meat also sent to Eastern markets. The somewhat less than six thousand "saddles" represented by the above statement must, it appears to me, be far below the actual number, as one hunter informed me that he had himself alone killed over three thousand buffaloes a year for several years, and I met other persons who claimed to have each killed an equal number. These statistics would alone indicate a slaughter of at least twenty thousand buffaloes along the line of the Kansas Pacific Railway during the year 1871, to which must be added other thousands killed by travellers and amateur hunters, and by the officers and soldiers stationed at the different military posts in the same region.

I have been unable to obtain statistics of the shipment of buffalo products over this road since 1871, as such information, writes the

* Ross (Alexander), The Red River Settlement; its Rise, Progress, and Present State, pp. 242–265.

† Trans. Am. Phil. Soc., New Series, Vol. XII, p. 151.

present Superintendent of the road, is not in available shape, and to obtain it would involve considerable expense. There has, however, been a great falling off in the annual amounts shipped since that date, in consequence of the great decrease of the buffalo throughout the region which this road passes.

Respecting the quantity of the products of the buffalo shipped over the Atchison, Topeka, and Santa Fé Railroad during the years 1872, 1873, and 1874, I have been favored with the following statement by the General Superintendent, Mr. C. F. Morse:

Statement of Buffalo Products shipped over the Atchison, Topeka, and Santa Fé Railroad during a period of three years, from 1872 to 1875.

Hides, in 1872	165,721
" in 1873	251,443
" in 1874	42,289
Robes, in 1872	No account.
" in 1873	" "
" in 1874	18,489
Meat, in 1872	No account.
" in 1873	1,617,600 lbs.
" in 1874	632,800 "
Bones, in 1872	1,135,300 lbs.
" in 1873	2,743,100 "
" in 1874	6,914,900 "

From the above statement it appears that the number of hides shipped over this road during a period of three years was nearly half a million, while the robes, of which the number shipped in a single year only is given, would make the number exceed this sum. In addition to this number we have to add, for the number of buffaloes utilized or sold as meat, only the small number of from three to eight thousand a year more!

In answer to inquiries respecting the shipment of buffalo products over the Union Pacific Railroad, I have been kindly informed by Mr. E. P. Vining, General Freight Agent, that no large amount of buffalo products has been received by this road, and that consequently no statistics of the business have been kept, as is the case with all the important branches of their business. These statistics respecting the shipments over the railroads relate only to the Kansas range of the buffalo, and hence refer merely to a limited district, and to the slaughter by white hunters alone.

In respect to the recent destruction of the buffalo north of the United States, Mr. J. W. Taylor, United States Consul at Winnipeg, B. N. A., whose valuable communication on the buffalo has been previously quoted, informs me that about eighteen thousand robes were sent to the Minnesota market from the Saskatchewan district alone during the year ending September 30, 1872, while as many more were either consumed in the country or sent to Europe by the way of York Factory, or about forty thousand in all. By far the larger part of the buffaloes killed in the Saskatchewan district, however, are converted into pemmican and dried meat, and being killed in summer, do not enter at all into the above statement made by Mr. Taylor. From these data it is evident that the destruction of the buffalo in the Saskatchewan region in 1872 must have amounted to considerably more than a million, and these mainly cows.

In forming a general estimate of the annual destruction of the buffalo in recent years, it is necessary to add to the large sums already given the large number killed by the different Indian tribes still residing in or near the ranges of the two herds, as well as the thousands killed for frontier consumption, and the many thousands more of which no use is made. Even approximate data for the last-named elements of the problem of course do not exist, but the total killed between 1870 and 1875 cannot have been less than about two and a half millions annually. The effect of this destruction upon the already terribly thinned herds has been most marked, and if continued at a proportional rate will unquestionably in a few years exterminate the race.

2.—PRODUCTS OF THE BUFFALO.

The flesh of the buffalo is, of course, its most important product, either to the white man or the Indian. It has not only always formed a large part of the food of the Indian tribes living within its range, but has also proved hardly less important to the whites during their first exploration of the country it inhabited. The various military and other surveys of the great central plateau of the continent, as well as the numerous private expeditions to the same region, could have been accomplished only at greatly increased expense and privation had not the buffalo supplied to the persons engaged in these enterprises a never-failing and ready means of subsistence.

The buffaloes, in common with deer and elks, have also often been invaluable to the pioneer settler, insuring him food during the first few years at least of his frontier life. As already noticed, Boone and his party subsisted almost wholly during their first winter in Kentucky on the flesh of this animal, and throughout the prairie portions of the country, from Illinois westward to the Rocky Mountains, the buffalo has subserved a most important purpose in the westward progress of civilization. The vast influx of settlers that follows the opening of new railroads across the Plains, such as that which still sets into the valley of the Arkansas along the line of the Atchison, Topeka, and Santa Fé Railroad, thus find a sure subsistence until they can open up and improve their farms; and, as one writer has remarked, "by the time the last buffalo has disappeared from Kansas, the frontier will be subdued to civilization and be self-supporting."

From lack of speedy and cheap means of transportation the consumption of buffalo meat was, until recently, necessarily limited to the people living near or within its actual range, and to parties traversing the country it inhabited. Upon the opening of the Kansas railways, however, many car-loads, as already shown by the above-given statistics, were shipped during winter to the Eastern cities. While Chicago, St. Louis, Cincinnati, and the other larger cities of the Mississippi Valley formed the principal markets for its sale, it was also sent in large quantities to Boston, New York, Philadelphia, Baltimore, and the other chief cities of the East.* When arriving in good condition, as was

*As already noticed, upward of one million pounds were shipped, as saddles, over the Kansas Pacific Railway during the winter of 1871–72, besides hundreds of barrels of tongues and cured "hams" during the same period. Since that time the shipments over this road have greatly diminished, but the reduction was for a year or two more than balanced by the additional shipments over the Atchison, Topeka, and Santa Fé road, which in 1873 were over one and a half million (1,617,600) pounds. In 1874, however, the shipment was less than half this amount, there having been already a marked decline in the amount of buffalo products transported over this road also.

usually the case, it rivals beef and venison in cheapness if not in quality, besides having the special feature of novelty.

The meat of the buffalo is often spoken of as being dry and tough, and far inferior in quality to beef. This is in a measure true, the flesh of middle-aged and elderly bulls being of this character, that of old bulls being eaten only when none other can be obtained. The flesh of a young fat cow, or of a yearling or two-year-old bull, however, is not surpassed by the finest beef, from which it cannot usually be distinguished. During some two months spent on the Kansas plains in 1871–72, I ate it daily, and would never ask for, as indeed I have never tasted, finer beef than the buffalo meat, which was almost exclusively used. Often at the hotel in Hays City, as well as at other public tables in the buffalo country, have I heard the beef praised by Eastern travellers, who frequently expressed their surprise at the excellent quality of this article set before them. Often, too, in the same connection, our Eastern traveller would ask about buffalo meat, whether it was fit to eat, whether it was much used for food, and whether he would be likely to get a chance to taste it in his journey across the plains. When told that he had just partaken of it, that it was buffalo beef which he had been praising, and that it was the staple meat of the table throughout the buffalo country, at the hotels and restaurants as well as in the hunter's camp, his surprise amounted almost to incredulity, which only the strongest assurances would remove. The age and condition of the animal, as already stated, have much to do with the quality of the meat, and a more miserable semblance of food could hardly be set before one than a steak cut from one of the old "lords of the prairie."

The tongue of even an old bull is always regarded as a delicate morsel, and is often saved when no other part of the animal is touched. The hump is generally considered to be next in delicacy and tenderness. A few hunters killed buffaloes during the autumn months for the purpose of curing the meat. The best pieces only, from young and tender animals, were selected, and, when properly cured, were fully equal to the best dried and smoked beef found in the Eastern markets. A single hunter at Hays City shipped annually for some years several hundred barrels thus prepared, which the consumers probably bought for ordinary beef.*

Further northward, on the plains of the Saskatchewan, Assinniboine, Red River, and Upper Missouri, large quantities of the meat were formerly made into pemmican. In this form it proves invaluable to the Northern *voyageurs* and trappers, of whose commissariat it formed the chief resource. Hind states that the Hudson's Bay Company formerly obtained from the Plain Crees, the Assinniboines, and the Ojibways, pemmican and dried meat to supply the brigades of boats in their expeditions to York Factory, on Hudson's Bay, and throughout the interior.*

Pemmican, though made sometimes from the meat of other animals, as deer, elk, moose, mountain-sheep, and reindeer, is prepared principally from the buffalo. It is put up in bags of from ninety to one hundred and ten pounds' weight (according to different authorities), and

* Dr. Richardson's testimony respecting the quality of bison meat is as follows: "The flesh of the bison, in good condition, is very juicy and well flavored, much resembling that of well-fed beef. The tongue is deemed a delicacy, and may be cured so as to surpass in flavor the tongue of an English cow. The hump of flesh covering the long spinous processes of the first dorsal vertebræ is much esteemed. It .... has a fine grain, and when salted and cut transversely, it is almost as rich and tender as the tongue."—*Fauna Boreali-Americana*, Vol. I, p. 282.

† Narrative of the Canadian Exploring Expedition, Vol. I, p. 311.

consists of nearly equal parts, by weight, of pounded dried meat and tallow. The method of its preparation has been repeatedly described by different Northern travellers,* whose accounts differ somewhat in respect to the details, as they do in respect to its flavor and desirability as an article of food. The Earl of Southesk † speaks of it as scarcely endurable, and Captain Butler says that, when prepared in the best form, it "can be eaten, provided the appetite be sharp and there is nothing else to be had,—this last consideration is, however, of importance." ‡ It proves, however, to be exceedingly nutritious, and is the favorite food of the Indians and the half-breed *voyageurs*, and was formerly so extensively used in the Red River Settlement that the supply was never adequate to the demand.§ According to Mr. Sibley's account, as furnished him by the Rev. Mr. Belcourt,|| a Catholic priest residing among the Red River half-breeds, the dried meat and the pemmican are prepared by these people as follows:

"The meat, when taken to the camp, is cut by the women into long strips, about a quarter of an inch thick, which are hung upon the lattice-work prepared for that purpose, to dry. This lattice-work is formed by small pieces of wood placed horizontally, transversely, and equidistant from each other, not unlike an immense gridiron, and is supported by wooden uprights (trépieds). In a few days the meat is thoroughly desiccated, when it is bent into proper lengths, and tied in bundles of sixty or seventy pounds' weight. This is called dried meat (viande séche). Other portions, which are destined to be made into *pimikehigan*, or pemican, are exposed to an ardent heat, and thus become brittle and easily reducible to small particles by the use of a flail; the buffalo-hide answering the purpose of a threshing-floor. The fat, or tallow, being cut up and melted in large kettles of sheet-iron, is poured upon this pounded meat, and the whole mass is worked together with shovels until it is well amalgamated, when it is pressed, still warm, into bags made of buffalo-skin, which are strongly sewed up, and the mixture gradually cools and becomes almost as hard as a rock. If the fat used in the process is taken from the parts containing the udder, the meat is called *fine pemican*. In some cases dried fruits, such as the prairie-pear and cherry, are intermixed, which make what is called *seed pemican*. The lovers of good eating judge the first described to be very palatable, the second better, and the third excellent. A taurean of pemican weighs from one hundred to one hundred and ten pounds. Some idea may be formed of the immense destruction of buffalo by these people when it is stated that a whole cow yields one-half a bag of pemican, and three-fourths of a bundle of dried meat; so that the most economical calculate that from eight to ten cows are required for the load of a single vehicle."¶

The same account says that "the men break the bones, which are boiled in water to extract the marrow to be used for frying and for other culinary purposes. The oil is then poured into the bladder of the animal, which contains when filled about twelve pounds, being the yield

* See Ross, Red River Settlement, pp. 262–264; Sibley, in Schoolcraft's History, Condition, and Prospects of the Indian Tribes, Part IV, p. 107; Hind, Canadian Exploring Expedition, Vol. I, p. 312, Butler, The Great Lone Land, p. 153, &c.

† Saskatchewan and the Rocky Mountains, p. 302.

‡ The Great Lone Land, p. 134.

§ Ross, Red River Settlement, p. 165.

|| Mr. Belcourt's account appears to have been previously communicated to Major S. Woods, by whom it was published in the original French as early as 1849, in his report of his Expedition to the Pembina Settlements. See Congress. Rep., 31st Congress, 1st Session, House Ex. Doc., Vol. VIII, No. 54, pp. 44–52.

¶ Schoolcraft's History, Condition, and Prospects of the Indian Tribes, Part IV, p. 107.

of the marrow-bones of two buffaloes."* Ross states that "a bull in good condition will yield forty-five pounds of clean rendered tallow," and that cows when in good order yield on an average about thirty-five pounds.†

Prior to the time of railroad communication with the Plains, however, the most important commercial product of the buffalo was its robes. For many years, as evident from the statistics already given, not less than one hundred thousand robes were annually purchased of the Indians, a considerable portion of which found their way to European markets. In recent years there has been a marked decline in the production of robes, owing in part to the rapid extirpation of the buffalo, but more especially to the great depopulation, through wars and contagious diseases, of the Indian tribes of the Plains, by whom most of the robes have hitherto been prepared. A few are still gathered in the United States by the Indian traders, and of late white hunters have turned their attention to their preservation. Thus in the above-given returns of the shipment of buffalo products over the Atchison, Topeka, and Santa Fé Railroad occurs the item of eighteen thousand four hundred and eighty-nine robes in the statement for the year 1874.

To the Indians of the Plains the buffalo has not only ever been an unfailing source of food,—whose flesh, Catlin states,‡ they prefer to that of the antelope, deer, or elk,—but has also furnished them, to a great extent, with shelter and clothing; the heavier, coarser skins of the bulls being used as lodge-coverings, and those of the cows for beds and clothing.

According to the Jesuit missionaries, the women of the Illinois Indians used to employ the hair of the buffalo in making bands, belts, and sacks; and these and other tribes used also to make shields of the hides, and spoons, ladles, etc., from the horns and bones. Gomara, in speaking of the Indians of the Plains, says, "and of their hides they make many things, as houses, shooes, apparell, and ropes: of their bones they make bodkins: of their sinewes and haire, thread: of their dung, fire: and of their calves-skinnes, budgets, wherein they drawe and keepe water. To bee short, they make so many things of them as they have need of, or as many as suffice them in the use of this life."§

During the last few years many skins of buffaloes have been taken by the white hunters for the purpose of preparing leather from them. At the lowest estimate more than a million buffaloes have been sacrificed for this purpose in Kansas alone during the last five years. I say *sacrificed* in this connection advisedly, because the amount realized by the hunters from the sale of these hides scarcely brings them a return equal to the wages of an ordinary laborer in other pursuits. The "buffalo-skinners," as they are sometimes derisively termed, practice their ignoble calling mainly during the warmer months, when the weather will not permit of the shipment of meat to the Eastern markets, and seem to follow the business more from a love of the wild, semi-barbarous, out-door life of the plains-hunter than for any anticipated profit.

Generally in hunting buffaloes for their hides only the old bulls are killed, which are of little account in a pecuniary point of view for any other purpose, but some hunters are so reckless of even their own interest as to take any animal that comes in their way. Aside from the diminution in the number of buffaloes resulting from this reckless and

* Ibid., p 107.
† Red River Settlement, p. 262.
‡ North American Indians, Vol. I, p. 24.
§ Translation in Hakluyt's Voyages, Vol. III, p. 456.

almost unremunerative slaughter, the herds are harassed and kept wandering from place to place the whole year, which of course greatly interferes with their multiplication. It should be said, however, that this destruction of the buffalo in summer for its hide has not generally met with the approval of the better class of hunters, among whom there has been at times a strong feeling against it, it being chiefly carried on by those who were too unthrifty to seek employment in other pursuits during the time when buffalo-hunting for the Eastern market was not in season. Sometimes the more intelligent and influential portion of the hunters would warn the transgressors to desist from their unseasonable slaughter or immediately leave the country, on pain of summary treatment,—an admonition which was generally so effective as not to require a repetition.

The hide of the buffalo makes but an inferior, porous kind of leather, useful, however, for certain purposes, such as covers for carriage-tops, belt-leather, etc. The average net price realized by the hunter is generally less than a dollar per hide, usually from fifty to seventy-five cents, while it occasionally happens that in shipping a car-load of hides to the Eastern market the hunter is left in debt to the broker, whose deduction for freight and charges for commission exceed the price allowed for the skins.

The coarse wool of the buffalo early attracted attention as an article of commercial value. The early Jesuit explorers stated that the Indians were accustomed to weave it into ornamental or useful fabrics, and usually enumerated it as one of the products of the buffalo that would render the animal valuable under domestication. Charlevoix says that the wives of the Illinois Indians were accustomed to spin the buffalo-wool and make it as fine as that of English sheep.* Marquette says, referring to the same tribes, "they presented us with belts, garters, and other articles made of the hair of bears and buffaloes"; and adds that "their chiefs are distinguished from the soldiers by red scarfs made of the hair of buffaloes, curiously wrought."† Father Marest also enumerates among the employments of the Illinois Indians the making of "bands, belts, and sacks" from the hair of the buffalo.‡ Brackenridge, in a work published in 1814, says: "The wool of the buffaloe has a peculiar fineness, even surpassing that of the merino. I have seen gloves made of it, little inferior to silk. But for the difficulty of separating the hair, it might become a very important article of commerce. Should any means be discovered of effecting this, or should it be found that at certain seasons there is less of this mixture, the buffalo wool must become of prime importance in manufactures." This author adds in a footnote as follows: "It is curious to observe, that in the instruction to Iberville by the King of France, two things were considered of the first importance, the *pearl fishery* and the *buffaloe wool*. Charlevoix observes, that he is not surprised that the first should not have been attended to, but he thinks it strange that the second should be neglected even to his time."§

The early explorers of the country east of the Mississippi evidently very generally looked upon the buffalo as an animal that would prove

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* Charlevoix says, in describing the Illinois Indians: "Their Wives are sufficiently dexterous: They spin the Buffalo's Wool, and make it as fine as that of *English* Sheep. Sometimes one would even take it for Silk. They make Stuffs of it, which they dye black, yellow, and a dark-red. They make Gowns of it, which they sew with the Thread made of the Sinews of Roe-Bucks."—*Letters*, etc., English ed., p. 293.

† Hist. Coll. Louisiana, Vol. II, p. 288.

‡ Kip's Early Jesuit Missions, p. 199.

§ Views of Louisiana, p. 57.

of very great economic value. M. de la Galissonnière, in a "Memoir on the French Colonies in North America," written in 1750, speaks especially of the prospective value of the buffalo to the French settlers of the Illinois country. After describing the vast prairies "waiting only for the plough," he refers to their being "covered with an innumerable multitude of buffaloes,—a species," he says, "which will probably not run out for many centuries hence, both because the country is not sufficiently peopled to make their consumption perceptible, and because, the hides not being adapted to the same uses as those of the European race, it will never happen that the animals will be killed solely for the sake of their skins, as is the practice among the Spaniards of the River de la Plata.

"If the Illinois buffaloes do not supply the tanneries with much," M. Galissonnière continues, "eventually, advantages at least equivalent may reasonably be expected, on which we cannot prevent ourselves dwelling for a moment.

"1st. These animals are covered with a species of wool, sufficiently fine to be employed in various manufactures, as experience has demonstrated.

"2nd. It can scarcely be doubted that, by catching them young and gelding them, they would be adapted to ploughing; perhaps, even, they would possess the same advantage that horses have over domestic oxen, that is, superior swiftness; they appear to be as strong, but perhaps are indebted for this to wild breeding; in other respects, they do not seem difficult to tame; a 4 or 5 year old Bull and Cow have been seen that were extremely gentle.

"3d. Were the Illinois country sufficiently well settled to admit of the people inclosing a great number of these animals in parks, some of them might be salted, a business susceptible of being extended very considerably, without Illinois possessing a large population for that purpose. This trade would perhaps enable us to dispense with Irish beef for Martinico, and even to compete with the English, and at a lower rate, for the supply of the Spanish Colonies." *

It appears that in 1821 a joint-stock company was formed in the British Red River Colony, under the high-sounding title of the "Buffalo Wool Company," whose express objects were "to provide a substitute for wool, which substitute was to be the wool of the wild buffalo, which was to be collected in the Plains, and manufactured both for the use of the colonists and for export, and to establish a tannery for manufacturing the buffalo-hides for domestic purposes." A capital of two thousand pounds sterling was raised, and orders sent to England for machinery, implements, dyes, and skilled workmen. Two immigrations of operatives arrived, including "curriers, skinners, sorters, wool-dressers, teasers, and bark manufacturers, of all grades, ages, and sexes." For a time money was plenty, wages high, and the prospects golden. But events proved the scheme to be grounded on miscalculation, which, with the extravagant expenditure indulged in by the company, soon brought grief, not only to all the participants, but in a measure affected the fortunes of the whole colony. It was found that "the wool and the hides were not to be got, as stated, for the picking up; the hides soon costing the company 6*s*. each, and the wool 1*s*. 6*d*. per pound." But, according to Ross (from whom these statements are compiled), "the bottle and the glass" were too freely circulated; spirits were imported by the hogshead, and scenes of disorder and intemperance followed; both officials

* Documents relative to the Colonial History of the State of New York; procured in Holland, England, and France, by John Romeyn Brodhead, Esq., etc., Vol. X, pp. 230, 231.

and operatives were "wallowing in intemperance"; the hides were allowed to rot, the wool to spoil, and the tannery proved a complete failure. The company, besides expending their capital, found themselves irretrievably in debt to their bankers, and bankruptcy followed. "A few samples of cloth," continues Mr. Ross, "had, indeed, been made and sent home; but that which cost two pounds ten shillings per yard in Red River, would only fetch four shillings and sixpence in England!" But, though the enterprise itself disastrously failed, mainly through mismanagement and gross indiscretion, its indirect results were nevertheless beneficial to the colony.*

Dr. Richardson also states that the wool of the buffalo "has been manufactured in England into a remarkably fine and beautiful cloth, and in the colony of Osnaboyna, on the Red River, a warm and durable coarse cloth is formed of it." †

Although the soft woolly hair of the buffalo is evidently well adapted for the manufacture of cloth, I have heard of no other attempts toward its utilization. Of late, however, a traffic has sprang up along the line of the Kansas railroads in the bones, which are gathered for the purpose of shipment east for the manufacture of fertilizing material. Mr. C. F. Morse, the General Superintendent of the Atchison, Topeka, and Santa Fé Railroad, writes, under date of June 2, 1875, that the "bone business is still quite heavy, and will probably last for one or two years longer." From his accompanying statements of buffalo products shipped over that road during the last three years, it appears that the shipment of bones in 1872 amounted to eleven hundred and thirty-five thousand three hundred pounds; for 1873, twenty-seven hundred and forty-three thousand one hundred and ten pounds; for 1874, sixty-nine hundred and fourteen thousand nine hundred pounds, or treble the amount of the previous year, and six times that of 1872.

Among the products of the buffalo, mention of "buffalo chips," or *bois de vache*, as the French *voyageurs* term it, should not be omitted. This material, as most persons doubtless well know, is simply the dried excrement of the buffalo, which the traveller on the treeless plains finds a very serviceable substitute for wood. As Dr. Elliott Coues has recently remarked, in an interesting and very humorously written article on this subject, "As an agent in the progress of civilization, the spirit of which is expressed in the remark that westward the course of empire takes its way, the buffalo chip rises to the plane of the steam-engine and the electric telegraph, and acquires all the dignity which is supposed to enshroud questions of national importance or matters of political economy. I am not sure, indeed, that it is not entitled to still higher rank, for it is certain, at any rate, that we move in some parts of the West without either steam or electricity (mules replacing both), where it would be as impossible to live without buffalo chips as to exist without flour, coffee, and tobacco." ‡ In the narrative of military reconnaissances and other Government explorations of the Plains, as well as of those of private explorers and travellers, the first meeting with buffalo-chips is chronicled as something intimately affecting the welfare of the party, as it not only generally gives promise of soon meeting with herds of the animals themselves, but insures fuel for the camp-fire and for culinary purposes in regions where other sources of fuel are either precarious or entirely wanting. In the history of travel across the great interior plains, from those of Texas to those of the Saskatchewan, no other element,

* Ross (Alexander), Red River Settlement, pp. 69–72.
† Fauna Boreali-Americana, Vol. I, p. 282.
‡ "Chips from the Buffalo's Workshop."—*Forest and Stream*, (extra sheet,) April 1, 1875.

not even water, figures more prominently. Its absence in the treeless districts necessitates the transportation of wood as an indispensable part of the camp stores, while its presence not only renders this needless, but insures all those ordinary comforts of camp-life that the conveniences of a camp-fire always bring. Hence its importance as a civilizing agent cannot well be overrated. The misery experienced when, during rainy seasons, it is temporarily too wet to burn,—the deprivation of the "cup that cheers but not inebriates," and of all means of cooking,—gives one a most vividly realizing sense of what his condition might be, for days and weeks, were it not for this invaluable resource.

How long the chip will endure the vicissitudes of the weather under the dry atmosphere of the Plains it is impossible to say, but its decomposition is slow, as it will remain in a serviceable condition for years. After an exposure of six months it burns quite readily, but is not at its best as an article of fuel till it has had the suns and frosts of a year. It burns in much the same manner as peat, and though making but little flame yields a very intense heat. Strips of buffalo fat thrown on at intervals during the evening add a bright blaze, furnishing the explorer with ample light by which to write up his notes of the day's work, and enlivening the camp with all the cheer afforded by the piñon and pitch-pine camp-fires of the mountains or other wooded districts. Especially grateful does this "buffalo-chip" fire thus become in the long cold evenings of the hunter's winter camp on the Plains.

Another use to which buffalo chips are sometimes put is that of marking trails, and even surveyor's lines and points, it temporarily serving the office of stones and stakes in places where timber and stones are not to be obtained, as is the case over so large a part of the Great Plains.

3.—THE CHASE.

An account of the means and methods by which the buffalo has become so nearly exterminated forms an interesting chapter in its history, since they have varied at different times and at different localities, in accordance with the customs of the different Indian tribes, and with the wants and implements of the white man.

When the Jesuit missionaries first visited the Illinois prairies, it seems to have been a general custom with the Indians of the Mississippi Valley to hunt the buffalo by the aid of fire, accounts of which have been left us by Hennepin, Du Pratz, Charlevoix, and others. Hennepin says: "When the Savages discover a great Number of those Beasts together, they likewise assemble their whole Tribe to encompass the Bulls, and then set on fire the dry Herbs about them, except in some places, which they leave free; and therein lay themselves in Ambuscade. The Bulls, seeing the Flame round them, run away through those Passages where they see no Fire; and there fall into the Hands of the Savages, who by these Means will kill sometimes above sixscore in a day."*

Charlevoix's account of the Indian method of hunting the buffalo is as follows: "In the Southern and Western Parts of *New France*, on both Sides the *Mississippi*, the most famous Hunt is that of the Buffaloe, which is performed in this Manner: The Hunters range themselves on four Lines, which form a great Square, and begin by setting Fire to the Grass and Herbs, which are dry and very high: Then as the Fire gets forwards, they advance, closing their Lines: The Buffaloes, which are extremely afraid of Fire, keep flying from it, and at last find themselves

* A New Discovery of a Vast Country in America, p. 90, London, 1698.

so crouded together that they are generally every one killed. They say that a Party seldom returns from hunting without killing Fifteen Hundred or Two Thousand. But lest the different Companies should hinder each other, they all agree before they set out about the Place where they intend to hunt," etc.*

Mr. J. G. Shea also alludes to the general custom among the Indians of the Upper Mississippi of hunting buffaloes by fire, of which the buffaloes have a great dread. Finding it approaching them, "they retire towards the centre of the prairie, where, being pressed together in great numbers, the Indians rush in with their arrows and musketry, and slaughter immense numbers in a few hours."†

Mr. Catlin, in his "North American Indians," has described with considerable detail the methods of hunting the buffalo among the Sioux Indians, and has given a series of six plates illustrative of the chase.‡ According to this author, the chief hunting amusement of the Indians of the vicinity of the Teton River, a small tributary of the Missouri, which joins the latter at old Fort Pierre, in Southern Dakota, consists in the chase of the buffalo. Being bold and desperate horsemen, they almost invariably pursue the buffalo on horseback, despatching him with the bow and lance with apparent ease. The horses, being well trained to the chase, as well as very fleet, soon bring their riders alongside their game. The Indian, as well as his horse, is divested of everything that might prove an encumbrance in running, the Indian even throwing off his shield and quiver as well as his clothing; taking in his left hand five or six arrows drawn from his quiver, he holds them ready for instant use, while he plies a heavy whip with his right. Riding near the rear of the herd he selects his animal, which he separates from the mass by dashing his horse between it and the herd, and, riding past it to the right, discharges his deadly arrow at the animal's heart, which penetrates "to the feather." Some, our author says, also pursue the animal with the lance. In this manner the Sioux were accustomed to destroy immense numbers of the buffalo, pursuing them in large hunting-parties, and killing hundreds and even thousands in a single hunt. Mr. Catlin refers to one of these grand hunts that occurred just before his arrival at the Fur Company's post at the mouth of the Teton, in May, 1833. A large herd of buffaloes appearing in sight on the opposite side of the river, a band of five hundred or six hundred Sioux horsemen forded the river about midday, and, recrossing the river at sundown, brought with them to the post *fourteen hundred fresh buffalo tongues*, which they readily exchanged for a few gallons of whisky, "which was soon demolished," as our narrator states, "indulging them in a little and harmless carouse." Not a skin, nor a pound of meat, except the tongues, was saved from these slaughtered hundreds.

In winter, when from the depth of the snow these huge creatures are unable to move rapidly, they fall an easy prey to the Indian, who overtakes them readily upon his snow-shoes, and despatches them with his bow and arrow, or drives his lance to their hearts. This being the season for gathering the robes, it is also a period of great slaughter. The skins being stripped off, the carcasses are generally left to the wolves, the Indians laying in during the fall a supply of dried meat for the winter. Catlin has also given an illustration of Indians disguised in wolf-skins creeping upon a herd that is unsuspectingly grazing on the

* Letters, Goadby's English ed., p. 68.

† Discovery and Exploration of the Mississippi Valley, p. 18, footnote.

‡ North American Indians, Vol. II, plates cvii–cxiii.

level prairie, where they are shot down before they are aware of their danger by their disguised enemies.*

Lewis and Clarke describe a very novel method of destroying the buffaloes formerly practised by the Minnetarees of the Upper Missouri. This mode of hunting was to select one of the most active and fleet young men, who, disguised with a buffalo-skin fastened about his body, with the horns and ears so secured as to deceive the buffalo, placed himself at a convenient distance between the herd of buffalo and some of the river precipices, which sometimes extend for miles. His companions in the meantime get in the rear and along the flanks of the herd, and, showing themselves at a given signal, advance upon the herd. The herd thus alarmed runs from the hunters toward the disguised Indian, whom they follow at full speed toward the river. The Indian who thus acts as a decoy, when the precipice is reached, suddenly secures himself in some crevice of the cliff which he had previously selected, leaving the herd on the brink. It is then impossible for the foremost of the herd to retreat or to turn aside, being pressed on by those behind, who see no danger except from the pursuing Indians. They are thus tumbled headlong over the cliff, strewing the shore with their dead bodies. The Indians then select as much meat as they wish, the rest being abandoned to the wolves. A little above the mouth of Judith River, on the Missouri, Lewis and Clarke passed a precipice, about one hundred and twenty feet in height, at the base of which lay scattered the fragments of at least one hundred carcasses of buffaloes, although many had already been carried away by the water.†

Lewis and Clarke also describe the Indian method of hunting the buffalo on the ice, as witnessed by them March 29, 1805, at their wintering-post on the Missouri River, about thirty miles above the present site of Fort Abraham Lincoln, Dakota Territory. Every spring, say these authors, as the river is breaking up, the plains are set on fire by the Indians. The buffaloes are thus tempted to cross the river in search of the fresh green grass that springs up immediately after the burning. In crossing they often find themselves insulated on large pieces of floating ice. The Indians seize these opportunities for their attack, passing nimbly across the trembling ice, where the footsteps of the huge animals are unsteady and insecure. The buffalo being thus unable to offer resistance, the hunter gives him his death-wound and paddles his ice-raft to the shore and secures his prey.‡

The Indians of the Northern Plains were long in the habit of hunting the buffalo by impounding them, or by driving them into an artificial enclosure constructed for the purpose, within which the buffaloes were at their mercy. Various descriptions of this method have been given by different travellers, but one of the most recent is that by Hind, in his "Narrative of the Assinniboine and Saskatchewan Expedition,"§ where he describes the method as practised in 1859 by the Plain Cree Indians of the Qu'appelle and Saskatchewan Plains. The pound is described as circular, enclosing an area of about one hundred and twenty feet in diameter, formed of the trunks of trees set in the ground and bound together by withes, and braced by external supports. Converging rows of bushes extend from the pound a distance of several miles into the prairie, where their extremities are about one and a half to two miles apart. These bushes are termed "dead men," and serve to guide the

* North American Indians, Vol. II, pp. 249–257.
† Lewis and Clarke's Expedition, Vol. I, p. 235.
‡ Lewis and Clarke's Expedition, Vol. I, p. 175.
§ Canadian Exploring Expeditions, etc., Vol. I, pp. 355–359.

buffaloes into the pound. When all is ready for action, skilled hunters mounted on fleet ponies, partly surround a herd and start them in the direction of the pound, being aided by confederates stationed in hollows, who, when the buffaloes take a wrong direction, rise and wave their robes to change their course. If when the "dead men" are reached the buffaloes are disposed to pass through them, Indians stationed behind appear, and by the shaking of robes urge on the herd toward the pound. Thus the band is pressed on between the narrowing lines of "dead men" to the entrance of the pound. This is closed by a heavy tree-trunk placed about a foot from the ground, inside of which is a ditch sufficiently deep to prevent the enclosed buffaloes from jumping out. No sooner has the fatal leap been made than the imprisoned animals rush wildly around the enclosure in search of some point of escape. With the utmost silence, women and children hold their robes before every orifice, until the whole herd is brought in. When all are enclosed the slaughter begins; the hunters, climbing to the top of the fence, spear or shoot, with bows and arrows or fire arms, the bewildered buffaloes now so wholly within their power. Soon rendered frantic with rage and fear, the stronger toss, crush, or impale the weaker. In this dreadful scene of confusion and slaughter, says Hind, "the shouts and screams of the excited Indians rise above the roaring of the bulls, the bellowing of the cows, and the piteous moaning of the calves. The dying struggles of so many huge and powerful animals crowded together create a revolting and terrible scene, dreadful from the excess of its cruelty and waste of life, but with occasional displays of wonderful brute strength and rage; while man, in his savage, untutored, and heathen state, shows, both in deed and expression, how little he is superior to the noble beasts he so wantonly and cruelly destroys."

"The conflict over," says Hind, "animals of every age, from old bulls to young calves of three months old, were huddled together, in all the forced attitudes of violent death. Some lay on their backs, with eyes starting from their heads, and tongues thrust out through clotted gore, and others were impaled on the horns of the old and strong bulls. Others again, which had been tossed, were lying with broken backs, two or three deep. One little calf hung suspended on the horns of a bull, which had impaled it in the wild race round and round the pound." Of the two hundred to two hundred and fifty animals usually killed at each impounding, only the best and fattest are utilized, the flesh of these being removed and dried in the sun.

Sometimes the attempts at impounding are unsuccessful, an instance of which is mentioned by Mr. Hind. After the pound was nearly full, an old bull espied a narrow crevice which had not been closed by the robes of those on the outside, whose duty it was to conceal every orifice; making a dash at this, he forced himself through, breaking the fence, when the whole herd ran helter-skelter through the gap, a few only being speared or shot through with arrows in their attempt to escape.

Simpson says that in January, 1840, the buffaloes were so numerous about Carlton House as to render it necessary to remove the haystacks into the Fort to prevent their being devoured by the buffaloes. In the vicinity of the fort were three camps of Assinniboines, each of whom had its buffalo pound, into which they drove forty or fifty animals daily; "and I afterwards learned," says Simpson, "that in other places these pounds were actually formed of piled-up carcasses." *

* Simpson (Thomas), Narrative of the Discoveries on the North Coast of America, etc., pp. 402, 404.

Audubon states that the Gros Ventres, Blackfeet, and Assinniboines often also took the buffalo in large pens in a similar manner. Two converging fences, built of sticks, logs, and brushwood, form in a similar way a funnel-shaped entrance to the enclosure or "park," as it is usually called, which may be either square or round according to the nature of the ground. The narrow end or entrance is always on the verge of a sudden break in the prairie, ten or fifteen feet deep, and is made as strong as possible. When the pen is ready a young man, very swift of foot, starts at daylight towards the herd that is to be taken, provided with a bison's hide and head, with which he is to disguise himself for the purpose of acting as a decoy. On nearing the herd he bleats like a calf, and makes his way slowly towards the mouth of the converging fences leading to the pen. Repeating the cry at intervals, the buffaloes follow the decoy, while mounted Indians, riding to and fro along the flanks and rear of the herd, urge them on towards the funnel. A crowd of men, women, and children then come and assist in frightening them, the disguised Indian still occasionally bleating. As soon as the buffaloes have fairly entered the road to the pen, the decoy runs to the edge of the precipice, quickly descends, and makes his escape by climbing over the fence forming the pen. The herd follows on until the leader is forced to leap down into the pen, and is followed by the whole herd, which being thus ensnared is easily destroyed, even the women and children participating in the slaughter.*

This method, if not still practised in the Yellowstone country, was in use there at no distant date, since while with the Yellowstone Expedition of 1873 I several times met with the remains of these pounds and their converging fences in the region above the mouth of the Big Horn River. They are here, I was told, used in entrapping the elk and deer as well as the buffalo; and, according to Charlevoix, the Indians of Canada formerly hunted the moose, the caribou, and the deer in a somewhat similar manner.

On the plains, where no timber is available for the construction of pounds, the Indians pursue a different but an almost equally destructive method. The hunting party, numbering usually hundreds of horsemen, select such a portion of a large herd as they desire to destroy, and, surrounding them, thus cut them off from the rest of the herd, and prevent their escape in every direction by enclosing them with a cordon of armed horsemen. The slaughter is begun simultaneously on all sides; and whichever way the herd moves they encounter their invincible and deadly enemies. The slaughter usually continues until the whole "surround" is killed, often numbering hundreds of animals. In their casual hunts the Indians simply follow the herds on horseback, shooting from the saddle when in full pursuit, using either bows and arrows or the modern fire-arms with great dexterity.

Descriptions of the systematic expeditions of the Red River half-breed hunters have been given with greater or less fulness by McLean, Ross, Hind,† and others. The distinctive features of these grand hunting expeditions are their magnitude, the number of persons engaged in them, and the almost military character of their organization. As previously stated, these expeditions generally numbered from five hundred to upwards of twelve hundred carts, accompanied by from two hundred and fifty to six hundred hunters, nearly twice this number of women and children,

* Audubon and Bachman's Quadrupeds of North America, Vol. II, p. 49.

† McLean (John), Notes of Twenty-five Years' Service in the Hudson's Bay Territory, Vol. II, pp. 297–302; Ross (Alexander), The Red River Settlement, pp. 255–264; Hind (H. Y.), Canad. Expl. Expedition, Vol. II, pp. 110, 111.

besides a draught animal (either a horse or an ox) and a dog to each cart, and riding animals in addition for the hunters. Setting out from Fort Garry, the expeditions for many years hunted over the Pembina plains, extending their trips southward and westward over the prairies and plains of the Red River, the Shayenne, and the Coteau de Missouri. The Red River half-breed hunters have undoubtedly done more to exterminate the buffalo than any other single cause, and have long since wholly extirpated them throughout not only this vast region, but also over the extensive prairies of the Assinniboine, the Qu'appelle, and the lower Saskatchewan. Their method of hunting was for several hundred horsemen armed with fire-arms to make a grand simultaneous rush into the very midst of the immense herds. An attack that Mr. Ross witnessed he thus describes: "Our array in the field must have been a grand and imposing one to those who had never seen the like before. No less than four hundred huntsmen, all mounted, and anxiously waiting for the word 'Start!' took up their position in a line at one end of the camp, while Captain Wilkie, with his spy-glass at his eye, surveyed the buffalo, examined the ground, and issued his orders. At eight o'clock the whole cavalcade broke ground and made for the buffalo; first at a slow trot, then at a gallop, and lastly at full speed. Their advance was over a dead level, the plain having no hollow or shelter of any kind to conceal their approach. . . . . When the horsemen started, the cattle might have been a mile and a half ahead; but they had approached to within four or five hundred yards before the bulls curved their tails or pawed the ground. In a moment more the herd took flight, and horse and rider are presently seen bursting in among them; shots are heard, and all is smoke, dust, and hurry. The fattest are first singled out for slaughter, and in less time than we have occupied with the description a thousand carcasses strew the plain. Those who have seen a squadron of horse dart into battle may imagine the scene, which we have no skill to depict. The earth seemed to tremble when the horses started; but when the animals fled it was like the shock of an earthquake. The air was darkened; the rapid firing, at first distinct, soon became more and more faint, and at last died away in the distance. Two hours, and all was over; but several hours elapsed before the result was known, or the hunters reassembled; . . . . in the evening no less than thirteen hundred and seventy-five tongues were brought into camp."*

The dexterity in loading and firing on horseback while at full speed exhibited by these half-breeds, as well as their tact in recognizing their game on the field of slaughter after the killing is over, is represented as surprising. Formerly, when hunting with the old flint-lock musket, says Mr. Taylor,† they would drop a charge of powder into the palm of the hand, thence into the muzzle of the gun, following it with a bullet from a stock carried in the mouth, firing as often as this operation could be repeated. The use of the modern breech-loading arms, however, long since rendered this process needless. They seldom leave a mark to designate their own animals, though some do so, leaving first a cap, then a sash, and so on, until, as often happens, these means of designation fail, five or six to a dozen buffaloes being generally killed in a single run by a good hunter. Riding in clouds of dust and smoke, in company with hundreds of other horsemen, crossing and recrossing each other's tracks, among dead and wounded as well as among the terrified and fleeing animals, it certainly evinces, on the part of the hunter, no small degree of discriminating power, after an hour of such wild,

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* Red River Settlement, pp. 255–257.

† MS. Notes, as previously cited.

bewildering confusion, to tell not only the number of animals he has killed, but also the exact spot where each lies. Yet this, we are told, is constantly done.

According to Simpson, the Red River hunter, in winter, when the snow was too deep to pursue them on horseback, approached the buffaloes by crawling to them on the snow, disguised sometimes by a close dun-colored cap, furnished with upright ears, to give him the appearance of a wolf, which, through constant association, the buffaloes regard without dread. Towards spring, when the deep snow is covered with a hard crust, which, while it supports the hunter, proves a great impediment to the buffaloes, they are easily run down by the hunters, and despatched with daggers while floundering in the deep drifts, even women and boys assisting in killing the then almost helpless animals.*

The two modes of hunting the buffalo chiefly practised at present are the pursuit on horseback and the "still hunt." The first named is the one usually chosen when sport and excitement are the things mainly desired, the still hunt being practised when a supply of meat or of hides is the object. The latter method affords but little excitement, and entails, with proper precautions, little or no risk of life or limb on the part of the hunter. Parties hunting for pleasure prefer the chase on horseback, shooting from the saddle with heavy revolvers at close range when at full gallop. Success depends almost wholly, provided the hunter is a good rider, upon the speed and bottom of his horse, and is really about as noble sport as attacking a herd of domestic cattle would be. The chase on horseback of a drove of Texan cattle would be far more dangerous, and attended probably with as much excitement, except that in the case of the buffalo the hunter has the consciousness of pursuing a nominally wild animal, and hence legitimate game. That the chase on horseback affords the wildest excitement is an undeniable fact. The swift pursuit of the flying mass of buffaloes, the mingling with the terrified herd, the singling out of the victim, the rapid shots at the huge moving bulk of hair and flesh, at so close range that the game is almost within reach of the hand, the tottering fall or the headlong tumble of the doomed animal, the risk of pursuit by a wounded bull maddened with pain, the general din and confusion, with the double risk of collision with the blindly fleeing monsters or of being thrown by treacherous marmot or badger holes, or anon the long pursuit of an animal which, though pierced with a dozen balls, still rushes on, can, of course, yield only excitement of the intensest kind, both for the rider and his steed. This method is the favorite one with hunting parties from the East or from abroad, as well as of the officers and soldiers of the United States Cavalry, when the latter are stationed within or near the range of the buffalo, or are passing through its range, at the expense, usually, of several of the best horses in the command. The destruction of the buffalo during these hunts is not generally very great, though amounting annually, in the aggregate, to many thousands; but the demoralization of the herd produced by the fright and the chase has a most deleterious influence on their stability and increase.

The still hunt is far more fatal, and is the method adopted by the professional hunter, who throughout the year makes it his chief business to hunt the buffalo for its commercial products. The buffalo being naturally unsuspicious and sluggish, even to stupidity, is readily approached within easy range, even in a level country, where the slight herbage of the plains is the only shelter. Buffalo-hunting hence requires

* Narrative of the Discoveries on the North Coast of America, etc., p. 404.

much less tact and skill than the hunting of most other large game, especially deer and pronghorns. The chief precaution necessary is to keep to the leeward of the herd, in order not to give them the "scent," as this alarms them even when no enemy is in sight, being sufficient to "stampede" a herd at a long distance. The buffaloes can ordinarily be approached to within a thousand yards in a perfectly level and open country, and with a slight growth of herbage for shelter it is easy to creep up to within a hundred yards, and by aid of ravines to within twenty or thirty paces. I have seen hunters approach within thirty yards of a herd when their only cover was grass and weeds a foot or so in height. The old bulls are always less wary than the cows and younger bulls; they also, to a great extent, keep in the rear and on the outskirts of the herd. As generally only the younger animals are desired, and especially the young cows, the hunters often have to creep past the old bulls in order to get within range of the cows. Where slight inequalities of the ground have favored the hunters, I have seen them pass within a few paces of the quietly reclining, ruminating old bulls, in trying to get within range of the more desirable game beyond without the patriarchs of the herd being alarmed by the hunter's approach. The half-wild Texan steers are often far more wary than the unsuspecting herds of buffaloes.

The professional hunter, when desiring to load his teams with meat, will rarely make his first shot at a greater distance than fifty to seventy-five yards. If the shot result fatally, the herd rarely moves more than fifty yards before stopping to look for the cause of the mishap to their fallen companion, and turning half round to get a good view rearward, they thus present themselves in the best possible position to the hunter at still short range. Here others fall before the hunter's shots; the herd, again slightly startled, moves on a few paces, and again stops to gaze. The hunter, still keeping prostrate, approaches, if necessary, under cover of those already killed, and continues the work of destruction. The shots are thus often repeated till fifteen, twenty, or even thirty buffaloes are killed before the herd becomes thoroughly alarmed and, in hunter's parlance, "stampedes." By keeping prostrate the hunter is able to creep up to the herd again as it recedes, till he has killed enough to furnish loads for his teams; and even sometimes he has to rise and drive away the stupid creatures to prevent the living from playfully goring the dead! When the hunter is thus successful, it is termed "getting a stand on the herd." A "stand" is most surely made in nearly level ground. In shooting from ravines, the herd usually runs away after three to five or six of their number have fallen. During the rutting season, if a cow falls at the first shot, the hunter is pretty sure of a "stand," and of getting a dozen or more shots, if he keeps prostrate and uses due caution. As soon as he rises the buffaloes seem at once to recognize the cause of their trouble, and generally immediately stampede; but so long as he remains prone they seem to have no perception of the character of their enemy, and often do not notice him at all. A "stand" can usually be obtained, by due care, at any time from May to December, but during the rest of the year the buffaloes are more wary, and often very lean, and the hunters say that the poorer they get, the wilder they become.

The Kansas hunter for several years was generally able to reach the herds by an easy drive from either of the railroads that now intersect the State. Generally equipped with one to three four-mule teams, he was able, for a part of the season at least, to make daily trips from the herds to the points of shipment, although not unfrequently two days were required to enable him to load his teams and make the round trip. The chief of a party is usually mounted on a pony, and, riding in advance, often has enough animals killed to furnish loads for his teams by the time the latter reach the scene of action. The dead buffaloes are then speedily "butchered,"* a few minutes sufficing for each. The "saddle," or the two hind quarters, and the tongue are usually the only parts saved; but in the case of calves and very fat yearlings the whole carcass is taken. The usual weight of a saddle is about two hundred pounds, which is sold at an average price of about three cents per pound delivered at the cars, the buyer being generally on the spot to inspect it and superintend its packing for shipment.

The regular or "professional" hunter formerly followed the buffalo herds the whole year, moving eastward or westward along the lines of railroad as the buffaloes at different seasons changed their range. When the weather was too warm to allow of the shipment of the meat to Eastern cities, they killed the creatures for their hides, each hunter in this way destroying hundreds in the course of a few months, though getting hardly enough for them to pay his expenses. A few of the more enterprising preserved a portion of the meat by salting and smoking it. As no skins can be taken from those from which the quarters are taken, an animal is thus sacrified for each hide taken and for each saddle saved.

The life of a buffalo-hunter is one of hardship and exposure, and yet one of remarkable fascination to those who have ever engaged in such pursuits. In winter, owing to sudden changes of temperature, the hunter is often in great danger, since he is liable to be overtaken by storms and extreme cold when far out on the prairie, many miles from any means of protection. The early part of the winter of 1871–'72 was one of remarkable severity in the West, even as far south as the plains of Northern Kansas, where, in December, 1871, several hunters perished from the cold, and many others were maimed from having been frostbitten, some of whom narrowly escaped with their lives. Within the winter range of the northern herds of the Kansas buffaloes, a lone tree here and there, at the head of some ravine, usually forms the hunter's sole dependence for firewood. His own improvidence, however, often deprives him of many comforts, as well as a considerable degree of security, which a little trouble and care would secure to him.

The life of a hunter seems always to tend more or less to barbarism, but especially is this the case with the buffalo-hunter. The "buffalo rangers" of the Red River Settlements are described by Ross, Hind, and others, as speedily becoming unfitted for agricultural or other civilized pursuits. Improvident and unthrifty in their habits, they riot in plenty during a part of the year, and again verge upon starvation before the arrival of their annual hunting season. The buffalo-hunter of the Plains contrasts unfavorably in many respects with his Rocky Mountain brother. With the less degree of skill required in the chase of the stupid, unwieldy bison, as compared with the tact and caution required in the successful pursuit of the watchful pronghorn, the timid deer, the elk, or the bighorn, there is a corresponding lack of thrift and energy on the part of the hunter. In place of the buckskin suit of the Rocky Mountain hunter, the buffalo-hunter goes clad in a coarse dress of canvas, stiffened with blood and grease. His hair often goes uncut and uncombed for months together, and his hands are frequently unwashed for many days. The culinary apparatus of a whole party consists of a single large coffee-pot, a "Dutch-oven," and a skillet, and the

*The hunters appear to generally restrict this term to the dressing of the slain animals; "butchering," in their parlance, does not include the killing.

table-set of a tin cup to each man, the latter vessel often consisting merely of a battered fruit-can. Each man's hunting-knife not only does duty in butchering the buffalo, but is the sole implement used in despatching his food, supplying the places of spoon and fork as well as knife. The bill of fare consists of strong coffee, often without milk or sugar, "yeast-powder bread," and buffalo meat fried in buffalo tallow. When the meal is cooked, the party encircle the skillet, dip their bread in the fat, and eat their meat with their fingers. When bread fails, as often happens, "buffalo straight," or buffalo meat alone, affords them nourishing sustenance. Occasionally, however, the fare is varied with the addition of potatoes and canned fruits. They sleep generally in the open air, in winter as well as in summer, subjected to every inclemency of the weather. As may well be imagined, a buffalo-hunter, at the end of the season, is by no means prepossessing in his appearance, being, in addition to his filthy aspect, a paradise for hordes of nameless parasites. They are yet a rollicking set, and occasionally include men of intelligence, who formerly possessed an ordinary degree of refinement. Generally none are more conscious of their unfitness for civilized society than themselves, and after a few years of such free border-life they can hardly be induced to abandon it and resume the restraints of civilization.

Although successful in the pursuit of the buffalo, their success arises from the unsuspicious nature of their victims rather than from skill in the use or selection of their arms. The improved breech-loading United States musket is their favorite weapon, and most of them will use no other. A few employ Sharp's and Winchester rifles; arms of small caliber, however, they generally despise. Yet with these heavy arms, used, as they are, at short range, only about one shot in three proves fatal, many of the poor beasts getting but a broken leg in place of a fatal shot.* This is owing in part to carelessness or lack of skill in shooting, and in part to the inaccuracy of the arms. However good the gun may be originally, it soon deteriorates and is eventually ruined by rough usage. A few of the hunters have good guns, take good care of them, and use them effectively, killing their game as readily at three hundred and four hundred yards as do the others at one-fourth that distance. A rifle having a calibre of $\frac{44}{100}$ inches is as effective a weapon against the buffalo as need be used, if accurate and skillfully employed, the fatality of the shot depending not so much upon the size of the ball used as upon the part of the animal hit. I have seen, for instance, an old buffalo bull shot entirely through the body at a distance of two hundred and thirty yards by a ball from a six-pound rifle, having a calibre of only $\frac{44}{100}$ inches, the wound killing the animal almost instantly.

4.—DOMESTICATION OF THE BUFFALO.

Now that the buffalo is apparently so nearly exterminated, it is greatly to be regretted, not only that its ultimate extinction has been so rapidly hastened by improvident and wanton slaughter, but that no persistent attempts have as yet been made to utilize this valuable animal by domestication. Never, perhaps, was the time more favorable for such experiments than now, since there are not only intelligent settlers living within or near the boundaries of its range, where the experiments might be tried without any of the risks that would attend a change of

* When returning from a buffalo-hunt on the Kansas plains in January, 1872, my party fell in with a small band of these unfortunates, about thirty in number, nearly all of whom were in some way maimed, the greater part having broken legs.

climate, but easy access to its haunts from the Eastern States is afforded by railroads, by means of which, at comparatively little cost and trouble, numbers might be taken to any portion of the older States of the Union.

The early explorers of the Mississippi Valley believed that the buffalo, besides being valuable for its flesh and hide, might be made to take the place of the domestic ox in agricultural pursuits, and at the same time yield a fleece of wool equal in value, in respect to quality, to that of the sheep. That the buffalo calf may be easily reared and thoroughly tamed needs not at this late day to be proved. The known instances of their domestication are too many to admit even of enumeration, but they have usually been kept merely as objects of curiosity, and little or no care has been given to their reproduction in confinement, and few attempts have been made to train them to labor.

As early as 1750, Kalm states that young buffaloes had frequently been taken to Quebec and kept among the tame cattle, but he adds that the climate there seemed too severe for them to bear, and that they commonly died in three or four years. The same writer also states that the calves of "the wild cows and oxen . . . which are to be met with in Carolina and other provinces to the south of Pennsylvania," had been obtained by "several people of distinction," who "brought them up among the tame cattle." "When grown up," he adds, "they were perfectly tame, but at the same time very unruly, so that there was no inclosure strong enough to resist them if they had a mind to break through it; for as they possess a great strength in their neck, it was easy for them to overthrow the pales with their horns and to get into the cornfields; and as soon as they had made a road, all the tame cattle followed them. They likewise copulated with the latter, and by that means generated, as it were, a new breed."*

Bernard Romans also says (writing a century ago), "The bounteous hand of nature has here given us an animal which, *by experience*, we know may easily be domesticated, whose fine wooll might yield good profit, and whose flesh is equal at least to our beef, and yields as much tallow; i mean the buffaloe."†

Gallatin also says that they were not only domesticated in Virginia, but that they were bred with domestic cattle, and that the mixed breed was fertile. "As doubts have lately been raised upon that point," he says, writing forty years ago, "I must say that the mixed breed was quite common fifty [now ninety] years ago, in some of the northwestern counties of Virginia; and that the cows, the issue of that mixture, propagated like all others. No attempt that I know of was ever made by the inhabitants to tame a buffalo of full growth. But calves were occasionally caught by the dogs and brought alive into the settlements. A bull thus raised was for a number of years owned in my immediate vicinity by a farmer living on the Monongahela, adjoining Mason and Dixon's line. He was permitted to roam at large, and was no more dangerous to man than any bull of the common species. But to them he was formidable, and would not suffer any to approach within two or three miles of his own range. Most of the cows I knew were descended from him. For want of a fresh supply of the wild animal they have now merged into the common kind. They were no favorites, as they yielded less milk. The superior size and strength of the buffalo might have improved the breed of oxen for draft, but this was not attended to, horses being almost exclusively employed in that quarter

* Kalm (Peter), Travels in North America (Forster's translation), Vol. I, p. 162.
† Nat. Hist. of East and West Florida, p. 174.

for agricultural pursuits."* He adds that the buffalo is very intractable, and is not known to have been domesticated by the Indians.†

Sibley observes, in speaking of the buffalo of the Red River of the North, that "in spring the calves are easily weaned, and when trained to labor become quite useful. One farmer, who had broken a bull to the plough, performed the whole work of the field with his aid alone."‡

Mr. Robert Wickliffe, in a letter addressed to Messrs. Audubon and Bachman, dated Lexington, Kentucky, November 6, 1843, has quite fully recorded the results of his own efforts at domesticating the buffalo. He says: "The herd of buffalo I now possess have descended from one or two cows that I purchased from a man who brought them from the country called the Upper Missouri; I have had them for about thirty years, but from giving them away and the occasional killing of them by mischievous persons, as well as other causes, my whole stock does not exceed ten or twelve. I have sometimes confied them in separate parks from other cattle, but generally they herd and feed with my stock of farm-cattle. . . .. On getting possession of the tame buffaloes, I endeavored to cross them as much as I could with my common cows, to which experiment I found the tame bull unwilling to accede, and he was always shy of the buffalo cow, but the buffalo bull was willing to breed with the common cow.

"From the domestic cow I have crossed half-breeds, one of which was a heifer; this I put with a domestic bull, and it produced a bull-calf. This I castrated and it made a very fine steer, and when killed produced very fine beef. I bred from the same heifer several calves, and then, that the experiment might be perfect, I put one of them to the buffalo bull, and she brought me a bull calf, which I raised to be a very fine large animal, perhaps the only one in the world of his blood, namely, a three-quarter, half-quarter, and a half-quarter of the common blood. After making these experiments, I have left them to propagate their breed themselves, so that I have only had a few half-breeds, and they always proved the same, even by a buffalo bull. The full-blood is not as large as the improved stock, but as large as the ordinary stock of the country. The crossed or half-blood are larger than either the half-blood or common cow. The hump, brisket, ribs, and tongue of the full and half-blooded are preferable to those of the common beef, but the round and other parts are much inferior. The udder or bag of the buffalo is smaller than that of the common cow, but I have allowed the calves of both to run with their dams upon the same pasture, and those of the buffalo were always the fattest; and old hunters have told me that when a young buffalo calf is taken, it requires the milk of two cows to raise it. Of this I have no doubt, having received the same information from hunters of the greatest veracity. The bag or udder of the half-breed is larger than that of full-blooded animals, and they would, I have no doubt, make good milkers.

"The wool of the wild buffalo grows on their descendants when domesticated, but I think they have less of wool than their progenitors. The domesticated buffalo still retains the grunt of the wild animal, and is incapable of making any other noise, and they will observe the habit of having select places within their feeding-grounds to wallow in.

"The buffalo has a much deeper shoulder than the tame ox, but is

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* Gallatin (Albert), A Synopsis of the Indian Tribes of North America; Trans. Amer. Antiquarian Soc., Vol. II, p. 139, footnote.

† Dr. Woodhouse states that he had seen "a few of these animals tamed in the Creek nation, running with the common cattle."—SITGREAVES'S *Report of an Exped. down the Zuñi and Colorado Rivers*, p. 57.

‡ Sibley (H. H.), in Schoolcraft's History, Condition, and Prospects of the Indian Tribes of the United States, Vol. IV, p. 110.

lighter behind. He walks more actively than the latter, and I think has more strength than a common ox of the same weight. I have broken them to the yoke, and found them capable of making excellent oxen; and for drawing wagons, carts, or other heavily laden vehicles on long journeys, they would, I think, be greatly preferable to the common ox. I have as yet had no opportunity of testing the longevity of the buffalo, as all mine that have died did so from accident, or were killed because they became aged. I have some cows that are nearly twenty years old, that are healthy and vigorous, and one of them has now a sucking calf.

"The young buffalo calf is of a sandy red or rufous color, and commences changing dark brown at about six months old, which last color it always retains. The mixed breeds are of various colors; I have had them striped with black, on a gray ground, like the zebra, some of them brindled red, some pure red with white faces, and others red without any markings of white. The mixed bloods have not only produced in my stock from the tame and the buffalo bull, but I have seen the half-bloods reproducing, viz, those that were the product of the common cow and wild buffalo bull. I was informed that, at the first settlement of the country, cows that were considered best for milking were from the half-blood, down to the quarter, and even eighth, of the buffalo blood. But my experiments have not satisfied me that the half-buffalo bull will produce again. That the half-breed heifer will be productive from either race, as I have before stated, I have tested beyond the possibility of a doubt.

"The domesticated buffalo retains the same haughty bearing that distinguishes him in his natural state. He will, however, feed or fatten on whetever suits the tame cow, and requires about the same amount of food. I have never milked either the full-blood or mixed breed, but have no doubt they might be made good milkers, although their bags or udders are less than those of the common cow; yet, from the strength of the calf, the dam must yield as much or even more milk than the common cow."*

From the foregoing the following facts are sufficiently attested: (1) That the buffalo is readily susceptible of domestication; (2) that it interbreeds freely with the domestic cow; (3) that the half-breeds are fertile; and (4) that they readily amalgamate with the domestic cattle. The advantages that arise from the mixed race are less clearly apparent, as their adaptability to labor seems as yet to have not been properly tested, although the experiments of Mr. Wickliffe offer encouragement in this direction. A larger race than either of the original stocks seems,

*Audubon and Bachman's Quadrupeds of North America, Vol. II, pp. 52–54. Mr. Wickliffe's account of his observations and experiments has been repeatedly quoted by different writers on the subject of the domestication of the buffalo (see Baird, Patent-Office Report, Agriculture, Part II, 1851–'52, pp. 126–128; Hind, Canadian Exploring Expedition, Vol. II, p. 113), and embraces nearly all of importance as yet published relating to the subject.

In this connection may be noticed the astonishing dogmatism with which Schoolcraft, four years after the publication of Mr. Wickliffe's account of his experiments in domesticating the buffalo, and three years after its republication by Professor Baird, asserts that while "the calf of the bison has often been captured on the frontiers, and brought up with domestic cattle," and been "measurably tamed," that "*it produces no cross*," and "*is utterly barren in this state*." He alludes also to the statement of Gomara that it is susceptible of domestication, his statement being revived, Schoolcraft adds, and "in a manner galvanized by a justly eminent writer [Humboldt], after the *uniform observation* of the French and English colonists of America, *disaffirming* [!], for more than two centuries, the practicability of its domestication"; and further states that "*all* visitors and travellers who have spoken on the subject coincide in the opinion that the bison is *incapable of domestication*, and that it is not without imminent peril to themselves that the fierce and untamable herds of it are hunted."—*History, Condition, and Prospects of the Indian Tribes of the United States*, Part V (1856), p. 49.

however, to result from the crossing of the buffalo with the cow, and a probable improvement in milking qualities.

The domestication of the buffalo has heretofore been undertaken only in regions where farm-labor was done chiefly by the use of horses or mules. Galissonière, as already noticed (see *anteà*, p. 198), writing a century and a quarter ago, believed the buffalo would "be adapted to ploughing," and that "they would possess the same advantage that horses have over domestic oxen, that is, superior swiftness," but the question has as yet received little attention. Being more active than the domestic ox, it seems highly probable that they might make a superior farm animal, especially since, as Professor Shaler suggests to me, they would be far better able to endure the intense heat of summer than ordinary cattle, besides being swifter and stronger.

From what is already known of the behavior of the buffalo under domestication, it seems altogether tractable and docile. A letter written by Mr. P. B. Thompson, sr., to Professor Shaler, respecting the domestication of the buffalo in Kentucky, bears further on this point. Mr. Thompson says (under date of "Harrodsburgh, Ky., October 30, 1875"): "In reply to your inquiry relative to the buffaloes formerly owned by Col. George C. Thompson, of Shawnee Springs, Mercer County, permit me to say that my remembrance of them runs back at least fifty years. My first recollection is that there was a bull and three cows. They were kept in a park of about sixty acres of blue-grass. In the same park were about fifty deer, and from seven to twelve elk. The animals in the park were fed but little, and given the same food as other cattle. The elk and deer were but slightly domesticated, but the buffaloes became as gentle as any other cattle that were not constantly handled. I have been often within a few feet of them, and have no doubt that they could have been used as beasts of labor, or that the females would have submitted to milking. There were but few young, they being poor breeders, which was probably the effect of neglect. They were very long-lived; one of them must have been thirty years old, the others over twenty. The bull died many years ago; the last cow about a year since.

"During the whole time I do not think they ever broke a fence, or went beyond the limits of the park unless driven. Other cattle were put in the park, and it was used at times for a calf lot. They were not vicious to either cattle, horses, hogs, or sheep. The two last left were cows, who survived the bull at least fifteen years. They were calved in the park, and, as I have said before, were docile and harmless."

No attempt appears as yet to have been made to perpetuate an unmixed domestic race of the buffalo. Probably after a few generations they would lose much of their natural untractableness, and when castrated would doubtless form superior working cattle, from their greater size and strength and great natural agility. While on the plains in 1871 I made extensive inquiries as to the possibility of the buffalo being domesticated and trained to work, and while the general opinion seemed to be that such a thing was wholly feasible, I could not learn that it had been properly attempted. I heard of instances where buffaloes had been broken to the yoke, and, though strong and serviceable, they were at times rather unmanageable. When on a journey they are liable, it is said, when thirsty, "to break for water," rushing precipitately down the steep banks of the nearest stream to slake their thirst, dragging after them the wagon to which they may be attached, with, of course, rather unpleasant results.

The fate of extermination so surely awaits, sooner or later, the buffalo in its wild state that its domestication becomes a matter of great interest, and is well worthy of the attention of intelligent stock-growers, some of whom should be willing to take a little trouble to perpetuate the pure race in a domestic state. The attempt can be hardly regarded otherwise than as an enterprise that would eventually yield a satisfactory and probably a profitable result, with the possibility of adding another valuable domestic animal to those we already possess. It seems probable, also, that a mixed race might be reared to good advantage.[*]

[* Since the original publication of this paper, some months since, I have met with the following interesting account of the successful attempt to domesticate the buffalo in Howard County, Nebraska, published in the Turf, Field, and Farm newspaper of New York City, in the issue of November 10, 1876. An attempt to communicate with Mr. Cunningham, the authority for the statements given below, having proved unsuccessful, I can only give the matter at second-hand. The account in full is as follows:

"It has been fully demonstrated, and may be now set down as an established fact, that the cross of the buffalo with milch cows are of a gentle disposition, and yield a fair amount of very rich milk. The male produce of this cross make excellent bulls, and when crossed with good milkers of any of the milch families, yield largely of a rich quality of milk, from which the finest butter can be made. In certain sections of Nebraska, especially in Howard County, half and quarter bred buffalo stock is quite common. Notwithstanding the dairy stock in that State, crossed originally with the buffalo, were of an ordinary character, the half-breds yield an average of fourteen to sixteen quarts per day, the milk being of a rich and fine flavor, making the best of butter, and very nearly equalling the Jerseys in the quantity obtained from a given proportion. These facts are obtained from J. W. Cunningham, esq., now of Erie, Pa., formerly of Howard County, Nebraska, who vouches for their correctness, having largely experimented with these half and quarter bred buffalo cows. This will prove of great value to thousands of breeders and farmers in the far West, and notably so in view of the fact that besides the dairy quality which these half-breds possess in a remarkable degree, they take on flesh and fat rapidly, and make excellent beef."

In another column of the same issue occurs the following:

"The long-mooted question whether the buffalo cannot be successfully utilized for dairy purposes is now in a fair way of being satisfactorily settled. The apprehensions hitherto entertained regarding the untamable nature of the buffalo, and that the characteristics of this branch of the bovine family would be certain to crop out through indefinite crossings, appear to be totally groundless. As will be seen under the head of stock items, in this day's issue, the buffalo, or more properly American bison (*Bos americanus*), is being used extensively in portions of the State of Nebraska bordering on the wild prairies of the far West for stock purposes, and that half and quarter bred females of the bison family yield an abundant supply of rich milk. A remarkable feature connected with this cross of the bison with domestic cattle is the fact that the color of the bison and the majority of its distinguishing characters disappear after successive crossings. Its outward conformation is also in process of time in a great degree lost sight of. The hunch, or lump of flesh covering the long spinous processes of the dorsal vertebræ, becomes diminished with each successive cross, and will doubtless also disappear entirely as the original type becomes merged in the domestic animal.

"Mr. J. W. Cunningham, now living at Erie, Pa., formerly of Howard County, Nebraska, in a recent letter presents many interesting facts in connection with this subject, based upon his own experience, which renders them of great importance to the farmers and breeders of the western country. He writes: 'The buffaloes on my ranch consisted of two young cows and one bull. I fed them carefully with the cows, but kept them confined at night. In the spring it was discovered that two of my cows were with calf by the buffalo bull. The calves proved to be both heifers. When three years old they became mothers, the sire being of short-horn stock. The calves were weaned, and the mothers, although showing some of the buffalo characteristics, proved to be very good milkers, quite gentle, giving an average of fourteen quarts of milk per day for at least five months, and such rich milk I never saw. This strain of buffalo stock extends through a considerable section of Howard County. I have a half-bred bull of this stock which proves to be both useful and attractive. There are others, I learn, in other sections of Nebraska who own half and quarter breeds that prove to be very hardy.' From other sources in the West we learn that the cross of the American bison with native and grade short-horn cattle has proved completely successful, experiments having been tried on a sufficiently large scale to satisfy the most skeptical people. Utilizing the buffalo for dairy purposes is an old custom in the hot countries of the eastern continent, where almost all the cheese is made of buffalo milk. The business in this country is comparatively new and not yet fully developed, but we may reasonably hope to see it spread like wildfire in the course of a few years throughout the entire western country."—J. A. A.]

ERRATA.

NOTE.—Owing to the author's absence in the West, proof was not read by him; hence a number of typographical errors occur, which are here corrected.

Page 601, line 20, for *not* read *most.*
Page 608, line 15, for *Pcver* read *Peace.*
Page 608, line 19, for *lower* read *locust.*
Page 609, line 37, for *Ball* read *Boll.*
Page 636, line 25, dele *head.*
Page 636, line 27, for *are* read *it is.*
Page 659, line 45, for II read LXIII.
Page 664, line 15 from bottom, for 7, *a* read 6, A.
Page 664, line 13 from bottom, for 7, *b* read 6, B.
Page 664, line 10 from bottom, for 7, *c* read 6, C.
Page 664, line 9 from bottom, for 7, *d* read 6, D.
Page 664, line 6 from bottom, for 7, *e* read 6, E.
Page 665, line 1 from top, for 7 *f* read 6, F.
Page 665, line 5, for *Tremotodes* read *Trematodes.*
Page 665, line 14, for *Chironomas* read *Chironomus.*
Page 665, line 38, for 6, *g* read 6, G.
Page 665, line 5 from bottom, for Smerton read Emerton.
Page 666, line 21, for 7 *a, f, i, and k* read 6 A, F, I, K.
Page 667, line 13, for *h* read H.
Page 668, line 21, for *p.* — read *p.* 622.
Page 673, line 5, for *Eucaliptus* read *Eucalyptus.*
Page 684, line 2, for *white* read *uhler.*
Page 684, line 10 from bottom, for *chorian* read *chorion.*
Page 689, line 18, for (*p.* —) read (*p.* 639).
Page 694, line 25, for *botanist* read *entomologist.*
Page 696, line 6, for 2 *a* read 1 *a.*
Page 696, line 10, for IV read LXV.
Page 696, line 19, for *larva remains* read *larvæ remain.*
Page 707, line 38, after *p.* insert 696.
Page 712, line 37, after *Army-worm* insert *Leucania.*
Page 713, line 26, for *cenalium* read *cerealium.*
Page 713, line 38, for *Anguilluta* read *Anguillula.*
Page 715, line 18, for 6 read 7.
Page 718, line 25, for 8, *b*, read 9 *b.*
Page 719, line 7 from bottom, for *nitella* read *nitela.*
Page 720, line 2 from bottom, for *ches* read *elus.*
Page 725, line 29, for *Le Bauer* read *Le Baron.*
Page 726, line 4 from bottom, after *Fig.* insert 1, *e*, Pl. LXVI.
Page 727, line 2 from bottom, for *craspiena* read *crassispina.*
Page 727, line 5 from bottom, for *scjeanii* read *dejeanii.*
Page 729, line 40, for *heed* read *breed.*
Page 730, line 7 from bottom, for Fay read Say.
Page 730, line 9 from bottom, for *muria* read *murina.*
Page 730, line 18 from bottom, for *cinerea* Foster read *fabricii* Le Conte.
Page 733, line 14, for *clarata* read *clavata.*
Page 755, line 5 from bottom, after *page* insert 732.
Page 767, line 8 from bottom, for 32 read 34.
Page 772, line 12, for *cucumen's* read *cucumeris.*
Page 773, line 16, for *grunt* read *snout.*
Page 774, line 9, for *apiifolia* read *apiifolia.*
Page 774, line 10, for *Pylygonia* read *Polygonia.*
Page 774, line 14, for *Bœhmeria* read *Bœhmeria.*
Page 782, line 2, for *pampinating* read *pampinatrix.*
Page 785, line 20, for 55 read 51.
Page 786, line 1, for *flanda* read *flavida.*
Page 786, line 17, for *Erythionenis* read *Erythroneuris.*
Page 790, line 32, for *Pristophora* read *Pristiphora.*

ERRATA—Continued.

Page 794, lines 14, 15, dele *which may in time leave the oak on which it feeds and attack the apple*
Page 794, line 4 from bottom, for *Le Barm* read *Le Baron.*
Page 795, line 11, for *Le Barm* read *Le Baron.*
Page 802, lines 16, 37, for *Tornicus* read *Tomicus.*
Page 807, line 29, for *Lapper* read *Lappet.*

INDEX.

For *Anisopteryœ* read *Anisopteryx.*
For *Anomys* read *Anomis.*
For *Bœhmeria* read *Bœhmeria.*
For Californian Lapper-Moth read Californian Lappet-Moth.
For *Chocaltis* read *Chloëaltis.*
For *Clisiocampa constrictu* read *Clisiocampa constricta.*
For *Chœnocampa pampinating* read *Chœrocampa pampinatrix.*
For *Dicerea prologata* read *Dicerca prolongata.*
For *Doryphora sejeanii* read *Doryphora dejeanii.*
For *Epicautaue* read *Epicauta.*
For *Erythionenis* read *Erythroneuris.*
For *Eufitchea* read *Eufitchia.*
For *Excorista* read *Exorista.*
For *Eyrytoma* read *Eurytoma.*
For *Haltica cucumenis* read *Haltica cucumeris.*
For *Lugus* read *Lygus.*
For *Meromyga* read *Meromyza.*
For *Pristophora* read *Pristiphora.*
For *Tornicus* read *Tomicus.*

REPORT ON THE ROCKY MOUNTAIN LOCUST

AND OTHER INSECTS NOW INJURING OR LIKELY TO INJURE FIELD AND GARDEN CROPS IN THE WESTERN STATES AND TERRITORIES.

By A. S. Packard, Jr., M. D.

LETTER OF TRANSMITTAL.

Peabody Academy of Science,
Salem, Mass., April 29, 1877.

Dear Sir: I herewith present a report on the Rocky Mountain locust and other insects injurious to the field and garden crops of the Western Territories, including a few injurious species found on the Pacific coast, which section of our Union is happily remarkably exempt from noxious insects. I have included in the report a few forms found injuring the timber-trees of Colorado, and described others, which, from the habits of their allies in the Eastern States, will undoubtedly in future years be more or less destructive. I have also introduced accounts of certain eastern species which will probably from time to time be transported to the Western States and Territories east of the great plains. Accounts of the cotton army-worm, the northern army-worm, as well as the tobacco-worm, etc., are introduced to give completeness to the subject.

My report is partly based on the results obtained in Colorado, Wyoming, and Utah, while attached for seven weeks to your survey, late in June, the whole of July, and early in August, 1875. I have also received assistance from Mr. P. R. Uhler, who, as a member of your Survey, visited Colorado the same summer. My thanks are due to him as well as to Mr. William N. Byers, of Denver, Colo., editor of the Rocky Mountain News, for valuable information regarding the locust, and also to Mr. John L. Barfoot, curator of the Salt Lake Museum, for notes on destructive insects in Utah. Acknowledgments and thanks are due to other gentlemen whose names are mentioned in the following pages.

Some of the matter relating especially to eastern insects is taken from my own notes made for a number of years past in Maine and Massachusetts. I should also acknowledge the important information and illustrations derived from the nine annual reports of Prof. C. V. Riley, State entomologist of Missouri; from the fourteen annual reports of Dr. Asa Fitch, State entomologist of New York; as well as Harris's "Treatise on the Injurious Insects of Massachusetts." Some of the facts and a large proportion of the illustrations are taken from my "Guide to the Study of Insects," published by Henry Holt & Co., New York, and from the "American Naturalist."

In preparing the accounts of the Hessian fly, wheat-midge, the wheat joint-worm, and chinch-bug, as well as the cotton army-worm, I became painfully aware of the unreliable and fragmentary nature of our knowledge of the distribution and habits of these insects, and of the great need of a systematic and thorough inquiry into their natural history.

The facts here presented may often seem disconnected and desultory, but few except experts in natural history are perhaps aware how difficult a task it is to follow out the transformations of any particular insect, and study thoroughly its habits in its different stages of growth. Unlike fishes, birds, and quadrupeds, which have similar habits at all stages of growth, an insect, with its three separate stages of larva, pupa, and adult, leads, as it were, three lives, with different surroundings, and in each of these stages may be regarded as a different animal. Then it is often extremely difficult to ascertain of what beetle or moth or bee such or such a grub or caterpillar is the young. Our entomologists are not numerous enough, and often, from their time being taken up with the pursuit of their profession, usually not that of science, are unable to be long enough in the field to observe for themselves the habits of insects. Unfortunately, also, so backward is the science of entomology in this country, that its students are at present fully engrossed with the labor of classifying and describing the adult insects. When it is to be borne in mind that there are within the limits of the United States, probably at a low estimate, 10,000 species of *Hymenoptera* (bees, wasps, ichneumon-flies, saw-flies, etc.), nearly as many butterflies and moths, about 10,000 species of two-winged flies (*Diptera*), as many beetles (*Coleoptera*) and bugs (*Hemiptera*), and several thousand species of grasshoppers, etc. (*Orthoptera*), and neuropterous insects, such as dragon-flies, caddis-flies, etc., etc., the whole amounting to upward of 50,000 species of insects, not to speak of the spiders, mites, and ticks, centipedes and millipedes, it is evident that in the mere preliminary work of identifying and properly describing these myriad forms—an intellectual work requiring quite as much good sense, discretion, and knowledge as is shown in the pursuit of medicine, the law, or teaching—it is evident that all this work, which is simply preliminary in its nature, is a vast one, and that the combined exertions of many minds over several generations will not exhaust the subject. As it is, there are in this country only about thirty entomologists who publish anything relating to insects. Necessary as it is, this work of classification is by no means the highest and most useful branch of natural science. He who studies carefully the habits and structure of one insect, and, if it is injurious to agriculture, lays before the farmer or gardener a true story of its life, is a true benefactor to agriculture, and at the same time benefits science more than he who describes hundreds of new species.

We have little idea how many kinds of insects are preying upon our field and garden crops, our shade, ornamental, and forest trees. There are, probably, within the limits of our country 5,000 different kinds, which are either at present engaged in the work of devastation, or are destined to be, with the growth of civilization, which means in this instance the destruction of the natural food of these insects and the substitution of a similar diet, our choicest grains and fruits, in its stead.

In the densely-populated countries of Europe the losses occasioned by injurious insects are most severely felt, though from many causes, such as the greater abundance of their insect-parasites and the far greater care taken by the people to exterminate their insect-enemies, they have not proved so destructive as in our own land. MM. Pasteur and Quatrefages, whose names are illustrious as original investigators, were commissioned by the French government to study the causes of the silkworm disease, *pebrine*, and, as the result of their studies, silk-culture, an interest involving millions of dollars, will probably again be restored to France and Italy. It should be remembered that this remarkable result is due, primarily, to the most abstruse researches upon a microscopic plant by specialists, for the pure love of science. Their cloister studies, put to practical account, saves the destruction of one of the largest agricultural interests in Southern Europe. In like manner, had the United States encouraged the entomologist and botanist in their studies, and caused them to be turned to practical account, we should not have had to give up the cultivation of wheat in the Northeastern States; our cotton-crop could perhaps have been doubled, and our garden and field crops would have regularly yielded a steady return to the producer.

Let us look for a moment at the losses sustained in the United States from the attacks of insects. The annual agricultural products of this country by the last census amounted in value to $2,500,000,000. Of this amount we in all probability *annually* lose over $200,000,000 from the attacks of injurious insects alone. The losses from the ravages of the locust in the border States in 1874 were estimated at $45,000,000. The estimated money loss occasioned by the chinch-bug in Illinois in 1864 was over $73,000,000; in Missouri, in 1874, it was estimated at not less than $19,000,000. The average annual loss from the attacks of the cotton-worm is probably between $25,000,000 and $50,000,000. Add to these the losses sustained by the attacks of over a thousand other species of insects which affect our cereals, forage and field crops, fruit-trees and shrubs, garden-vegetables, shade and ornamental trees, as well as our hard and pine forests and stored fruits, and it will not be thought an exaggeration to put our annual losses from the ravages of insects at $200,000,000. If the people of this country would only look at this annual depletion, this absolute waste, which drags her backward in the race with the countries of the Old World, they might see the necessity of taking effectual preventive measures in restraining the ravages of insects with care and forethought, based on the observations of scientific men. I believe that from $50,000,000 to $100,000,000, or from one-quarter to one-half of this annual waste, could be saved to the country. It is to be hoped now that the National Government has caused the locust evil to be investigated, such other insects as the chinch-bug, cotton-worm, Hessian fly, &c., may hereafter be examined and reported upon.

With thanks for the liberal spirit you have shown in causing the injurious insects of the Territories surveyed by you to be studied, and for the generous way in which this report has been illustrated, thereby greatly increasing its practical usefulness to the people of the Territories visited,

I remain, very truly, yours,

A. S. PACKARD, JR.

DR. F. V. HAYDEN,
United States Geologist-in-Charge.

INSECTS INJURING CEREALS, GRASSES, ETC.

THE WESTERN MIGRATORY LOCUST, *Caloptenus spretus* of Thomas, appearing periodically in vast swarms in Utah, Montana, Idaho, Dakota, British America, and Colorado, and Texas and Indian Territory, and periodically migrating eastward to Minnesota, Iowa, Nebraska, Kansas, and Western Missouri; a medium-sized grasshopper, with red hind legs, consuming entire fields of grain, corn, grass, etc., eating both stalk and leaves.

As a study of the habits, distribution, and ravages of the western migratory locust is of special importance, and the desire for fresh information regarding the habits of the insect in its home on the elevated plateau of the Rocky Mountains led Professor Hayden to urge me to give special attention to these points, I shall devote a good deal of space to a description of the habits of this insect, whose ravages have been and are still destined to be so calamitous.

I will first give an account of my own observations in the Western Territories, and then give a general account based on the facts observed by different entomologists, and close with suggestions as to the remedies to be employed and measures that should be taken by Government and State and Territorial authorities to anticipate future invasions. I have not attempted to give a full historical sketch of locust invasions in the line of States lying directly west of the Mississippi River, beginning with Minnesota and ending with Texas, forming the eastern limits of the locust region, since this has already been done by Professor Riley in his seventh and eighth annual reports on the injurious insects of Missouri, and the facts given by him and others are epitomized in the tabular view of the locust migrations inserted near the end of the present report. Mr. Allen Whitman, in his valuable "Report on the Rocky Mountain Locust, for 1876," has given an account of the locust invasions in that State, with valuable notes on the habits of the insect. From the data he has there published I have been able to correct the tabular view of locust invasions I had extracted from my report and published in advance in the American Naturalist for January, 1877. In addition to what is stated in his report for 1876, Mr. Whitman writes me, under date of February 18, 1877: "I cannot find that there was any appearance of locusts in Minnesota in 1855. The only authority that I know for it is the article by A. S. Taylor, in the Smithsonian Report for 1858, which mentions them as appearing on the reservations, or, at least, among the Indians."

THE LOCUST IN COLORADO.

I first saw the effects of the ravages of this locust along the railroad leading from Cameron, Mo., to Kansas City, June 24, 1875. It was stated to me that the devastations of the grasshopper extended over an area of 300 square miles, beginning at a point about 50 miles east of Kearney and extending about 70 miles west of Kansas City. At this date the locusts had left the country two weeks previous, but a few feeble stragglers being left, with red mite under the wings. The corn and wheat fields were bare; now and then scattered, half-eaten corn-stalks indicated the former presence of a flourishing field; rarely had a field been left untouched. It was evident that the swarms were local in their attacks. As regards the devastations of the locust in Missouri in 1875, the reader is referred to Prof. C. V. Riley's "Eighth Report on the Noxious, Beneficial, and other Insects of the State of Missouri," 1876, where ample details are given.

At Lawrence, Kans., the town and surrounding country had been swept by vast swarms, leaving scarcely a green thing, except in one portion of the town which had been left untouched. Until June 25 the air had been filled with locusts flying at a great height, but after that date they were not seen, and but a few stragglers were observed, hopping feebly about the roadside. The marks of their jaws were apparent on the fences and on the bark of apple and peach trees, in which rings had been gnawed. The grounds about one house had been protected by tarred boards nailed to the fence, and by ditches within the inclosure which were emptied as fast as they were filled, at least 70 bushels having been taken out. An attempt was made to save valuable fir-trees by covering them with blankets, the edges of which were kept down by soil, but still the locusts crept under. Peach-trees were defoliated, the fruit devoured, and the stones left attached to the stems, while the branches were girdled. As the habits of the grasshopper were studied at Lawrence by Prof. F. H. Snow, of the University of Kansas, and published in the Transactions of the Kansas Academy of Science for 1875, I condense his statements as the results of the observations of an accomplished entomologist living farther west than any other trained observer. Professor Snow first observed the recently-hatched locust on the 6th of April. "They were very diminutive in size, and when disturbed by my walking among them, would hop only two or three inches high, looking very much like the grains of sand in rapid motion upon a vibrating acoustic plate." About the 10th of May the young locusts began to desert their hatching-grounds, which, it should be borne in mind, is where the locusts which had arrived from the Rocky Mountain plateau during the previous summer laid their eggs, the latter being the parents of the brood observed by Professor Snow. As these locusts increased in size they spread around, and it was at this time, namely, before the wings are formed, that they were most injurious. In fifty-five days after hatching, the locust acquires its wings and takes flight. They were first seen to rise and take flight, for their final departure, on June 3. By the 12th of June, just two weeks from the time of their last molt, very few remained in the pupa (or partially-winged) condition. The destruction in 1875 was confined to a narrow strip on the eastern border of Kansas, along both sides of the Kansas Pacific Railroad.

Between Lawrence and Topeka the damage was much less than about Lawrence, and west of Topeka I could not see that the crops had been affected. At Fort Riley very few locusts were seen along the railroad-track. Reaching Denver June 26, a few locusts, the remains of the spring swarms, were seen hopping over the ground. At Denver, 5,211 feet elevation, the young hatch from March 15 until May 15; there is an early and a late brood. A farmer told us that he saw the young on the snow March 20, and again after another fall of snow March 28. A month later, about the middle of April, a second brood, and about the middle of May a third brood appears.

At Boulder the injury from grasshoppers had been light; the grasshoppers appeared in greatest numbers about the 1st of May, stripping some cornfields, and destroying about half the crop, and then went up the Boulder Cañon, May 15. They were still not infrequently seen on the plains.

June 30, at Nederland up the Boulder Cañon, I first saw the locusts flying in the air, toward the west, the wind blowing from the east. Their pupæ were very abundant on grass, logs, etc. I was told that they had become fledged on the 25th–27th, and immediately began to fly westward up the cañon. At Caribou (9,167 feet elevation), the grasshoppers had destroyed the first crop. Around the base of Arapahoe Peak, between 11,000 and 12,000 feet elevation, adult winged locusts were seen, but no young.

July 2, in riding from Nederland to Blackhawk, the air was filled with grasshoppers at an altitude of several hundred feet, sailing on the wind and driven eastward. The stage-driver told me that they had been flying five days. The potato-plants were at this point 5 inches high. At Blackhawk, (7,543 feet elevation), the pupæ of the locust was abundant, as well as winged individuals.

At Golden, at base of the Foot Hills (5,729 feet elevation), July 3, the locust had been fledged for five days, and the pupæ were still abundant mingling with the pale-green pupæ of *Caloptenus bivittatus* and the larvæ and adult of *Œdipoda carolina.*

At Idaho Springs (7,330 feet elevation), July 5, the young larvæ of the locust were smaller than I had yet seen, being about a quarter of an inch long, and in all stages, from the lately-hatched to the pupæ and winged individuals. I was told, however, that the first brood of locusts hatched about the end of April and early in May, but that winged individuals did not appear until June 20. On Gray's Peak, July 7, owing to the coolness of the day, a little snow falling on the summit and rain below, no grasshoppers, wingless or winged, were seen. In Kelso Gulch, near Georgetown, no young were seen, and but a few winged ones. At Georgetown (8,412 feet elevation), on the flats near the town the young were a quarter to one-half an inch long. Mr. R. S. Morrison informed me that the locust at Georgetown begins to hatch about the 1st of June, a month or more later than at Denver, and continues to hatch out until the 1st of July, as the localities differ in height. About June 23, he said, the locusts begin to get their wings, but they do not migrate until August, when they assemble in great swarms on the mountains, and falling on the snow in immense numbers, are eaten by the bears.

July 9, at Floyd's Hill the grasshoppers were seen by thousands flying westward up the cañon. I did not go into South Park, but was told by an intelligent young man that at a point about a thousand feet below the level of the park he saw the locusts flying about June 25.

July 12, in the Garden of the Gods (about 6,200 feet elevation), while there were few to be seen on the ground, the air was filled with them, flying at all distances from 100 to more than 1,000 feet, for their altitude could be approximately measured by the highest sandstone column of the Cathedral Rocks. When a locust takes wing, it rises more readily on a light breeze and flies off in a zigzag course, gradually rising in height until it sails about, if the wind is light, in an uncertain course. In the Garden of the Gods, where the breeze was northeast, they were driven southwest; but farther up the valley, toward Manitou Springs (6,297 feet elevation), when the wind was westerly, they were borne in an easterly direction. Their rapidity of flight seemed to depend on the strength of the wind, and when the latter was light, individuals could be seen flying about in all directions, crossing each other in their flight, but the swarm as a whole were moving with the wind. A few pupæ were seen on the ground.

At Manitou, the locusts are said to have hatched out in April, and to have taken two months to get their wings. A few pupæ were still to be seen in the oats, and in the spring they did a good deal of damage, thinning the oats and devouring the beets and other garden-vegetables. There were few grasshoppers to be seen in the air at half past 8 in the morning, but by 11 o'clock there were many more. There is probably good ground for the popular opinion that they descend to the ground at night and fly up toward midday, flying by day and resting and feeding at night.

At this date I was informed by a man who had just arrived from Fair Play (elevation 9,964 feet) that there were few locusts (*C. spretus*) in South Park (8,000 to 10,000 feet elevation) and Arkansas Valley this summer.

Mr. W. H. Holmes, assistant on the Survey, writes from Southern Colorado that the grasshoppers had "eaten up everything" on the La Plata.

On July 14, I ascended Pike's Peak, and at an elevation of about 8,000 to 9,000 feet found larvæ in the second stage and pupæ of *C. spretus.* Some not more than one-fifth of an inch long were seen clustering on the fallen trees by the side of a brook, while the adults were flying perhaps 1,000 feet overhead. On the extreme summit (elevation 14,147, Parry's estimate 14,216, feet), the locusts were flying, though not in great abundance, at least 500 feet above the top; some fell with a thud on the rocks and seemed paralyzed or were found benumbed on the snow. I did not notice that they were flying in any determinate direction, but as vast numbers of a green Haltica covered the low alpine vegetation, I judge that as these had evidently been borne up by currents of wind from the plains below, the locusts had been carried up in a similar manner, especially as they were more abundant on that day at an elevation of 8,000 to 9,000 feet. That, however, even at this latter elevation, the winged locusts had probably come from the plains east of the mountains seems evident, as the young born at this altitude had not yet acquired their wings. Indeed, it seems to me exceedingly doubtful whether those born above an altitude of 8,000 or 9,000 feet arrive at maturity if they do acquire wings; their flight is only local, from one cañon to another. It seems evident that the vast swarms which appear occasionally must have been hatched on the plains to the west and northwest, at an altitude of 5,000 to 7,000 feet.

As regards the inferences to be drawn from my own observations in Colorado, which were made between June 27 and July 19, namely, after the spring brood had taken flight and before the late summer swarms had arrived on the plains, I would state:

1. That in the cañons and mountains above an elevation of about 8,000 feet the young were too few in number and too late in their development to supply the material for the swarms that visited the plains about Denver in August.

2. The grasshoppers seen by me sailing in the air between about 6,000 and 9,000 feet elevation were probably derived from the April and May broods of the plains about Denver, east of the foot-hills of the Rocky Mountain Range.

3. The August swarms which spread over the plains about Denver and the country north and south, within a hundred miles or so, originated in Colorado, but probably not the adjacent Territories, and were derived from those bred on the plains about Denver directly east of the mountains, which were borne aloft in June, and then collected in large swarms and migrated back, borne by westerly winds, later in the season, to find suitable places for laying their eggs. It is not improbable that the earliest local swarms, such as devastated the plains of Colorado, bred in the plains about Denver, and gathered for about a month in the lower portion of the mountain valleys into the compact and well-organized swarm which, to some extent, devastated the Colorado Plains. Undoubtedly the sexual instinct leads large swarms, bred during favorable seasons, to migrate in search of broad plains which afford the proper conditions for the deposition of their eggs and the nourishment of their young. But it is evident that the parks and cañons of the Rocky Mountains of Colorado, all of which lie above an altitude of 7,000 feet, present conditions of elevation, climate, extent of territory, and food too unfavorable for the production of the immense swarms which at long intervals devastate the Colorado Plateau and portions of Kansas and adjoining States. It is most probable, however, that the late August and early September broods of locusts noticed by Mr. Byers about Denver may have been born and bred during exceptionally dry seasons in the plains of Wyoming and Montana, and thus appeared in Colorado a month later than those bred east of the mountains. It is doubtful if the young individuals (larvæ) which I saw at different elevations up to

about 9,000 feet ever arrived at maturity; they may winter over and acquire wings in the spring, but this is improbable.

In Northern Colorado the grasshoppers may have in part taken wing from the Laramie Plains of Wyoming and the plateau east of the Black Hills, while the swarms devastating Southern Colorado may have been in part indigenous and in part derived from the plains of New Mexico on the south and Utah on the west.

As I was not able to observe the locust in spring or late in the summer, I am obliged to rely on the statement of others regarding the habits of the locust at these periods. The following letters from W. N. Byers, esq., written at my request, give an able summary of the results of his observations and are of value, as the leading points confirm my own impressions. It will be seen that I quite agree with Mr. Byers's view that comparatively few of the swarms originate in the mountain cañon, as originally stated by the late Mr. B. D. Walsh (based on the statements of Drs. Parry and Velie), and reiterated by others:

DENVER, COLO., *August* 22, 1875.

DEAR SIR: Your letter of 16th instant is before me, and fearing that it may be mislaid or overlooked if not answered until "the close of the season," I will endeavor to reply, so far as able to do so, now.

Some years ago I answered a similar inquiry from Prof. Cyrus Thomas, also of Dr. Hayden's Survey, and I think it found place in some one of the reports. My opinion respecting the hatching-fields, &c., of the grasshopper was then seriously questioned, but Professor Thomas, after another year's observation and study, freely admitted that I was right. I presume you have seen what I wrote at that time, or if you have not, that you can readily do so. My opinions have not changed since. I may here say that I first made the acquaintance of the destructive grasshopper in 1852, about the 1st of August, upon the plains of Northern Utah and Southern Idaho, at which time they were flying east-northeast in swarms that obscured the sun.

Their breeding-places may be in any part of this arid portion (the western half) of the United States. The *great* swarms that attain maturity and migrate are hatched, doubtless, within altitudes ranging from 4,000 to 7,000 feet above sea-level. At 7,000 to 8,000 feet they may so far mature as to make short flights and remove to new localities not far distant. Above 8,000 feet they seldom, if ever, become able to fly, though I have seen myriads of them hatched at 10,000, 11,000, and even up to 12,000 feet above the sea. Probably they did not attain more than one-third of their growth before being destroyed by autumn frosts and snows.

The most favorable hatching-grounds are the plains like this east of the mountains, upon which are situate Denver, Pueblo, Greeley, Cheyenne, Fort Laramie, &c., from 4,000 to 6,000 feet above the sea. Where they settle down to propagate their species they must have subsistence; hence there must be fertility and vegetation. As to the latter, they are not very particular, but are sure to take the best there is. Sexual union begins in August and the deposit of eggs soon after, and both continue then until stopped by severe frosty weather, say in October. They choose, first, plowed ground; second, comparatively loose sandy or gravelly land, partially but not thickly covered with grass or other vegetation; third, the most favorable spots where they may happen to be and from which they are not able to get away. The female, with her nether extremity, perforates a hole in the ground about as deep as the length of her body, and deposits a cluster of eggs that resemble in size and form the eggs of the caterpillar-moth attached to the twig of an apple or cherry tree, except that in the place of the twig there is a hollow space. They are cemented together by a glutinous substance, which is doubtless impervious to water. The eggs deposited, the hole above them is soon filled and leveled by wind or rain. In a warm winter young grasshoppers are frequently found hatching out at various periods. They have been noted here in November, in February, March, and April, but of course only in limited areas and small numbers; and such do no harm, being soon destroyed by cold. The main hatching begins about the second week in May, and lasts, say, a month. At higher altitudes, from 7,000 to 12,000 feet (if eggs happen to have been deposited there, which is rarely the case), the hatching continues from the above dates until the last of August or even into September, owing to the altitude. But from all these latter no harm need ever be feared.

The flight of moving swarms is governed mainly by the prevailing winds, although they seem to be controlled somewhat by choice or laws of their own. A change of wind, or particularly a sudden chill, even slight, brings a flight of them quickly to the ground; but if the next day is fair and warm, and the wind favorable, they again circle into the upper air and resume their flight. They may tarry for several days, their march depending upon the weather and the sun's warmth—the warmer the better for them.

The "cañons of the mountains" (a very prevalent idea in the East) produce but *very few* grasshoppers—probably not 5 per cent.; the higher cañons none that ever leave them.

I suppose that the swarms that devastated Nebraska and Kansas in 1874 were natives of the plains of the Upper Missouri branches, the Yellowstone, Powder River, and the North Platte—that great plateau-land lying between the Black Hills and Rocky Mountain chains in Montana and Northern Wyoming.

The same flights overspread Eastern Colorado in 1874, destroyed the late crops and deposited their eggs. The latter hatched out in May and June (very irregularly), and the young ate up the early crops, and one, two, and in some cases three subsequent plantings. In July most of them took flight, but frequent swarms have appeared since in various parts of the Territory, and they are now doing considerable damage in several counties. Their movements this year have been very erratic and entirely uncertain. These various flights—none of them very numerous—have been in various directions, and there seems as yet little disposition to deposit eggs. I am told that most of them are afflicted with parasites, and if so they will soon disappear. They perished from that cause in 1865. It would be easy to learn exactly the nature and habits of this plague, provided observers can be secured all over this arid region. They afflict some portion of it every year. The scourge only moves from place to place. If Government can secure report, for instance, from every district in which they hatch next spring, then trace the flight of the moving swarms during the summer and fall, their habits can be accurately determined. It is a far more simple task than the operations of the Signal Service Bureau.

If at any time I can serve you further, or if you desire more definite report this fall of the season's results, please let me know.

Meantime, believe me, very truly, your obedient servant,

WM. N. BYERS.

A. S. PACKARD, JR., M. D., *Salem, Mass.*

HOT SULPHUR SPRINGS, COLO., *October* 1, 1875.

DEAR SIR: In response to your postal card of August 30, I have but little more to report respecting the grasshopper. I have studied them with some care here this fall, and will give in brief the result. The first flights came to this neighborhood in the first week of August—not numerous—and most of them disappeared in three or four days. In the second week of August others came and in great numbers, and they have remained ever since. I was absent the latter half of August. In the first week of September I was again here and found them pairing. Many of the females were boring holes and appeared to be depositing eggs, but on examination it was found that very few actually were deposited. The bottom of the hole generally contained a small quantity of frothy, gelatinous matter, such as accompanies the eggs; but I think in only two instances during that week did I find eggs, and then only six to ten. The next week, however, brought on the height of the season. Myriads were boring in the ground everywhere, and from one-half to two-thirds of the perforations were found to contain from 15 to 30 eggs each, from one inch to two inches below the surface. In many places the earth was perfectly honeycombed by their nests. At this time (the second week in September) they had begun dying quite rapidly, and the living were feeding largely upon the dead. As the season advances they subsist more and more upon the dead and eat less vegetation. Now (October 1) they are eating the dead and dying when not too torpid to care about eating at all.

I was again absent the last half of September, and have returned but two days ago. There are still plenty of grasshoppers here, but most are dead. Occasionally a couple are seen paired, but I have found none depositing eggs.

I learn that last year eggs were deposited in North Park and that they hatched there in countless swarms the present season. I presume our flights came from there. At any rate we are certain of the young ones here next year. The altitude here is 7,725 feet above the sea. The west half of the park escaped them. They extended but five or six miles west of this point; that is, the swarms that deposited eggs. The first swarms (1st to 5th of August) were more general, but did not stay.

About Denver, and over a large portion of the agricultural country in that neighborhood, the flying swarms were bad in the latter part of August, but most of them moved on. Only in a few and comparatively limited neighborhoods were many eggs deposited.

Of those that died here a few were killed by a parasite, developing a maggot which eats out the body of the grasshopper; but the great majority perished from exhaustion and cold—old age, perhaps.

Very truly, yours,

WM. N. BYERS.

A. S. PACKARD, JR., M. D., *Salem, Mass.*

P. S.—Since writing the above I have made another grasshopper survey, and find numbers of them yet depositing eggs.

By the same mail with this I send you a small box of the eggs. I find in some places the ground at the proper depth is fully *one-fourth* filled with their eggs. From this you may form some idea of their incredible numbers. I find also that numerous burrowing insects, worms, &c., are living off them.

W. N. B.

The earliest swarm of which I can find authentic information is one seen at Boulder, Colo., by Professor Robinson, and whose history he has kindly given in the following account. It seems impossible that this swarm which began its migrations so early as July 20 could have been raised among the parks or cañons of the mountains. We are forced to the conclusion that they were bred on the plains, and collecting and massing east of the mountains were borne by westerly currents beyond the usual breeding-grounds of the species across the plains to Eastern Kansas.

UNIVERSITY OF KANSAS,
Lawrence, Kan., October 11, 1875.

DEAR SIR: I will very gladly give you my observations upon the swarming of the locusts from the Rocky Mountains eastward in the summer of 1874.

I arrived at Denver on my westward trip about the 23d of June. During a stay of six or seven days in the city, I made frequent excursions to the neighboring country, visiting "ranches," rambling through fields of grain and over the prairie, with eyes wide open for locusts, potato-bugs, &c., of whose ravages I had previously read many reports. At this time I found very few locusts anywhere, not enough to do any perceptible damage to vegetation. About the 1st of July I went over the Snowy Range down into Middle Park. Here I eagerly renewed my search for locusts, urged on by the desire to use them as trout-bait; and you may be sure I hunted them vigorously, for with nearly every locust I could catch a fine trout. But the trout were far plentier than the locusts. Coming out of the mountains about the 20th of July, by way of Golden City, just at the base of the foot-hills, I encountered the advance of an immense swarm of locusts sweeping from the north, filling the air from the ground upwards for hundreds of feet. Two or three miles from the hills their flight appeared to swerve somewhat more toward the east. I passed through the swarm about five miles from where they were first encountered. The next day they settled down to business in the wheat-fields near Denver.

The 28th of July, leaving Denver for Lawrence, I overtook them at Salina. The 13th of August they first appeared in Lawrence. They staid about ten days, long enough to eat everything green, and then passed on to the southeast. Where food was abundant they traveled slowly. They were ten days in going from this place to Olathe, 27 miles farther east, and five or six weeks in reaching Sedalia, Mo.

Yours, respectfully,

D. H. ROBINSON.

In addition to the facts regarding the locust in Colorado in 1875, I may cite the following facts from Professor Riley's eighth report. Mr. N. C. Meeker, of Greeley, writes that "on the plains, they appeared late in April and the first of May; along the foot-hills in May; in the timber-region and along the Snowy Range from June to July. * * About the 1st of July, the first hatched in the plains-region departed toward the south. A week ago (August 20) those hatched in the Blue Mountains came down upon us and then departed in a southeasterly direction; but now we are having them from the Snowy Range in what may seem incredible numbers. Their numbers, however, are almost nothing in comparison with the myriads that keep southward every day about noon. I estimate that they cover in the sky east and west a space twenty or thirty miles wide, while they move in a body half a mile deep. They consume about two hours in passing, and we can estimate from this statement how much ground they would cover if they should all alight." It seems from this extract that so far north as Greeley the locusts came late in August from over the mountains to the westward, and not from the north, *i. e.*, Wyoming; while those hatched earlier in the season on the plains, went southward. "Signal-service observations made at Denver show that from the 20th of July to the end of August swarms repeatedly passed, and invariably from the north and northwest, notwithstanding that the prevailing direction of the wind was from the south." (Riley's report.)

I also add a letter from Mr. Meeker, published in the New York Tribune:

GREELEY, COLO., *May* 25.

We are trying every way we can think of to drive away the grasshoppers, and we are now in the midst of the battle, but the wounds of the conflict are mainly inflicted by the insects. Ordinarily, the grasshoppers are not hatched out of their eggs until the 1st of June. Before this period the ground is so wet and cold in consequence of the spring rains that the insects are not hatched out. This year we had no spring rains to speak of, hence the ground was warm and dry, and the insects appeared about the 25th of April. At this time the wheat was just starting, and the insects ate it as fast as it grew. Our wheat is sown in February and March, and it is of a superior quality, better than the winter-wheat of the Eastern States. If there had been the usual spring rains it would have been at least a foot high by the time the grasshoppers appeared.

Wheat that is starting is greatly injured by being irrigated, and usually it does not need irrigation. If the soil is light the water quickly cuts gulches which constantly deepen, and flooding the ground all over is impossible, especially if the land inclines any way. But after the grain has grown to some height its roots fill the surface-earth and the water cannot cut through them, and it forces its way hither and thither among the blades of grain, much as one is obliged to do in a crowd of men. So it spreads over the field and evenly with a little aid. When wheat is in this condition, and the young grasshoppers are hatched in sandy places open to the sun, they cannot eat the wheat as fast as it grows, and besides it is an easy matter, by irrigating the fields, to drown them, or at least to keep their numbers small. But even when they are eating the wheat in a half a dozen fields, or in a dozen fields in one neighborhood, as fast as it grows, there will be many other fields where the wheat is not molested, and by the time the pests are grown and have wings to fly a large breadth of wheat will be strong and vigorous, and consequently will mature. Usually, therefore, the young grasshoppers—which came to our fields only once before, two years ago—do but little damage, and the average yield of wheat during the year mentioned was as great as that of the Eastern States; while in ordinary years it is more than double. In this place and all through Colorado the gardens are as bare as in January, for no attempt has been made to plant vegetables. The grasshoppers do not touch pease, however, and these are growing fast.

But most of the mourning is about the condition of the wheat-fields. We have on the northwest about 4,000 acres sowed with wheat, and owned by thirty or forty farmers. The wheat is all gone, and that region looks like a desert. It is true that there are a few fields in the midst left, but we expect to hear every day of their destruction northeast and east of the railroad and along what is called Free Church. The owners are constantly on guard. When an advance detachment of grasshoppers appears it is attacked with fire and water, and thus for the present the enemy is kept at bay. On this side of the river, all the five-acre, ten-acre, and twenty-acre lots are without vegetation. To the south there are several hundred acres of wheat where the wheat is over knee-high and growing as if in a race for its life. We may save 500 acres of wheat out of 5,000, which will give us bread, but we expected to have obtained $150,000 from this year's crop. Meanwhile we are waiting. Corn will be planted in hundreds of fields within ten days. All kinds of garden-vegetables are now growing in boxes in the houses, waiting their chance to appear with safety in the outer air. I expect to sow half an acre of beets and get a large return. There is no seed-wheat in the country; if there were a crop could be grown; and there is scarcely corn enough for seed. There is no barley, nor have the farmers money to buy any.

All this is a fair description. As a people we are certainly better off than those further east, because we have water at our command, because our stock-range is preserved, giving to those keeping cattle their usual returns, while our mines of silver and gold are unfailing. But these resources do not help our farmers at all. There are some families now utterly destitute. Every dollar they had or could borrow was put into the ground, and it will never return. Friends of such in the East should help them if possible. Probably county commissioners can give some relief; the legislature may; Colorado is entirely out of debt. The grangers can do nothing for each other, for all are involved.

The total destruction of crops between the Mississippi and the Rocky Mountains is appalling, and I estimate that the number of people afflicted is nearly three millions. We, here, do not believe a word in the statements made from time to time that the grasshoppers are dying, or that a parasite is eating them. We have seen them come out of water, mud, and snow as strong as ever. They are "iron-clad." I wish I were as sure of one proposition as I am that a machine will be invented that will take them up from the ground and "leave not a wretch behind."

Additional facts regarding the occurrence of the locust (*C. spretus*) in Colorado and other Territories will be found in the following extracts from an article in the Daily Inter-Ocean, Chicago, October 9, 1875, from the pen of Prof. Cyrus Thomas, State entomologist of Illinois:

Their hatching-ground is known to extend over the vast area roughly designated by the following boundary-lines: On the east, the one hundred and third meridian; on the south, the south line of Colorado and Utah; on the west, the west line of Utah extended north to British America; the northern line being somewhere in British America—even this area in the northern part being expanded indefinitely east and west. Now for the proof. While connected with the United States Geological Survey, under Dr. Hayden, for four years, I traveled over a large portion of this area, traversing it on various lines east and west and north and south, studying somewhat carefully the habits of these destructive locusts. During this time I noticed them in the larva and pupa state, or depositing their eggs at the following places: At various points along the east base of and in the bordering valley of the mountains in Wyoming and Colorado, from North Platte near Fort Laramie to the Arkansas River; in Laramie plains, and around Fort Bridger; from Utah Lake, in Utah, to Fort Hall in Snake River Valley, Idaho; in Northwestern Dakota near the Red River of the North; and on both sides of the range in Montana along the valleys of Deer Lodge River, and the branches of the Upper Missouri. I also obtained satisfactory proof of the same thing occurring in British America, north of Dakota; in Middle Park, Colorado; and in the regions west of that point; in Wind River Valley, in Wyoming; in Central Montana along the Yellowstone, and in the Green River country west of South Pass. These facts, which are but a small portion of what might now be gathered, will give some idea of the work necessary to be done if we undertake to exterminate these insects by destroying their eggs in their native haunts. If it can be shown, which is doubtful, that the progenitors of the swarms which visit Kansas and Nebraska, after sweeping down from the mountain regions, deposit their eggs within the limited area heretofore mentioned as the point of departure east, then, and then only, is it possible to devise a preventive measure applicable to their native haunts, as this, with the exception of a comparatively small region around the headquarters of the Missouri, is the only portion of the broad plains lying along the east flank of the mountains susceptible of an extensive system of irrigation. Before alluding to their operations in Kansas, Nebraska, and other bordering States, I will present some facts in regard to their migrations in and from the mountains and northern regions which will assist the reader in forming a more correct idea of their habits and the extent of their operations; and here be it remembered I confine myself to the single species *Caloptenus spretus*. I have traced a swarm from the area west of South Pass to their stopping-place and hatching-ground north of Fort Fetterman, from Northeastern Dakota nearly to Lake Winnipeg, and have ascertained that some swarms have even extended their migrations, from some supposed southwest point, as far as the north side of this lake. It is also known that in one instance, at least, those which left Colorado moved in the direction of Texas; those visiting Salt Lake Valley have repeatedly come from the northeast, sometimes, doubtless, from Cache and Bear River Valleys, and at others from the Snake River region, while those hatched in Salt Lake regions moved south, in some instances returning with the change of wind. In 1864 those hatched east of the mountains in Northern Wyoming and along the Yellowstone in Montana swept down the east flank of the range upon the fields of Colorado, while a part moved east to Manitoba and Minnesota. In 1867 a swarm from the west side of the range poured into Middle Park and there deposited their eggs, but those hatched from these failed to scale their rocky bounds; yet, while these were vainly striving to leave their mountain prison, another horde from the barren regions beyond sweeping above them over the snowy crest, poured down upon the valleys east; and in another instance a swarm was seen passing for two days over Fort Hall from the southwest. On the other hand we find them extending their flight far into Texas in destructive hordes, yet New Mexico and Arizona appear to be comparatively free from them; at least the very extensive collections made by Lieutenant Wheeler's expeditions in these Territories during the last four years, which have been submitted to me, contain but very few specimens of the *C. spretus*, and during my visit to New Mexico in 1869 I found scarcely any specimens south of Raton Mountains, although comparatively abundant in Colorado, and even in San Luis Valley. I am therefore inclined to doubt the correctness of the statement made in reference to the grasshopper in these Territories in 1855, if intended to apply to this species.

These facts, if added to the experience of the last three years in Kansas, Nebraska, Dakota, Minnesota, and Manitoba, will suffice to show, not only how extensive their range is, but also how varied their flight is, and that there are no particular spots which can be said to form their permanent hatching-grounds. That they prefer the elevated sandy plateaus and terraces in the mountain districts is certain, but that any particular localities form the permanent hives from which the swarm issue cannot be maintained. Yet that those which visit Kansas and Nebraska, and even Dakota and Minnesota, originate usually within a certain portion of the mountain region appears highly probable. While there are some exceptions to the rule, yet it is evident that the general course of their flight east of the mountains is southeast. The distance traveled by any particular swarm, so far as I am aware, has never been positively ascertained, yet enough is known to indicate that this may extend for at least two or three hundred miles. The hordes which visited Colorado in 1864 are supposed by Colonel Byers to have originated in Montana, along the Yellowstone; and the swarm which I traced through Sweetwater Valley probably traveled over 200 miles; yet the evidence is not positive in either case, though strongly presumptive.

Maj. J. W. Powell informs me that in August, 1867, he encountered vast numbers of locusts in the region northwest of Pike's Peak, as he drove his wagons for five days through them, traveling at the rate of 20 miles a day. It is not probable that this was *C. spretus*.

In August, 1875, Mr. P. R. Uhler visited Colorado, and sends me the following notes on *C. spretus*:

When I first reached Golden, on August 6, small flocks of the *C. spretus* were flying from the direction of northwest (over the peaks evidently) and alighting on the hills and upon the crops in the irrigated fields; but these were nothing to the hordes which poured into the country near Manitou about August 13–16.

All the flocks that I saw consisted of *C. spretus*. I met with this species everywhere, from north of Denver to south of Cañon City, in the mountains and on the plains. But I did not see them as far east as Bijou. Perhaps they don't love that locality. And I noticed that the flocks alighted in particular spots, and did not appear all over the plains and hills west of Colorado Springs. Evidently they preferred some spots to others of the same kind of surface-soil.

In the Proceedings of the Davenport Academy of Sciences, Mr. J. D. Putnam writes as follows regarding his experience with the locust in Colorado:

I have collected this species in various parts of Colorado. It was quite plentiful on the plains between Denver and Boulder City in June, 1872, and later in the season I found it abundant in the mountains at Empire City. On August 1 they were very abundant high up above the timber-line on Parry's Peak. Vast numbers were chilled by the snow and lay at the base of the snow-drifts in heaps. They could be seen, filling the air like snow-flakes, to a great height above the extreme summit of the peak, 13,133 feet. The wind was from a westerly direction. In September, this year (1872), I found them in great abundance in Middle Park. In 1874 I first noticed this species on Gold Hill, Boulder County, July 8, and on July 11 they appeared at Valmont and other places on the plains in great abundance, and did great damage. They received several large re-enforcements during the following week. After remaining several days, these seemed to disappear, but only to make room for another swarm; and thus they kept coming and going during the rest of the summer until nothing eatable was left. At Empire City they were very abundant during the whole of my stay, from August to October, but they seemed to eat but very little, if anything. At Cañon City, in October, I found them very abundant. They were very sluggish, and the sidewalks were covered with the dead and dying. Large numbers were seen paired. The young grasshoppers hatched out abundantly early in April, 1875. In 1873 I found them in different parts of Western Wyoming, between Fort Bridger and the Yellowstone Lake; but on the plains bordering the Stinking Water River, in July, they were more abundant than I had ever seen them elsewhere before. In June, 1875, I collected a few near the transfer depot at Council Bluffs, Iowa. This is the most eastern locality I have yet seen it. In Utah last summer I failed to see a single specimen, although I looked specially for it. (Page 265.)

THE LOCUST IN WYOMING.

In going from Cheyenne to Salt Lake City, July 19 and 20, over the Union Pacific Railroad, no locust was seen, and the absence of insect-life within the limits of Wyoming was remarkable. As soon as the borders of Utah were approached, insects (but not the locust) became abundant. The locust, however, breeds as abundantly in Wyoming as in adjacent Territories, and is evidently one of the sources of supply for the swarms which invade Colorado. In proof of this I will first quote Professor Thomas, who makes the following statement in Hayden's Annual Report for 1876 on the Geology of Wyoming:

During the expedition of the present year, while traveling up the North Platte, between Fort Fetterman and Red Buttes (August 20–23), we observed vast numbers of this species. They were not on the wing, having to all appearances ended their flight, and were now pairing, doubtless intending to deposit their eggs there. Frémont encountered a similar swarm in passing over this part of the North Platte Valley. He remarks: "This insect has been so numerous since leaving Fort Laramie that the ground seemed alive with them; and in walking a little moving cloud preceded our footsteps. They had probably ceased their flight, and were preparing to deposit their eggs. By reference to my present report on the agriculture of this section it will be seen that here there appears to be an almost constant current of air sweeping down the Platte Valley from the west. When we reached South Pass City, I learned from Major Baldwin that about the first of the month (August) a large swarm had crossed over the pass from the west, moving eastward, and that they had not gone to Wind River Valley. I am satisfied that they did not go upon the Laramie Plains, as I visited that section twice during the season. Nor did we meet with any swarms during our passage up the Sweetwater; we may, therefore, reasonably infer that those we saw on the North Platte were the same that crossed the mountains at South Pass. From whence did they come? As we heard nothing of them during our passage down Big Sandy along the stage-road, I infer that they must have come from the northwest; but what distance I have no means of ascertaining."

Capt. W. J. Jones states in his "Report upon the Reconnaissance of Northwestern Wyoming," made in the summer of 1873, that in the Green River Basin "the region is infested with great swarms of grasshoppers." We have seen that Mr. Byers surmises that some of the swarms which devastate Colorado cross the Snowy Range from the Green River Valley.

THE LOCUST IN UTAH.

This Territory is much freer from the invasions of locusts than Colorado. In 1875 they were scarce, and had not been abundant for three years, all that were seen being evidently indigenous. In gardens in Salt Lake City, and in fields at Lake Point, in Salt Lake, in July, 1875, they were less frequent than the yellow-striped grasshopper (*Caloptenus flavovittatus*). I found them not unfrequently in Utah, though Mr. J. D. Putnam remarks: "In Utah last summer (1875) I failed to see a single specimen, although I looked specially for it." (Proc. Davenport Academy of Sciences, 266.) The invasions, as several persons told me, are from the north and northwest, the latter being the direction of the prevailing winds in summer. The swarms coming down from the north are sometimes turned back by the south winds, and when the wind changes over Salt Lake multitudes are drowned. The gulls, so common on the lake, were seen feeding on grasshoppers along the beaches. *Caloptenus spretus* is undoubtedly distributed over the entire Territory. Mr. J. L. Barfoot, of Salt Lake City, in charge of the museum, told me that he had received specimens (which I saw in the museum) from Kanab, in Southeastern Utah, and also from Dirty Devil Mountain. Professor Thomas also reports it as breeding in the southern and western line of Utah. In his letter to me Mr. Byers states that he first saw the locust in 1852, about the 1st of August, upon the plains of Northern Utah and Southern Idaho. Professor Thomas also gives the following data regarding its occurrence in Utah, in Hayden's Report on the Geology of Wyoming, 1870, p. 283:

As heretofore stated, they have been very destructive in Utah for the past three years, not only injuring very materially the growing crops, but eating the leaves from the fruit-trees to such an extent as to injure the fruit. From Dr. A. T. McDonald, of Provo City, I learned the following particulars in regard to the incursions of this insect into the Territory: That the prevailing cold and winter storms are from the northwest, but that the grasshoppers seldom come from that direction. On the contrary, they generally come from the northeast, through the cañons, being brought in by the local currents which sweep through these mountain openings, and that they generally pass off in a southwest direction, though the swarms that come in often remain and deposit their eggs, from which another brood arises in the spring. Sometimes, after a swarm has departed to the southwest, the wind changes, and they are driven back to be swallowed up in the lake or perish in the valley. The time of coming varies from the middle of May to the middle of August. The eggs that are deposited here usually hatch out in April and May. The growing crops receive their greatest injury from the young which are hatched in the valley. The usual method of fighting these young gormands is to drive them into the irrigating ditches, where they are drowned in the water. When they are a little older they are often checked by scattering straw along the edge of the ditches, and driving them into it early in the morning, and then firing it; those which are not destroyed by the fire being caught in the water of the ditch and drowned. But these methods of combating them are practicable only when they are in the larvæ and pupa states.

Dr. McDonald says that in Utah, at least, the females deposit their eggs in the ground in sacks—a fact heretofore noticed and published—on the gravelly elevated plateaus, or foot-hills. And from my observations this season I am inclined to agree with him in the opinion that these elevated table-lands, which are composed of coarse sand and gravel, and but slightly covered with vegetation, are the principal hatching-grounds of the migratory swarms. The local broods are to be found all over the Rocky Mountain region, from Raton Mountains as far north as I have been, and as far west, at least, as Salt Lake Valley. These are found hatching out in the grassy valleys and broad plains of the lower lands and up the mountain cañons almost to the snow limits. And these broods appear to have little or no connection with the migrating broods; but the solution of these questions will require more extended observations by those who can distinguish the species.

I also extract from Mr. Thomas's remarks on the same subject in Hayden's Report on the Geology of Montana, 1871, p. 451:

Caloptenus spretus.—Found the past season [1871] in great abundance in the north part of Salt Lake Basin. When we reached Ogden, June 1, I saw but very few specimens; but when we reached Box Elder Cañon, two weeks later, the larvæ were seen spreading out from points where they had evidently been hatched. When we passed through the hills to Cache Valley, a few miles farther, and but a few days later, I found them just entering their perfect state. By the time we reached the north end of the valley, about the 20th of June, they were taking wing and proceeding southward. Here the farmers, who have observed them closely for a number of years, say that they never lay their eggs in the lower level of the valley, but universally on the gravelly elevated terraces. So positive are they on this point that one farmer, to test the matter, last year offered $5 for every bunch of eggs that could be found on the lower valley level which had been deposited there by the insect itself, but none were brought to him. I think, therefore, we may conclude that it is pretty well settled that the usual hatching-grounds of the destructive swarms are on the gravelly terraces or uplands. Yet that considerable numbers are hatched in the narrow cañons of the moderately-elevated mountains I think is also certain, as I observed this year a large number of larvæ in Box Elder Cañon; but the elevation of this cañon is little, if any, more than that of Cache Valley. When I returned to Salt Lake Basin, early in August, I found the country swarming with myriads of these grasshoppers. And even after we had passed eastward on the railroad, to the heights near Aspen Station, I noticed the air filled with their snowy wings, but could not tell exactly the course they were taking, but thought they were moving southwest.

The following statements, which are quoted nearly word for word, are made by W. Woodruff and A. M. Musser in a Mormon paper. The locust appeared in Utah in the year 1855, and again from 1866 to 1872, inclusive. In 1855 they came from the west, in 1866 from the north. The subsequent years' products were produced from eggs, while relays came from all directions. They hatched out from April to June, and in 1855 and 1872 left in August and September, flying north and east, in dense clouds obstructing the sunlight. In 1855 foreign swarms came about July, in 1866 about September, and deposited eggs.

In 1855 about 75 per cent. of the cereals, vegetables, and fruits were destroyed by them. The following spring the people subsisted largely on thistle, milkweed, and other roots.

When eggs are not disturbed by the plow frost does not destroy them. During the years named they visited all parts of the Territory. Thousands of bushels were destroyed by the organized labors of the people, by driving them and burying them in trenches, by setting traps in irrigating ditches, by covering the ground with straw, under which they would shelter for the night, and in the morning burning the straw and insects. Men, women, and children, with the village poultry, in some places, moved to the fields in wagons and fought the common enemy from hatching to flying time. In some parts, it was estimated there were one hundred bushels of hoppers to the acre.

A notable local mathematician estimated that in *one season, one and a half million bushels* were destroyed by lighting in Great Salt Lake and drifting on the shores, forming an immense belt.

THE LOCUST IN NEW MEXICO.

Professor Thomas also states that it breeds in Snake Valley, Idaho. That it is common and destructive at times in New Mexico is shown from the statement published in the Monthly Report of the Department of Agriculture, at Washington, D. C., for July, 1876, where it is stated that the corn and oats were injured and the wheat-crop half destroyed by the "grasshopper," which must be *C. spretus*, as Taos is near the Colorado line. Professor Thomas reports a few specimens of *C. spretus* from New Mexico and Arizona in collections made by Lieutenant Wheeler's Expeditions during the last four years, and he himself found a few specimens south of Raton Mountains in 1869. In 1875, however, Lieutenant Carpenter, as he writes me, did not see any swarms in the region extending from Fort Garland to Santa Fé. "I could not learn," he adds, "that they had ever been troublesome in northern New Mexico."

THE LOCUST IN NEVADA.

Prof. Cyrus Thomas has kindly afforded me the following facts regarding the occurrence of *Caloptenus spretus* in Nevada, in a letter dated March 1, 1877:

I saw *C. spretus* in 1871 in abundance along the Humboldt River in Nevada, most of the way from where the Central Pacific Railroad strikes it (going west) to the sink or place where it disappears. At one point they were quite abundant, and evidently preparing to migrate, flying up in the air, their wings presenting that peculiar glassy, snowy appearance with which you are no doubt familiar. This, if I recollect rightly, was west of Humboldt Station; they were quite abundant at that station (Humboldt), where we dined, (going west), but were not migrating there or then; those referred to as seen west of Humboldt being seen as we returned east. You probably remember that saline or alkaline belt at the northwest extremity of Great Salt Lake; just beyond that I began to observe them, and from thence—not continuously, but at certain points—from there to, and a short distance west of, Humboldt Sink. The collections made by Wheeler's party in Southeast Nevada had no specimens which I could positively say came from that section. That year (1871), as we went out (June), we saw but few specimens in Salt Lake Valley, but they were quite numerous when we returned from California in August. They were also numerous in Cache Valley and Southern Idaho; in moderate numbers west of the range in Montana as well as east.

From the facts thus afforded by Professor Thomas, it is not improbable that this species in its normal form will be found to commonly occur in the treeless regions of the entire State of Nevada, and also of the eastern half of Oregon, and also, perhaps, of Washington Territory, west of the Sierra Nevada, to the south, and the Cascade Mountains to the north. Among these ranges, and to the westward, when the rain-fall is very considerable, and the land clothed with forests, we are to look for the non-migratory variety, *Atlanis*, which may there exist under conditions resembling those in which it lives in the Mississippi Valley, and the forest-clad Atlantic States and Canada.

It will be exceedingly desirable to trace the distribution of *C. spretus* southward of the present known limits, for it is not at all unlikely that it inhabits the Mexican Plateau, since Major Powell informs me that he found a locust, as he thought this species, numerous within twenty miles of the Mexican boundary on the Colorado River.

In Northern New Mexico Lieutenant Carpenter found this species (identified by Mr. Scudder) on Taos Peak, Sangre de Cristo Mountains, at a height of 13,000 feet (above timber-line), in July, 1875. (Scudder in Wheeler's Annual Report for 1876.)

NORTHERN RANGE OF THE LOCUST.

While the locust (*C. spretus*) breeds in Wyoming, Montana, and Dakota, in some cases swarming northward and eastward into the region about Manitoba, its northernmost limits in British America are said by Mr. G. M. Dawson* to be "the margin of the coniferous forest which opportunely follows the line of the North Saskatchewan River." As regards the northeastern limits, Mr. Dawson says: "The locusts are recorded, on one occasion at least (1867, by Professor Hind), to have reached the shores of the Lake of the Woods, but I have not heard that they did so in 1874. Their limit in this direction is pretty definitely fixed by the western margin of the great woods, about longitude 96°. They did not appear at Fairford Port, on the northern part of Manitoba Lake, nor at Lake Swan House (longitude 100° 30′, latitude 52° 40′), Cumberland House (longitude 102° 30′, latitude 54°), Prince Albert (longitude 105° 30′, latitude 53° 10′), or Fort Pitt (longitude 109° 20′, latitude 53° 30′).

They are very seldom seen at the second, and never at the third and fourth of these localities. The exemption of Prince Albert is noteworthy and instructive, as, on the testimony of several gentlemen acquainted with the locality, it is due to a *belt of coniferous timber*, which stretches between the North and South Saskatchewan Rivers here; and though grasshoppers in great abundance have visited the country south of the line thus formed, *they have never been known to cross it*, as will be seen farther on; that in 1875 great numbers flew westward to the Lake of the Woods.

Regarding its appearance at Manitoba in 1875 I quote as follows from Professor Dawson:†

From the reports now received from Manitoba and various portions of the Northwest Territory and published in abstract with these notes it would appear that during the summer of 1875 two distinct elements were concerned in the locust manifestation. First, the insects hatching in the province of Manitoba and surrounding regions from eggs left by the western and northwestern invading swarms of the previous autumn; second, a distinct foreign host, moving, for the most part, from south to north. The locusts are known to have hatched in great numbers over almost the entire area of Manitoba and westward at least as far as Fort Ellice on the Assineboine River (longitude 101° 20′), and may probably have been produced, at least sporadically, in other portions of the central regions of the plains, though in the summer of 1874 this district was nearly emptied to recruit the swarms devastating Manitoba and the Western States, and there appears to have been little, if any, influx to supply their place. Still farther west, on the plains along the base of the Rocky Mountains, from the forty-ninth parallel to the Red Deer River, locusts are known to have hatched in considerable numbers; but of these more anon.

Hatching began in Manitoba and adjacent regions in favorable localities as early as May 7, but does not seem to have become general till about the 15th of the month, and

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* Notes on the Locust Invasion of 1874, in Manitoba and the Northwest Territories. Montreal, 1876, 8vo, p. 16.

† Notes on the Appearance and Migrations of the Locust in Manitoba and the Northwest Territories, summer of 1875, by George M. Dawson, Assoc. R. S. M., F. G. S. (From advanced sheets of the Canadian Naturalist.)

to have continued during the latter part of May and till the 15th of June, while, according to Mr. Gunn and others, in cold, clayey land and where pools of water from the melting of the snow lay long, isolated colonies came out at still later dates. Mr. Gunn states that grasshoppers were even noticed to hatch in August and September in spots which had been covered with water all summer, a fact showing the very persistent vitality of the eggs, and apparently negativing opinions which have been expressed as to their destruction by damp. The most northern locality at which locusts are reported to have been produced from the egg is at Manitoba House, Manitoba Lake (latitude 51°).

The destruction of crops by the growing insects in all the settled regions was very great, and in many districts well-nigh complete. The exodus of these broods began in the early part of July, but appears to have been most general during the middle and latter part of that month and first of August. The direction taken on departure was, with very little exception, southeast or south. It is to be remarked that as there does not seem to have been during this period any remarkable persistency of northwest or northerly winds the insects must have selected those favoring their intended direction of migration, an instinct which has very generally been observed elsewhere. Though most of the parents, in 1874, came from the west and northwest, and Manitoba must have represented to those ending their flight there the southeastern limit of their range, the young insects of 1875 thus took a southeastward direction, just as though starting from their usual breeding-grounds in the far Northwest, and showed no disposition to return to the region whence their parents came. This direction of flight carried many of the insects at once into a country of thick woods, swamps, and lakes, and caused the repetition of the phenomenon of the appearance of grasshoppers in great numbers about the Lake of the Woods, a circumstance only once before noted, in the summer of 1857.* This previous occasion, however, differed from that of last year in being an extension of an invasion of Manitoba from the west or northwest and not resulting from insects hatching in that province.

It is probable that most of the grasshopper swarms of Manitoba thus entering the wooded country were there harmlessly spent, for though some northern swarms reached the State of Minnesota, the invasion appears to have been comparatively unimportant. Northern swarms are noted to have passed over Crookston (Polk County, Minnesota) and Fort Totten (Dakota), the greatest number appearing at the latter place July 19. The locust swarms described by Mr. Riley† in the following paragraph, from information furnished to the Chicago Tribune, dated July 13, probably also came from Manitoba: "The first foreign hoppers appeared on the Sioux City Road, alighting between Lake Crystal and Saint James on Wednesday last. A few days later they were observed at New Ulm flying southeast, and at noon of the same day struck the line of the road at Madelina, Saint James, Fountain Lake, Windom, and Heron Lake, covering the track for about 50 miles of its length." It will be observed on referring to the summary on another page that the insects produced in Minnesota itself flew southwest in the early part of July.

I have not been able to trace further the movements of these Manitoba broods, unless indeed it be supposed that some at least of the swarms which passed over Central Illinois early in September came from that quarter. These, however, Mr. Riley believes not to have been the true migratory locust, *C. spretus*.

Foreign swarms from the south crossed the forty-ninth parallel with a wide front stretching from the ninety-eighth to the one hundred and eighth meridian, and are quite distinguishable from those produced in the country from the fact that many of them arrived before the latter were mature. These flights constituted the extreme northern part of the army returning northward and northwestward from the States ravaged in the autumn of 1874. They appeared at Fort Ellice on the 13th of June and at Qu'Appelle Fort on the 17th of the same month, favored much, no doubt, by the steady south and southeast winds, which, according to the meteorological register at Winnipeg, prevailed on the 12th of June and for about a week thereafter. After their first appearance, however, their subsequent progress seems to have been comparatively slow and their advancing border very irregular in outline. They are said to have reached Swan Lake House, the most northern point to which they are known to have attained, about July 10, while Fort Pelly, farther west, and nearly a degree farther south, was reached July 20, and about seven days were occupied in the journey thence to Swan River Barracks, a distance of only 10 miles. It is more than probable that the first southern swarms were followed by others, which mingled with them, or even, in parts of Manitoba and the country immediately west of it, with the indigenous brood. From a few localities only in Manitoba, and those in its western portion, is the evidence pretty conclusive as to the arrival of foreign swarms from the south. Burnside, Westbourne, Portage la Prairie, Rockwood, and Pigeon Lake may be mentioned as affording instances.

* Not 1867, as erroneously printed in Notes for 1874.

† From Mr. Charles V. Riley's very interesting Eighth Annual Report on the Noxious Beneficial and other Insects of the State of Missouri.

Many of the grasshoppers observed, according to reports received by Mr. Riley, in Dakota, at Fort Thompson, Yankton, Fort Sully, Springfield, Fort Randall, and Bismarck flying northward and northwestward at various dates in June and July, no doubt eventually found their way north of the forty-ninth parallel. Those seen at Bismarck about June 6 and 7 probably belonged to the earliest southern bands above referred to, and, judging from the dates given by Mr. Riley, may have been produced in Nebraska, or more probably even still farther south. A portion of the southern and eastern army probably reached Montana, and may even have penetrated in diminished numbers into the districts in the vicinity of Bow River.

A considerable number of locusts appear to have hatched at about the same date as in Manitoba near the extreme western margin of the plains, especially in the country near Bow River. Foreign swarms arrived at Fort McLeod from the southwest, depositing eggs; and most of those hatching near Bow River, and farther north, seem to have gone southeastward early in August. No very definite or wide-spread movement of swarms appears, however, to have occurred during the summer of 1875 in this region, nor, if we may judge from the very meager accounts received, in the corresponding portion of Montana.

During the summer of 1875, the conditions described in the Notes for 1874 as occurring in the region west of the one hundred and third meridian were reproduced in Manitoba, and over a great area of the Western and Southwestern States, with results even more disastrous to the crops than those of the winged invasion of the previous year. We do not hear of any access of fresh swarms to Manitoba from the west or northwest, nor is it probable that any such occurred, notwithstanding the fact that in various parts of the province flights are reported to have passed over from northwest to southeast. From the dates and descriptions given, it seems certain that these were only those from the more remote parts of the province itself, and in many cases the broods hatched in any locality mingled with those coming from a little distance, and departed at the same time.

The most remarkable and exceptional feature in connection with the appearance of the locusts in 1875 is the extensive invasion of the wooded region east of Manitoba by the swarms produced in the province. This is the more noticeable when contrasted with the immunity enjoyed by Prince Albert on the Saskatchewan, alluded to in last year's Notes, which is owing to its separation from the general area of the plains by a belt of timber. On writing to Mr. Clarke, of Carleton House, on the subject, he informs me that this protecting belt of fir-timber is only four miles in width, and extends completely across between the north and south branches of the Saskatchewan. Judging from the above remarkable fact, and the known habits of the locust, I do not think that the incursion made into the forest-country can be looked upon as anything but exceptional, and perhaps showing that the locusts had lost their reckoning. Nor do I believe that it should discourage the cultivation of belts of woodland, which promises to effect in time a general and permanent amelioration of the grasshopper plague.

Broadly sketched, the movements of the locusts in 1875 conform to a general plan. All those hatching in Minnesota, Manitoba, Northern Dakota, and in the high western region of the plains, at least as far south as Colorado, on obtaining their wings, went southward, and this in some instances regardless of the direction from which their parents had arrived in the previous year. Swarms produced in Nebraska, Missouri, Kansas, Texas, and Indian Territory flew northward and northwestward, returning on the course of their parents, which had flown southeastward from that quarter. This movement can be traced over an immense area, from the northern borders of Texas almost to the Saskatchewan River.

Evidence appears to be fast accumulating to show that the general and normal direction of flight for any brood is to return toward the hatching-grounds from which their parents came, and it would seem that to complete the migration-cycle of the locust two years are required. The tendency which the swarms show to migrate on reaching maturity cannot be wondered at, as it is so commonly met with in other animals, and may be assisted by the mere lack of food in the district which has for a long time supported the young locusts. The fact, however—let us call it instinct or knowledge—that the young, while amenable to the migratory tendency, show a determination to exercise it in a direction exactly the opposite of the preceding generation is most remarkable

Professor Dawson writes me that, "during the summer of 1876, the grasshopper was scarcely seen in Manitoba, and a fine crop was harvested all over the province. Manitoba is safe for next summer, unless *invaded.* I have reason to believe, however, that during last summer the locust was very abundant in the far West, on the plains east of the Rocky Mountains, and north of the forty-ninth parallel. With regard to this region, however, I have only general information."

Through the kind suggestion of Prof. G. M. Dawson, of the Canadian

Geological Survey, I have received from Mr. Sanford Fleming, engineer-in-chief of the Canadian Pacific Railway, a copy of a "Map of the country to be traversed by the Canadian Pacific Railway to accompany progress-report on the exploratory surveys, 1876; Sanford Fleming, engineer-in-chief." On this map the "southern limits of the true forests" are laid down* on a line running in a general northwest direction from a little to the eastward of Fort Ellice, in about latitude 54° 30′, longitude 110° 10′. This line is indicated on the map showing the distribution of the red-legged locust (*C. femur-rubrum*). "The northern limit of true prairie-land" is also copied on the same map from Mr. Fleming's map. It runs from Turtle Mountain on the forty-ninth parallel, a little east of south of Fort Ellice, and runs in a general parallel course to the limit of forests, and ends at the Bear Hills, just south of the fifty-second parallel of latitude and in longitude 108°. Professor Dawson writes me that "no map yet shows even approximately the area of the Pever River Prairies, but these are separated by forests from those to the south, and are never invaded by *C. spretus*." This is most important and satisfactory information, and confirms Professor Dawson's statement as to the northeastern limits of the lowest area, which are herein already quoted. It would seem doubtful whether the Rocky Mountain locust breeds abundantly north of the Little Slave Lake. The data afforded by this map also confirm me in my indications of the western limits of the prairie region and temporary and periodical breeding-places of the Rocky Mountain locust, which probably follows approximately the meridian of 102°, pursuing a sinuous course indicated by a range of hills put down on the United States maps, from which Mr. Bechler has compiled the maps accompanying this report. The barren plains extend just north of the forty-ninth parallel as far east as longitude 104°, and this may be the southeastern limits of the permanent breeding-places of the locust north of the forty-ninth parallel.

That the return swarms from Missouri, Kansas, and Nebraska may reach British America is suggested by Mr. Allen Whitman in his report for 1876:

Whether or not it is a general rule that the locusts on acquiring wings seek the direction from which their parents had come in the preceding year (a rule which the experience of Minnesota fails to substantiate), it is certain at least that in 1875 "the main direction taken by the insects that rose from the Lower Missouri Valley country was northwesterly." (Riley's Eighth Annual Report, p. 105.) These swarms were traced by Professor Riley, moving northerly from the end of May through June and into July, and passing various points in Dakota, Wyoming, and Montana.†

They passed northward over Bismarck at various times between June 6 and July 15. (Same report, p. 86.) But a still more definite statement as to the final destination of these northward-moving swarms is found in an editorial of the Winnipeg Stand, of August 19, 1876, entitled "Locust flights." It is there stated that in 1875, "the locusts which hatched in Missouri, Kansas, and Nebraska, in an area of 250 miles from east to west, and 300 miles from north to south, took flight in June, and invariably went northwest, and fell in innumerable swarms upon the regions of British America, adjoining Forts Pelly, Carlton, and Ellice, covering an area as large as that they vacated on the Missouri River. They were re-enforced by the retiring column from Manitoba, and it seemed to be hoping against hope that the new swarms of 1876 would not again descend upon the settlements in the Red River Valley. Intelligence was received

* Professor Dawson informs me that this is taken from Palliser's Map, published as a blue-book by the British government, forming a part of the report on explorations in British North America.

† He adds (page 108): "Nor can I learn of any instance where these swarms that left our Territory deposited eggs." The different case of our own breed of locusts, laying eggs within two weeks after flying commences, is remarkable. But I am informed by Capt. J. S. Poland, commanding at Standing Rock, that a swarm from the south alighted near that post July 4, 1875, and deposited considerable quantities of eggs between the 4th and the 18th of July.

here that the insects took flight from the vicinity of Fort Pelly on the 10th of July, and then followed a fortnight of intense suspense."

There is, of course, in all this a failure to connect by any direct chain of continued observations the swarms that left the Mississippi Valley in 1875 and those which finally disappeared in the region of the mountains and in British America; still less is it shown that those swarms were the parents of those which are known to have hatched in the same regions in 1876, or even that those which are known to have hatched there were those which descended upon the lower country in July and August. But there is, at least, a strong series of probabilities.

THE INVASIONS OF THE LOCUST IN 1876.

Beginning with the southeasternmost point of the locust region—

Texas: I learn from G. W. Belfrage, of Clifton, Bosque County, in a letter dated December 14, 1876, that the locusts have for "two years made their visits, the first without serious results, the second this fall, so we cannot yet know what the offspring will do."

The following extracts from the Monthly Weather Reports give some idea of their movements: "Flying, at Fort Richardson, Texas, from 14th to 18th September; Corsicana, Texas, flying south 21st and 22d, west 23d. On 30th were destroying everything, and depositing millions of eggs."

In Texas, at Belmont farm, the grasshoppers remained alive all winter, and were found on wheat February 10 and March 25.

October 3 to 5, numerous at Corsicana; disappearing about 9th; abundant at Belmont farm 1st to 9th. "In Texas a dense cloud of grasshoppers appeared during the last ten days of November."

"*Palo Pinto:* The grasshoppers appeared on the 17th of September, and are as thick as they ever were here, destroying everything as they go. *Uvalde:* Appeared September 22, in quantities, arriving from the north, and causing some alarm. *McLennan:* Reached here on the 20th of September, and have materially damaged the cotton-crop by cutting off unripe bolls. *Bell:* Made their appearance in great numbers about a week since, and are destroying all gardens and every sward of grain. They have cut off the late corn and the young bolls on the late cotton. *Dallas:* Have cut short the cotton-crop. *Gillespie:* The first grasshoppers arrived on the 18th of September. Three days later they left, going west, being driven by an east wind."—(Agricultural Report, October.)

On applying to Mr. J. Ball, a well-known entomologist residing in Dallas, Tex., for information regarding the appearance of the locust in that State, he kindly sent me the Neue Zürcher Zeitung for November 1 and 2, 1876, containing two letters written by him, which I have condensed as follows: In October, 1874, the locusts appeared in Texas, but were not one-tenth as abundant as in 1876. At Dallas, at noon September 20, 1876, the air was filled with the first swarm of locusts; by 5 o'clock in the afternoon none were in the air. Previous to this date up to the night of the 19th the wind had been south; it changed on the 20th to the northwest, and this wind brought the locusts in a swarm which must have been many miles long and broad, and from 1,000 to 2,000 feet high, as far as the eye could see. At 10 o'clock, September 21, the air was again filled as at noon of the preceding day, the northwest wind still blowing, and the grasshoppers passed on as the day before, until 4 p. m. On the 22d the wind veered to the south, and the locusts flew during the day in large numbers irregularly about, like a swarm of bees. This continued until noon of the 23d, when a southwest wind bore a large number to the northwest. Until the 27th they remained engaged in egg-laying.

They laid their eggs in an unbroken, somewhat sandy soil, in little pockets buried several lines deep. Mr. Ball counted several hundred holes in a square foot of soil. They did not lay in cultivated, plowed land, and should they do so, plowing would be sufficient to destroy almost all the eggs. From the observations he made, Mr. Ball concludes that this great plague will diminish as the cultivation of the soil increases, and will finally be abated, as in Germany the locust invasions are much less numerous than formerly.

At Fort Gibson, Indian Territory, they appeared September 16 to 28. North of Texas, in Arkansas, Kansas, Missouri, according to the Monthly Weather Review, August 6, grasshoppers appeared at Lamar's, Nodaway County; Oregon, Mo., flying north 1st; northwest 2d, 4th, 6th; south 11th and 19th; northwest 22d; southwest 23d and 25th; and south 26th. For other details the reader is referred to Riley's Ninth Report, as State entomologist of Missouri), and Minnesota, as well as Iowa, according to the Monthly Weather Review, the locust appeared late in summer and laid their eggs, which will hatch out in greater or less numbers in the spring of 1877.

THE LOCUST IN NEBRASKA IN 1876.

How they swarmed in Nebraska last autumn may be seen from the following extract from a correspondent of the New York Tribune:

The grasshoppers are here. They have come to stay, and are busy perpetuating their species. Early in August they reached the western portions of this State, but were partial in their depredations, devouring everything in some localities, doing little damage in others. On the 12th of the month they made a forward movement, and appeared in the valleys of the Elkhorn, Platte, and Republican. Our local papers, acting on the "ostrich" policy, suppressed the facts or misrepresented them, and all were wishing for a favorable wind to carry the pests beyond our borders. But a soft, southerly wind, varied by an occasional thunder-storm from the northwest, prevailed till the 23d, when, aided by a stiff northwester, the grasshoppers rose and came from their exhausted feeding-grounds upon the east and south portions of the State. They came literally in clouds, looking like the frost-clouds that drift along the horizon on a winter morning. They are devouring "every green thing," including shade-trees and even weeds, such as the "Jamestown weed" and wild hemp. The great body of them seemed to pass south, moving in dense masses during the 23d, 24th, and 25th, and will probably be heard from in Kansas and Missouri. I have suffered a total destruction of 60 acres of corn, as fine as I ever raised. The amount of damage in Nebraska is hard to determine. The small grain was harvested; corn and vegetables alone suffer. Taking into consideration the fact that we always overestimate a standing crop of corn, and are disposed to underestimate our losses, I think we shall be fortunate if the corn realizes one-third the anticipated yield. A few words upon the "parasite" delusion. The grasshoppers last year were to a great extent infested with the coral-like insects, but my conviction is that they are no more fatal to them than fleas are to a dog. This season I have failed to find any "parasites." At present no natural enemy appears to interfere with the festive progress of the locust through this fertile region. Many have concluded, and I am one of them, that for the present the locust is an "incident" to this locality, the solitary "drawback" to our enviable lot, which can be obviated in part by new methods of farming, but which can be altogether removed only by one of these unexplained and beneficent interpositions of Nature by which certain species are occasionally overwhelmed with destruction, and appear again only after a lapse of years. Warned by Mr. Riley's example, I will venture no prediction as to next year, but present indications are that our small grain will suffer early next summer, when the eggs now being deposited are hatched, but that the late corn will be unmolested, in consequence of the flight of the new brood to their natural home in the Northwest.

Another correspondent, Mrs. C. L. Nettleton, of Red Willow County, Nebraska, writes as follows to the New York Tribune:

Locust prospects is a subject of much anxious thought with us, and I am tempted to write of our experiences in this valley of the Republican River. I trust that efforts to secure a thorough investigation and abatement of the pest may be successful. It seems to me a matter of national importance, as settlements must retrograde unless the locusts are checked. They came down upon us July 26–27, doing much damage, but left without consuming everything. August 5 they re-appeared in great numbers, looking in the distance like great clouds of smoke. Nearer and over our heads the air appeared to be filled with snow-flakes. Locusts were around, on us, and on everything, literally "covered the face of the earth." They began to come about 4 p. m., and the next day they had our fine field of corn stripped. It was like resisting fate to fight them. We tried smoking them, covered vines and portions of our garden with hay and blankets, giving the insignificant creatures a sort of hand-to-hand fight, in which they won by sheer force of numbers, and made us glad to retreat into the house. They brought with them an omnivorous appetite, eating things which they passed by in 1874—vines of melon, cucumber, squash, pumpkin, &c.

They took our tomatoes, potato-tops, indeed all our garden. They ate our strawberry-plants and young fruit-trees; also, our few flowers. Not content with such a varied bill of fare, they forced their way into the house and ate the house-plants. They staid with us five days, until they had ended their large meal by finishing up everything. Then while we were planning to catch them and barrel them up to fatten our poultry and swine, a friendly (?) northwest wind carried them off. Owing to the drought the small grain was a failure; the locust harvested the remaining crops, leaving the farmer no reward for his toil. They have visited the country every year since the settlers have come in, but only in 1874 and 1876 doing serious injury. They have been by far the most numerous this year. It has been an extremely hot, dry season, the prevailing wind south, often hot as from a furnace, and undoubtedly the unusual season has had much to do with the unusual numbers of the locust. Farmers with their crops harvested are like Othello with his occupation gone. Many have lost faith in the country and are leaving in "prairie schooners." We are about 70 miles from the Union Pacific Railroad. Some turn toward the setting sun, others southward, and others still go, they scarcely know where, in search of employment. It seems like a "sorry" going off to seek one's fortune—a journey in which a supply of hope and enthusiasm is needed.

According to the Monthly Weather Review, grasshoppers were seen at Richmond, Nebr., flying north on July 2 and 3, and flying with the wind 26th, 27th, 29th, 30th and 31st. August 5, at North Platte, Lincoln County, entire corn-crop destroyed, and in Dawson County one-fourth of crop destroyed; came from Dawson County to Buffalo County. 10th, Clear Creek, flying southwest; 11th, northwest; arrived in immense numbers 18th, and remained rest of month. 11th, alighted in immense numbers at Fremont, Dodge County, and commenced in the corn; country near Elm Creek, Buffalo County, cleaned out; column moving in a northwest direction, not many miles wide. 12th, very thick at Columbus, Platte County; came down the valley from North Platte, doing but little damage. At Grand Island, Hall County, loss small. 13th to 26th, at Omaha, numerous at times, flying in all directions. 18th to 31st, at De Soto. 23d, at Lincoln, Lancaster County, in vast numbers, but not so numerous as in 1874; passing south and southeast in clouds; corn considerably damaged. 24th to 31st, at Plattsmouth. 25th, in York County; have left nothing but harvested grain. Plattsmouth, flying about, September 1 to 15. Richmond, flying north 4th and 6th, northeast 20th, northwest 21st. *York:* The grasshoppers have called on us again. They came down August 10, from the northeast, and staid two weeks to a day. August 24 they left, going southeast. They have eaten almost everything green, destroying all garden-vegetables and taking the leaves off the trees. The fruit-trees, such as apple, cherry, and plum, are leafing and blossoming again. The plum-trees have ripe fruit and blossoms, which is something I never heard of before. *Furnas:* Came down in dense clouds from the northeast, so thick as to darken the sun, having the appearance of vast clouds of smoke. Nothing of the kind has equaled this raid since the earliest history of the country. Some have laid eggs. We are compelled, as in 1874, to note an almost total destruction of corn and all late vegetables. *Knox:* Entirely destroyed the corn and garden products and the oats so badly that many fields were not reaped. *Osage:* Came August 24, and are still here.

Have taken potatoes, buckwheat, and beans clean; have injured corn about 15 per cent. and are still at work on it. Have deposited eggs in great quantities. They incline to travel southeast, but the wind is against them. *Cuming:* Came from Dakota August 4, staid about ten days, injured late corn and potatoes, beans, gardens, &c.; deposited many eggs, and have nearly all gone southward. Insects will destroy their eggs, and birds, quails, and prairie-chickens will eat their young when quite small in untold millions. In their matured state nothing can successfully cope with them save quails, prairie-chickens, and other insectivorous birds. *Dodge:* Swept down upon us from the great northwest August 10, bringing terror to the hearts of our people. They remained about two weeks and deposited eggs in immense numbers. Hops were entirely destroyed; fruit-trees are stripped of their leaves, and in some sections of the new growth of bark. But half the corn is left. *Webster:* Injured corn slightly. *Franklin:* Damaged corn 50 per cent. Have now all gone southwest. *Adams:* Have taken about half the corn and injured young trees 50 per cent. *Saunders:* have re-appeared since the last report. Corn, potatoes, and sorghum have been largely damaged; tobacco, buckwheat, and beans have been wholly and gardens mainly destroyed, and the earth is filled with eggs. *Seward:* Came from the north in immense quantities. They fed upon the corn and cultivated grapes, and destroyed 80 per cent. of the buckwheat. A few linger still in the south part of the county, traveling southwest. *Thayer:* Alighted about a week ago. Have injured corn very badly, and taken all the garden products. *Boone:* Came in large numbers August 3. Have destroyed all buckwheat, beans, and late corn; stripped the foliage from all young trees, and killed young fruit-trees. They staid about three weeks; have all gone south. *Lancaster:* Are eating everything. *Platte:* In their flight south visited our county on the 10th of August, and in consequence of adverse winds remained two weeks. They entirely ruined late corn, made general havoc of vegetables, and filled our land with eggs. *Wayne:* Alighted and commenced work August 6 and 10. Injured late corn 25 per cent., potatoes slightly; deposited their eggs, and left August 13. *Antelope:* Came from the north, August 5, in countless numbers, and swept late corn, buckwheat, potatoes and beans clean. *Richardson;* First appeared yesterday, August 30, in small numbers from the northwest. *Merrick:* Crops promising up to 10th of August, when the grasshoppers came with the wind from the north. The next day the wind changed, and continued rather strong from the south for a week. The hoppers had to stay on the ground and could not do much damage. On the 18th, the wind being from the northeast, they left, but toward evening a lot more came. On the 24th, all left for the south. Buckwheat, late beans, garden-vegetables, late potatoes, &c., are all a total loss. On the 17th some deposited eggs where the ground was bare. *Hall:* Large swarms appeared from the northwest August 10 at noon. Commenced depositing eggs on the 13th and 14th; on the 14th some left; still larger masses came in their stead, mostly from the northeast. Farmers generally tried to smoke them out, but most abandoned the effort after the third day. I protected my garden for ten days, but from the 11th to the 13th they piled in on me so fearfully that I could not keep them from stripping nearly every tree of its foliage. They have eaten about one-third of the apples and half the early with all the late corn. On the 23d and 24th they left in a southern direction, the wind being from the northwest.—(Monthly Agricultural Report, August and September, 1876.)

I have also the following notes on its appearance in Nebraska from

Mr. G. F. Dodge, of Glencoe, Nebr. As Mr. Dodge is an entomologist, his testimony is of increased value:

GLENCOE, NEBR., *February* 4, 1877.

DEAR SIR:

* * * * * * *

Since I have been here I have given more attention to the *Caloptenus spretus* than to all other insects together. The result of my observations has been that I have formed a theory of the cause of immigration of this insect, which differs radically from any yet put forth. My record of the insect's visitations runs like this:

In 1873, *C. spretus* came from the south in May; remained a week or ten days; deposited eggs in large quantity at this place. I came here August 7; the insects had then about all attained their wings. During their growth they had done much damage to crops, destroying all the oats and corn where they were abundant. The insects did not move until August 16, when the wind, which had been from the south continuously during the month, veered round into the northwest. They arose about noon, and all left. Others flew over, going south from that time until cold weather. Some eggs were deposited in the fall.

In 1874, a few came from the southwest May 30, but only a few. May 10 the eggs laid the fall before were hatching. They pupated about June 1, became *imagines* about June 20, and went south with northerly winds June 30. July 23 immense swarm alighted, coming from the northeast July 23; staid three days, and went south. I saw no eggs deposited. Others went south in August, September, and October as usual.

In 1875, they arrived in small quantity from southwest May 12; could be seen flying north whenever we had a south wind, but especially on and after June 16. On that date myriads came from the southeast, staid one night, and, the wind continuing favorable, went on in a northwesterly course. June 29 I first saw hoppers flying south. After that they could be seen flying either north or south, as the wind might be, until the 10th of July, after which date they only appeared in the air when the wind came from the north.

In 1876, a very few came from the southwest May 14; saw some depositing eggs about May 30. August 10 an immense swarm came from the northwest and staid a week. The day they departed the wind began to blow from the northwest, changed to north, and finally to northeast. The air was full of the hoppers all day. They always changed their course to go with the wind. They left the ground full of eggs. In these the embryo was formed at least a month before the ground froze. By bringing eggs to the house and putting them in a warm place I have hatched them in seven days. Some of the same that were not kept so warm, but merely kept from frost and in the sun, have lain three weeks and do not hatch.

I think the above notes substantiate my position, which is that *spretus* is *double brooded*, rearing the first brood in the south, the second in the north; and that it migrates for this purpose, and not from hunger, as Riley asserts. I believe also that they are natives of the plains, and will always overrun this part of the country when a north or southwest wind drives them a little off their true north and south course during their period of migration. I do not believe that they are more liable to attacks of parasites here than elsewhere, and, indeed, think it not improbable that their present rate of increase is due to their having found more nutritious food in the cereals upon which they have fed for a few years past than they have known in the prairie-grass. A parallel case is that of the *Doryphora* 10-*lineata*, which increased with such rapidity upon the cultivated crops of the East.

In the Rocky Mountains this grasshopper follows the same plan of migration with the first favorable wind after they get wings, as I have observed here. They were abundant in Montana this year, and at my request an intelligent miner took notes of their habits, which he has transmitted to me. My observations show that as a rule all obtaining wings prior to June 20 will fly north; those becoming *imagines* after that date will fly south. This date might vary as the spring was late or early.

* * * * * * *

Hoping to make myself useful next season, I remain, yours, truly,

G. M. DODGE.

The following statement regarding the appearance of the locust, in Buffalo County, Nebraska, and the theory of its northwest origin, are worthy of preservation in this Report:

BUFFALO COUNTY, NEBRASKA, *August* 8, 1876.

EDITORS COUNTRY GENTLEMAN: The all-prevailing theme, the all-absorbing topic on all occasions, is the grasshoppers. Their devastation in almost the entire portion of Western Nebraska is not only general but terrible. Their numbers are almost as countless as the sands on the sea-shore; their powers of destruction seem to exceed that of the race that visited us in 1874 by fourfold. Now they are eating every green thing—the leaves from the trees, the grass in the ravines, the forest-trees along the Loup and Wood Rivers, corn, potatoes, tomatoes, everything. Our corn-fields to-day present the appearance of so many acres of naked bean-poles. They have covered the city of Kearney all over; in the houses; on the sidewalks; they even inspect the fine store-rooms of our dry-goods and grocery men; in fact I do not believe there is a square inch of territory in Buffalo County that has not been searched by these marauders. The first indication of their approach was on Friday, July 28. Almost from the first we saw they were an entirely new generation. They had huge appetites, and at once proceeded to find the sweetest and tenderest ears of corn in our fields. They poked their noses head downward, tail upward, into the very heart of our small cabbages. They almost dug up our onions by the roots. They ate up our melon-vines and then partook greedily of the unripe fruit. The wind remained in the south from July 28 till August 5, when about noon it suddenly changed to north-northeast. In less than twenty minutes, every hopper of this advanced guard wended their way southward. How happy we were! Vain delusion. At 4 p. m. the east, the north, the west, presented the appearance of dense clouds of smoke, like that of burning prairies. We saw it full 20 miles away. We gazed in wonder. The clouds approached, the air swarmed with hoppers. We could hear the sound of their wings. They were so close together, so dense, that they darkened the sun similar to an eclipse at midday. The first cloud passed. At 5 p. m. another, more dense, more terrible, more numerous passed over head, leaving a few stragglers to search for something to stay their stomachs. We thought by this time, surely the army had passed, but about 6 p. m. another writhing, moving mass was seen approaching. On its arrival just over our heads, down they came, like huge flakes of snow, so thick that the ground was in many places invisible. Here they remained till the next morning, scattered over the prairies. About 9 a. m. they began gathering in endless swarms into our corn-fields, and by 1 p. m. every leaf, ear, and in many places the stalks, were eaten, digested, and part of the army on their way southwest to hunt for and despoil new fields. About this time the wind changed to southeast, then veered to the south, and from that time until this writing (Tuesday evening, August 8) the hoppers are with us supping, as a last resort, on purslane, tumble-weeds, and even thistles. They will undoubtedly remain in this section until the wind changes again into the north. So much for the appearance of and destruction caused by these foes of the agriculturist. We see our entire season's work, except one-third of the crop of wheat, melt away almost in a moment, and we are helpless.

The query in my mind, as well as in the minds of many of my suffering neighbors, is where these hoppers come from. In carefully watching their progress two years ago, as well as this season, I am satisfied in my own mind that there is a slope of country to the north or northwest of Minnesota, in the British possessions, where these insects are indigenous; that in extremely dry seasons, like the present, the eggs deposited last fall hatch in such endless quantities that the locusts are forced to migrate; while in extremely wet springs, with heavy falls of snow or late frosts, in the territory where they originate, many of the infant progeny are destroyed. In July, 1874 vast numbers, it will be remembered, descended and spread over almost the entire territory west of the Missouri River. They deposited eggs in Kansas and Missouri, and in the spring of 1875, caused wide destruction in the southeast part of this State, the northeast part of Kansas and the northwest part of Missouri. This progeny seems to have been annihilated—various influences during the summer of 1875 causing them to be without the power of propagating their species. Now this season (1876), if I am not mistaken, an entire new generation can be traced from the Red River country of the north, through Western Minnesota, Southwestern Dakota, thus far into Western Nebraska. If I am correct in these observations, then, whenever our springs are dry, with but little snow or rain during the winter, followed by dry weather in June and July, we may expect grasshoppers in just such endless quantities as we have seen twice during the past four years. Whenever the winter, spring, and summer are just the opposite of the foregoing, then we will be comparatively free from these pests and our crops plenteous. I am satisfied in my own mind on the above points; and I believe further that the territory wherein these insects are indigenous, is not so large as to be beyond the control of a power, with a purse long enough to procure the necessary labor, to work the destruction of young locusts and eggs before they can make such descents upon us. Only the strong arm of Government, however, can wield this power; and sooner or later it must intervene, or this entire western territory, with its riches lying beneath the grassy sod, must be abandoned for all agricultural purposes.

Our corn, potatoes, and all our vegetable crops have already disappeared. Many of our wheat-fields were not cut at all; others yield all the way from two to twenty bushels per acre, according to location. There is as a general thing south of the Platte River a very large crop of small grain, which has been harvested, while the corn, potatoes, and vegetables are fine as they were last season. North of the Platte, throughout a portion of Hall County, all of Buffalo and Dawson Counties, the drought has been severe and continuous since the last of March. We have had a few showers; but, except immediately along Platte River, these showers have rarely been of length enough to wet the ground more than to the depth of one inch. I may say, I think, with perfect safety, that for two years past we have not had rain enough to saturate the ground to the depth of 3 feet, while the fall of snow in the winter season has been very light. In this connection it should be remembered that in digging wells we find the soil dry as an ash-heap, almost from the top of the ground to the water-line on a level with low water in our rivers, or on the divides to a depth of sometimes 140 to 60 feet. It will be easy to understand the effect of continual dry weather upon our crops and pockets.

I do not think that any of my near neighbors will complain or take me to task if I again say that a poor man with a family, and but little means, should think twice before attempting to make a home especially in Western Nebraska, for by the time this is in print no less than eight out of twelve families living near to the north and west of me will be on the way to Iowa and Missouri—some having already departed for the Pacific slope. Some are selling their claims and all their stock for less than half their value, while others are leaving their claims to hoppers, and to settlers desiring to try their luck. Many of my readers may think over in their minds the old adage that a "rolling stone gathers no moss," but permit me to ask a question: How much moss can a stone gather when visited continuously by drought, bugs, and hoppers?

Generally speaking, you can rarely find a more energetic race of men, both English and German, than those who are leaving us now. Some of them came here with money. They have sunk it all in their farms, in efforts to live and make a living, only to see it all swept away in a day. There seems at present to be no remedy except stock-raising, and this cannot be done in this country without capital. To commence with a cow or two, and live, clothe a family and school them, is almost an impossibility. One of my neighbors declares that he "will not live in a country where he has got to die in debt to his stomach."

F. N. C.

THE LOCUST IN KANSAS IN 1876.

In Kansas the locust visitation was less formidable and did not extend so far east as in 1875, as may be seen by the following letter of Professor Snow, dated University of Kansas, Lawrence, Kans., October 4, 1876:

Your postal card reached me upon my return from Colorado, and I have delayed replying to your inquiries because I wanted to know what the locust was going to do for us before writing about him. I came through Kansas from Colorado (Denver) on the 5th and 6th September. *Caloptenus spretus* at that time extended about 100 miles east of the mountains, last of which point no trace of it was to be seen during daylight on the 5th. Next morning we struck locusts in small numbers at Brookville (Saline County), 180 miles west of Kansas City; in full force at Salina, 12 miles farther east; and found the east front of this line 4 miles west of Abilene, in Dickinson County, and about 150 miles west of Kansas City. Observing and inquiring at the stations in this 30-mile belt, I invariably learned that the flight of the locust was from the *north* and not from the *west* as two years ago (in 1874).

Four weeks have now passed and the locust has not yet reached Lawrence, its eastern line being about 20 miles west of Lawrence, only about 100 miles farther east than it was four weeks ago. This eastern line extends across the State from north to south, the entire State west of this line having been visited. In many places the pest has come in immense numbers, while in many other places there has been but a light sprinkling. Little damage has been done thus far, almost none at all in comparison with two years ago, it being so late in the season that the crops of this year were secure. The fall-wheat, however, has been very generally eaten down, but has come up again when *drilled* after the departure of the hordes which remain but a few days in a place. Wheat sown broadcast has been generally killed, having been eaten down to the kernel. The great danger to be feared now is the spring-hatching of the eggs which have been deposited in varying abundance in the eastern part of the region visited. It is agreed on all hands that the present visitation is far less numerous than two years ago. The locusts are everywhere reported to be heavily parasitized by the red mite and the Tachina fly. Can it be that these hordes are the "spring-hatch" from Iowa, Minnesota, and Wyoming? While in the South Park in July, I found great numbers of young *spretus* along the streams from the mountain-sides. When on the summit of Pike's Peak July 28 and 29, the winged results were flying due east as high up in the air as the eye could reach. They did not descend upon us at Manitou until the 12th of August.

We quote also from the Monthly Weather Review:

Near Dodge City, April 30, the ground was thickly covered with the young. August 22 to 31, Dodge City, numerous and very destructive, causing entire loss of crops in many sections; 24th, Ellenwood, came from north and northeast; 29th, southwest; 31st, northeast and west. Fort Wallace, flying southwest 19th, north 23d, settling 24th; 31st, Atlanta, came in large numbers, injured fall-wheat, late corn, and gardens; also flying southeast. In September, Dodge City, abundant, flying north 2d and 4th, east 8th and 9th; less abundant 6th and 7th. In October they were reported "numerous and destructive at times during the month at Le Roy and Baxter Springs; reported nearly all gone at Creswell, 19th, and Council Grove 31st. In November grasshoppers were killed on the 14th by the snow-fall. *Brown:* The grasshoppers have destroyed about all the wheat, rye, and timothy that have come up, and will doubtless destroy all that has been sowed. The farmers have stopped sowing, owing to their presence. *Sedgwick:* The grasshoppers alighted on the 1st of September, not in such numbers as two years ago, but enough to eat all the young wheat and rye as fast as it appears. Many of the farmers are still sowing wheat. *Bourbon:* The grasshoppers appeared on the 28th of September, and are eating the wheat clean as they go. *Cowley:* The grasshoppers have taken all the early-sown wheat and rye, and they are still with us. They keep us from sowing wheat. *Douglas:* Owing to the prospect of another grasshopper raid but little wheat was sown until within two weeks. The early-sown looks fine. *Woodson:* Grasshoppers came on the 9th of September by the million, and have destroyed all the early-sown grain. *Chase:* The grasshoppers came September 9, and the wheat that had been sown is all destroyed. *Lyon:* The fall sowing of wheat and rye has all been devoured by the grasshoppers. *Osage:* On the 9th, 10th, and 11th of September the wind from the northwest brought billions of grasshoppers, and consequently all the small grain is a total loss. *Reno:* The farmers are still busy in sowing wheat; some ground is being planted for the third time; only about half the area will be sown that would have been if the grasshoppers had not come; all the early-sown was entirely killed. *Shawnee:* The grasshoppers have eaten about half of the wheat and rye sown; the farmers are sowing their grains over again. *Washington:* The farmers are now busy in sowing fall-grain; we do not fear the grasshoppers in the spring, for the farmers will plow all they can this fall and winter, with the expectation of killing the grasshoppers in the egg. *Saline:* All wheat sown before the grasshoppers came has been destroyed by them. Some farmers have lost 200 acres, and one has lost 1,200. *Mitchell:* Came from the north, the wind being from that direction, August 23. Began to come down at 9 in the morning, and by night the ground was literally covered with them. They commence to go into the crops as soon as the sun goes down, on the south and west sides of the field. They are eating the blades off the corn, which is loaded with them, and the leaves off the trees. Early corn is now quite hard and will not be seriously injured. *Pawnee:* Made their appearance August 24, coming from the northwest. Most of them passed over, but a few alighted, owing to the changing of the wind to the south. Corn is too far advanced to be injured, and they are not doing much harm except to gardens. *Washington:* Visited us August 24, at 11 o'clock in the morning, coming from the northwest. So far they have alighted on about half of the county. They are stripping the blades from the corn, but appear to pay more attention to the process of incubation than to feeding. The prevalence of a south wind has kept them here until to-day (August 31). The north wind is now blowing, and they are filling the air by the million, passing rapidly to the northwest. They have deposited no eggs, and done little damage. *Ellis:* A visitation from grasshoppers last week ruined the late corn, and injured all somewhat. *Reno:* Commenced to alight August 31, at 11 in the morning, and are eating everything green. At 2 p. m. to-day, September 1, many of them flew away. They have almost ruined the late crops, especially corn. *Norton:* Have ruined the corn-crops. *Barton:* Appeared August 24 from the north in vast swarms, and have destroyed all late corn and potatoes, beans, turnips, &c., and the wheat that was up. To-day, August 31, with a strong north wind, they are going south. They have made no deposit of eggs. *Graham:* Descended in clouds and remained five days, destroying our corn, buckwheat, turnips, and gardens. *Rice:* Have returned for the last week in as great numbers as two years ago. The corn, except the late-sod corn, which they have riddled, was out of their way. They have mostly left. *Republic:* Filled the air August 24, when corn-fields were ravaged and gardens disappeared in an afternoon. We have the assurance that we shall raise our own grasshoppers next year, for initiatory steps are being taken to give us a large supply. *Butler:* On the last day of August I was in Wichita, Sedgwick County. About 4 o'clock p. m., a very large column of grasshoppers passed over. In their flight they made a noise like the rattling of a train of cars. I do not know how far the column extended west, but it extended more than twelve miles east of Wichita. Their flight was toward the south. Although the main part passed over, enough stragglers were left in the valley of the Arkansas to eat every vestige of green wheat as fast as it came out of the ground. Some few appeared as far east as El Dorado, but no damage worthy of mention has yet been done in Butler County.—(Monthly Agricultural Report.)

THE LOCUST IN IOWA IN 1876.

In Iowa, Governor Kirkwood states that "the eggs have been laid in large quantities this season in a wide area of the western portion of the State, and the fear was expressed that they might come another season in swarms. In Northwestern Iowa the people are very careful to preserve the prairies from burning this fall, so that they may destroy the young in the spring." (Proceedings conference of governors, etc.) Concerning the grasshopper invasion of 1876, I extract the following data from the Monthly Weather Review, August 6: "Appeared at Storm Lake, Cherokee, and Sioux City, column extending to Lower Dakota and Lamar's, Mo.; at Fonda, Pocahontas County, damage slight; 25th at Unionville, Appanoose County, flying in large clouds at a high elevation, and Des Moines, Polk County, flying toward the Missouri in immense numbers. None have yet alighted in Central Iowa." *Crawford:* Injured corn 33 per cent. *Clay:* Have nearly ruined our crops. *Harrison:* Made their appearance on the 17th of August; reduced an extra corn-crop to an average; destroyed buckwheat and gardens; are injuring fruit and depositing their eggs over the whole country. *Humboldt:* Have injured corn and nearly ruined buckwheat and beans. *Calhoun:* Have trimmed around corn-fields and so injured buckwheat that it will not be cut. *Cherokee:* Came with a north wind, on the 6th of August; staid two weeks, and have deposited eggs to some extent; they damaged wheat slightly and a very heavy corn-crop at least 25 per cent. *Sioux:* Reduced corn to 40, wheat and barley to 70, oats to 80, and potatoes to 10. *Greene:* Swarm of grasshoppers are destroying the country. *Montgomery:* Came August 25; have done no injury as yet, except in a few gardens. They seem uneasy, as if they desired to leave. The wind has only been favorable for them one day since their arrival. *Audubon:* Came in clouds on the 24th of August; are doing some damage on the corn and filling the ground with eggs. *Guthrie:* Coming on us during the last week by millions; looks as if they intended to stay with us, and if they do, our crops will suffer greatly. *Pottawattamie:* Made their appearance in strong force on the 23d of August; have done considerable damage, and are laying eggs in large quantities. *Pocahontas:* Have come and gone again without doing much damage, except to gardens. *Sac:* The red-legged grasshoppers came about the 15th of August in such numbers as to materially injure our growing crops.—(Monthly Agricultural Report, August and September, 1876.)

"The Hamilton (Iowa) Freeman states that a gentleman, on examining the ground on which the insects had deposited their eggs, found 52 deposits in 4 square inches, or 13 per inch. The eggs in each deposit varied between 17 and 34, averaging about 25 to the cocoon. If these all hatched there would be 325 grasshoppers on each square inch. But most of the eggs were addled by the warm weather subsequent to their deposit. It is proposed to destroy them by burning over the prairies. In Woodbury, Iowa, the insects greatly injured the potato crop."—(Monthly Agricultural Report, November and December.)

THE LOCUST IN MINNESOTA IN 1876.

In Minnesota the eggs hatched out at Breckenridge May 23. In June the grasshoppers were infested by a "red-fly parasite," mite. In July, numerous at Breckenridge, 10th, 11th, and 12th; left, going southeast, 13th; appeared again 19th and 23d. In August, Breckenridge, swarms seen on 1st; very destructive 3d; flying and depositing eggs 6th to 12th; in the western counties, wheat, corn, oats, and barley have suffered severely. In September, Breckenridge, Minn., flying south, 26th. *Jackson:* Are here yet; it is a hard matter to estimate the damages done by them. *Meeker:* Will injure the wheat in a few places. *Nicollet:* Are destroying the crops and depositing their eggs. *Nobles:* Came upon us just as the earliest grains were ready to harvest; wheat, corn, and timothy are very badly damaged, and other crops totally destroyed. They have laid eggs for a crop next year. *Pope:* The prospect of uncommonly good crops was very fine until about two weeks ago, when the grasshoppers came. Though they did incalculable injury, yet they did not stay long enough to effect a total destruction of crops. The air was filled with the pest, clouding the sun. They did not seem to design utter destruction of vegetation, but rather to leave their progeny. Eggs were laid all over the region. This work done, they rose on favoring winds and went southeast. Their stay on an average was about one week—in some places only four days; in others ten. *Redwood:* Damaged all the crops; the vines of beans and potatoes have been almost wholly eaten up and the foliage of fruit and certain forest-trees almost wholly stripped off. *Sibley:* In eight townships the crops have suffered severely from grasshoppers. *Stearns:* The advance-guard came on the 22d of July; the main army appeared the next day about 11 a. m., and by 4 p. m. every bush, flower, tree, shrub, fence, and field was literally covered with them. They are still with us and are depositing their eggs. *Stevens:* There would have been a full average of all crops, and perhaps more, had not the grasshoppers visited this county. *Todd:* The grasshoppers struck us the 19th of July, and have destroyed at least 67 per cent. of the crops of this county. As near as I can find out, the column is about 17 miles wide. They came in from the west by north. One of the finest crops we have had for ten or twelve years is destroyed. There is barely enough left to pay for reaping. Yesterday I cut barley that should have yielded 58 bushels per acre, and I will scarcely get 5. The heads are cut off and lying on the ground. *Watonwan:* Have destroyed the wheat-crops of the county. *Yellow Medicine:* In the counties Renville, Chippewa, and Swift, and parts of Kandiyohi and Yellow Medicine oats and barley are a complete failure on account of the grasshoppers. *Blue Earth:* The western towns are alive with grasshoppers, but they have come rather late to seriously injure wheat or oats. *McLeod:* Came from the northeast about the middle of July, and spread nearly over the whole county; have injured oats, barley, and late corn considerably and wheat to some extent, and have deposited many eggs. Some are reported as hatching and others as being destroyed by a worm or insect, but millions apparently will be left to hatch next spring. *Yellow Medicine:* Grasshoppers and dry weather have nearly ruined the corn crop and taken nearly all the oats. Half of the State is covered with grasshoppers. *Redwood:* Grasshoppers and drought have destroyed the crops this year more than ever before. *Swift:* Have done a great deal of damage; they commenced depredations about the 5th of July; there have been three or four swarms; they are now mostly gone, but have left their eggs in great numbers. *Faribault:* Injured corn 10 per cent., potatoes 50 per cent., and nearly destroyed beans. About the 15th of August they lit down on us from the northwest in countless numbers. They were about eight days in passing over the county and seeding it with eggs to such an extent as to destroy all hopes of crops for the coming year. *Meeker:* Destroyed nearly all the beans. *Nicollet:* Came with the wind from the north and west, and went south and west. Of cereals they cut the oats most; destroyed much of the corn and potatoes and garden stuff. They have been depositing their eggs for the last two months. *Brown:* Reduced corn, wheat, and rye to 25; oats, barley, and buckwheat to 10. *Blue Earth:* Injured the corn somewhat and ruined beans. The county is literally filled with their eggs. Some of the eggs are being eaten by a small worm or maggot and some by a small red bug. *Nobles:* A small amount of corn and wheat escaped the grasshoppers; other crops are almost a total loss. *Stevens:* Have cut down our crops fearfully within the past month. *Todd:* Are all over the county; there is scarcely a foot of prairie or timber land on which eggs cannot be found. *Stearns:* Overrun the county and deposited millions of eggs. *Rock:* Everything was favorable for excessive crops when the grasshoppers came. They reduced wheat 30 per cent.; corn and oats 67; potatoes 75, and ruined beans.—(Monthly Agricultural Report, August and September, 1876.)

Further particulars regarding the locust invasions of Minnesota I extract and condense from a valuable "Report on the Rocky Mountain locust for 1876," by Allen Whitman:

Contrary to what was stated by Mr. A. S. Taylor, there was no locust invasion of Minnesota in 1855, but "late in July, 1856, invading swarms came from the northwest into the Upper Mississippi Valley, and gradually spread along the river during the season, much the same as they have done in the past summer [1876], and reaching nearly the same limits." * * * Again, in 1864, swarms appeared early in July, along the Upper Minnesota River, and spread eastward gradually during the season, and reached about as far east as in 1874, *i. e.*, to the third tier of towns in Le Sueur County. Scattering swarms also visited Manitoba in the same year, and probably some portions of these reached Northwest Minnesota, for we hear of slight appearances of them in the Red River and the Sauk Valleys in 1864 and 1865. But the greater portion of the injury was done in the Minnesota Valley, and was followed by a general departure to the southwest in 1865. * * * * It seems very likely that the swarms which entered Minnesota in 1864 were hatched at no great distance, and were the offspring of swarms that had alighted in Eastern Dakota in the preceding year. This may, perhaps, be inferred from the following letter of the Rev. S. R. Riggs, missionary at the Sisseton Indian agency, dated September 9, 1875:

"In 1863, it will be remembered that on General Sibley's expedition to the Missouri we met with the *ravages* of the grasshoppers in various parts of Dakota, partcularly, as I remember, near Skunk Lake (in Minnehaha County), where the large grass had been eaten to the bare stalks, and our animals fared badly. In 1865 I visited a camp of Dakota scouts, near the 'Hole in the Mountain,' at the head of the Redwood. That was in the month of August. The valley of the Minnesota, clear out to the coteau, was so full of grasshoppers as to make it unpleasant traveling. For the next four years, I traveled every summer on the Missouri River, coming over to and from Minnesota. Every season I met with grasshoppers at some point on the east side of the Missouri. In 1867, and also in 1868, we found them near Fort Randall. In 1869, in August, we met them above Fort Sully, near Grand River. In all the cases they were only in small battalions, and appeared to have come there from other parts.

"Again, in 1871, slight and scattering swarms of locusts appeared in Stearns, Todd, Douglas, Pope, Otter Tail, Becker, and Polk Counties, and perhaps in others. * * * The invasion of 1873 was something unusual in its character from the earliness of its arrival, the direction from which it came, and from the fact that it was the beginning of a visitation which has been prolonged to the present time by what, judging from former years, would appear to be unusual circumstances. Each summer since 1873, instead of being the scene of a general departure of the hatching-swarms, as in former years, has seen portions of those swarms alighting but a few miles from where they were hatched (generally in the next range of counties, and sometimes in other parts of the same county), and depositing eggs for another brood. In addition to these, new swarms coming in from the northwest in 1874 and again in 1876 have added greatly to the area of devastations in both these years, and in the latter year to the area of egg-deposit."

The map appended to Mr. Whitman's report clearly shows the successive encroachments of the locusts in the State. The parents of those that have bred within the State since 1873 "reached the southwestern corner of the State about the 1st of June, 1873, brought by a wind that had been blowing freshly from the southwest for several days." The progeny of these spread northward in 1874, but while fresh swarms entered the State in 1874 from the northwest, they did not, probably, add much to the stock of eggs deposited by the Minnesota brood, and Mr. Whitman thinks it "probable that the locusts which hatched in Minnesota last spring were, to a considerable extent, the descendants of the swarms which entered the State in 1873."

Mr. Whitman believes that in Minnesota there is not a return-flight of freshly-fledged locusts toward the Rocky Mountains, as shown by Mr. Riley and others to take place in Nebraska, Kansas, and Missouri. On the contrary, "the wind which sweep clear away the hatching-swarms of the more southern States carry our own but a few miles from their birthplace." He seems to incline to the belief that "some cause for the fact that portions of our swarms remain here to breed can be found in an early stage of egg-laying. While those observed late in summer to fly northwestward did not lay eggs, "on the other hand our own (Minnesota) stock were seen in 1875 to be laying within eight days after their flight commenced, and in the places where they first alighted, and during the past season the laying had already begun on the 3d of July, and by the 10th had become general in the western part of Nicollet County, within a few miles from their hatching-ground, and within two weeks from the time when the flying began. This early period of laying may be of itself a sufficient cause for portions of our swarms remaining here, while the less mature pass on."

From one year to another Mr. Whitman has noticed a natural decrease in the number of locusts breeding in Minnesota:

Numbers of locusts have hatched out and have died without reproducing themselves. In this connection, the State of Minnesota has an advantage over more southerly regions, in the fact that we are situated nearer to the breeding-grounds of invading swarms. Of these, the earlier comers are more likely to pass over us before reaching the full period of their development, while the later comers are cut off by our earlier frosts; and of the eggs which are left with us, being deposited earlier in the season, more are likely to hatch in the fall and become harmless. On the other hand, the invaders are more likely to mass their forces in more southerly States, reach them in full maturity, and remain later in the season, while the eggs, being deposited later than ours, remain mostly unhatched until spring. These considerations enable us to understand why certain counties in Missouri, where the locust hatched in 1875. presented in May such a picture of devastation and desolation as Minnesota has never seen in all its locust experience.

The locust has also become shorter lived, and many were killed by the Tachina maggot, while of the invading swarms of the present year "large numbers of the bodies of the dead could be found in the fields early in September," and "large numbers remained alive until they were killed by frost, and even then died with eggs unlaid." Another effect of naturalization during the last four years, says Mr. Whitman, is that "while it has lost some portion of its inclination or its ability to migrate, it has also lost somewhat of its gregarious character." Indeed, had it not been for the new-comers in 1876, "next year would have seen the insects so few and so scattered as to be incapable of great damage, and they might become in a year or two as flitting and as unnoticeable as the red-legged locust that breeds with us every year." Mr. Whitman adds that, "in regard to changes in color and appearance, while the locusts which hatched in Minnesota last spring had when fully developed something of the darkness and dullness of old age, the brightness and fierceness of the fresh invaders was apparent to every one." Mr. Whitman concludes, and we think the facts reported by him bear out his statement: "Nothing is more certain than that we might, by general and continued effort, practically eradicate the offspring of almost any one year's invasion; nothing is more probable than that in almost any season the whole body of our hatching-swarms might be utterly swept away from our midst by favorable winds; and, finally, if we may judge from the last four years, our breeding-swarms would decrease gradually from one year to another, and if not re-enforced from abroad would finally become so few and so scattered as to be harmless."

Mr. Whitman says that the facts observed in Minnesota do not substantiate the rule observed by Riley and others in Missouri, Kansas, Nebraska, &c., of a return migration in a northwest direction for the purpose of egg-laying, since they remain in part in the State and lay early in the season.

The origin of the swarms which entered Minnesota in 1874 and 1876 is not definitely known, but Mr. Whitman states that "it is probable that both in 1874 and 1876 the swarms that came into this State, at least in the earlier part of the season, were hatched in or near British America. This is to be inferred from the direction of their coming, the fact that we know of extensive hatching-grounds in British America in both these years, and that we know of no nearer hatching-ground."

The losses sustained by the State of Minnesota during the last four summers, ending with that of 1876, amounts to at least $8,000,000.

THE LOCUST IN DAKOTA IN 1876.

In Dakota, according to the Weather Signal Review, grasshoppers were active at Bismarck March 4; they were reported to have appeared on the prairies near Pembina in May, but few appeared at Pembina in June; in July they "first appeared at Pembina, flying northeast 8th and 9th, southeast 11th, 12th, 17th, 20th, and south 13th;" swarms of grasshoppers at Yankton 27th, 28th, 29th, 30th, and 31st; at Fort Sully, flying northwest and alighting 15th; northwest, 26th; numerous 16th, 27th, 28th, 29th, 30th." August 6 they "appeared in the extremesoutheastern part of the State; 10th to 29th at Fort Sully, numerous; decreased during 30th and 31st. At Yankton during early part of month, destroying all the corn; about 10th began to depart and all gone in a few days. 26th, Bismarck, swarms flying southwest." They disappeared September 1 at Fort Sully.

Buffalo: The entire corn-crop has been eaten by the grasshoppers; wheat and oats, owing to the drought, ripened early, and were harvested in time to escape them. *Clay:* Have destroyed nearly all the corn and about half the wheat and oats. They are now depositing eggs. It is the worst grasshopper raid ever known. *Hanson:* We are again visited by the everlasting grasshopper. They have been with us for the last four days, and have left nothing of corn or buckwheat but the naked stalks. Oats are badly damaged; wheat and barley were nearly harvested before they came, and potatoes and sorghum were slighted by them, but they went through the gardens like a whirlwind. *Minnehaha:* Have made their appearance slightly, and have damaged some fields. *Richland:* Are now upon us. They came yesterday, August 1, a few days late. Gardens are all swept clean; not very much damage done to grain. *Stutsman:* Did but little damage except to oats, which they nearly destroyed. There are none here at present.—(Monthly Report of the Department of Agriculture, August and September, 1876.)

Governor Pennington states that he has never seen the young in Southern Dakota, and that the locusts fly over the southern portion of the Territory from the breeding-places in the northern. This view needs confirmation, we think.

THE LOCUST IN COLORADO IN 1876.

In Colorado the movements of the locust were closely observed by my friend, Mr. W. N. Byers, who has kindly sent me the following interesting account:

DENVER, COLO., *August* 26, 1876.

I think I reported to you the time and character of the grasshopper invasion and of their depositing eggs in this part of the country last year. In consequence of the latter the young ones hatched out in great numbers during the month of May. The farmers fought them actively and in most cases successfully. Those that hatched in plowed ground were destroyed by turning them under deeply at the proper time, or if the crop was already growing they were destroyed by the judicious use of fire, coal-tar, or kerosene. For this purpose they have a number of ingenious devices, and each agency is very effective in destroying the infantile grasshopper. Where they attempted to invade growing fields they were stopped by streams of water in or from the irrigating ditches. In these streams traps and screens were placed by which the insects were caught by the bushel, or a scum of kerosene was placed on the water, if standing or moving slowly, and this was equally fatal to them. The battle lasted but a short time, and almost every farmer who tried saved his crops. Early in the summer they disappeared, no one could tell how or where. The small-grain crop mainly matured with excellent yield, but the breadth of ground planted was reduced through fear of the insects.

Right in the midst of harvest, on the 3d of August, flying swarms began coming from the north and north-northeast. They alighted from day to day, but generally moved on the next day and continued their march across the State toward the south. After about a week their course changed to southwest, and they moved into the mountains, covered South Park, and at last accounts were reaching the headwaters of the South Arkansas and Rio Grande Rivers. On the first day of this new direction the flight was the most remarkable ever seen here by civilized people. During the whole day the air was literally thick with them as far as the eye could reach. But few came down. Thus they came and went for about three weeks. Toward the last nearly all had disappeared. They damaged corn and growing vegetables in Northern Colorado perhaps one-third, though the damage was very unequal—some places nearly total, and in others very slight, and some localities escaped altogether. In Southern Colorado the damage to similar crops was much greater; probably an average of two-thirds.

Two days ago a new swarm came and settled down in this neighborhood. I have no knowledge as to the extent of the country covered by them. They are pairing,* and as the weather is getting quite cool I do not think they will move much more. We are probably fated to another generation of them next year, but our farmers have succeeded so well in fighting them, and found it so much easier than they expected, that they snap their fingers at the thought of being eaten out by the young ones. But when they fly there is no power to resist them. This is the third year of the plague, and we are pretty sure of the fourth.

We think here that the first swarms came from the high plains of Wyoming, and the later ones from Western Dakota, Eastern Montana, and, perhaps, from British America. This judgment is based upon reports of their hatching in Wyoming, Dakota, and Montana. It would be a very simple matter to determine their movements exactly and predict their march with almost exact certainty.

Beside the information given in Mr. Byers's letter of August 1, I find it stated in the Colorado Farmer that in Larimer County they eat up the grain in the last of August, having been very destructive. In the same paper for September 7, M. W. D. Arnett gives the following account of their visitations:

To the Editor of the Farmer:

Perhaps a history of the visitation of the locust or grasshopper may be interesting in forming some conclusions as to what may be reasonably expected in coming seasons. In 1864, they came to my place August 26. Wheat and other similar grain was harvested; corn was full and getting ripe, but they eat it up almost entirely. They also deposited their eggs in vast numbers, which hatched out in 1865 and destroyed nearly all the crops. I saved my own by ditches, which was mostly oats. In this year, the young fry left as soon as fledged, going southwest. On August 5, 1865, an army of grasshoppers came and harvested the oats almost entire, leaving but a small amount of wheat and nothing else. In 1866 they came, I think, on the 9th of September, when small

* Farmers report that they are depositing eggs in some portions of the country.

grain and corn were out of the way, the latter being too dry for them to eat. They deposited a large amount of eggs in 1866, which done much damage in the spring of 1867. Now, the only difference in their visitations in '64, '65, and '66, between that of '74, '75, and '76, is this: In '74 they came thirty-five days sooner than in '64; in '75 they came ten or twelve days later than in '65; in '76 they came forty-two days earlier than in '66. From '67 to '74 we had but little losses from them. A light band occasionally done a little harm.

Their movements in all respects in '64, '65, and '66 have been precisely duplicated in '74, '75, and '76, and from this I conclude we will have six or seven years' rest now. Could we be informed definitely of where their eggs are deposited north of us, we would know just what to do to escape losses. Those south and west we need have no fears of. This dreadful plague must be stopped. Already it has prevented many from immigrating to the great and fertile West, and those here are looking and wondering where they can go to escape this plague, and if it was not for that adhesive power that holds people to their adopted homes, Colorado would soon be left to the grasshopper and red man.

The following notes are taken from the Monthly Weather Review of the Weather Signal Bureau, 1876: February 19, locusts hatched out at Golden; Estes Park, March 3. At Golden, eggs laid August 24, 1875, hatched out April 21, 1876. In June, in Colorado, were frequently attacked by the red mite. July 11, "a storm of grasshoppers at Pike's Peak." August 2, at Denver, "came from north in great numbers; very destructive 3d; continued numerous until 11th; had all left by 13th; from 22d to 28th flying in the air, but few alighting; diminished in number 29th to 31st; 3d, passed over Pueblo, going north; no damage. 5th, Golden, flying southeast about 6th to 13th, leaving 13th to 26th, returning from northwest 23d, and flying northwest 24th and 25th; 12th, near Denver, made a clean sweep of the mountain-ranches; came in dense, thick clouds, but have mostly moved away. 31st, Fort Garland, air filled, flying with the wind. September 8, at Fort Garland, they were seen flying northeast. At Golden, flying east-southeast 2d and 4th; flying northwest 6th; flying west and northwest 15th; flying east-southeast 23d; flying northwest 25th. Denver, more or less abundant, 1st to 24th. Flying northeast at Golden 2d. Summit of mountains near Denver covered with many thousand bushels of dead grasshoppers.

THE LOCUST IN WYOMING, UTAH, AND NEW MEXICO IN 1876.

In Wyoming, at Cheyenne, grasshoppers were reported alive May 14; abundant from the 7th to the 31st August; "flying southeast 1st, 10th, 24th; south, 6th; northwest, 8th. October 3d, a few grasshoppers were seen flying."

In Utah, September 28, at Salt Lake City, migrating; at Coalville, Utah, flying south 26th, 27th, 28th.

In New Mexico "they appeared June 19" (Monthly Weather Report); Taos, wheat half destroyed by grasshopper (Agricultural Report, July).

THE LOCUST IN MONTANA IN 1876.

Lieut. W. L. Carpenter, U. S. A., in a letter dated Camp Robinson, Nebraska, December 10, 1876, gives me the following notes and comments on the locust:

Upon the high plateau separating the valley of the Platte from the waters-shed of the Lower Yellowstone, swarms of newly-hatched grasshoppers were observed during the last of May, 1876. They appeared to exist in small colonies of a few square rods in extent. Several such were seen during the day, and the aggregate number of individuals must have been very large. They were just able to hop, and were consequently hatched on the ground where they were observed. About July 12, immense swarms appeared in Western Nebraska and devastated that region. These insects I believe to be the same observed in May, which upon reaching maturity moved eastward, instead of going northward, as is usual with the spring broods hatched in the Missouri River Valley. No northward or return flight was noticed over the Big Horn region during the season of 1876.

About the last of July, 1876, the great flights from the northwest swarmed over the country along the eastern base of the Big Horn Mountains. They came in such numbers as to create a hazy atmosphere which was at first supposed to be due to prairie fires. During severals days they covered the earth and obscured the sun. Their line of flight was from the west of north, and in general appeared to conform to the contour of the mountain-range, following it to the southward and eastward. For some time after reaching the ground they seemed bewildered and inactive, but gradually recovered and commenced eating voraciously and pairing off. I did not, however, observe them lay eggs here. After remaining about a week they nearly all left one afternoon just as a stiff breeze was springing up from the northwest, their flight being still to the southeast. Of those which remained behind, about one-fourth appeared disabled for vigorous flight from the presence of the eggs of the parasitic mites which destroy so many; the little red oblong mites which were firmly attached to the under side of the wings, impeding them greatly and causing their ultimate destruction. Many other individuals had a sickly appearance, though I could discover nothing unusual affecting then excepting a general paleness of the body and wings and extreme weakness. These swarms appeared in Western Nebraska about the middle of August.

Upon leaving the Big Horn Mountain I passed in a northeasterly direction over the region drained by the Rose Bud, Tongue, Powder, and Yellowstone Rivers, and everywhere found evidence, in the condition of vegetation and the large quantity of "frass" on the ground, that a flight had also been here. I believe this to have been part of the great flight observed at the base of the Big Horn Mountains, and it consequently must have covered, at the same time, about 12,000 square miles of territory.

It would appear as though the great swarms, which are so destructive to eastern vegetation, follow in their eastward flight the general trend of our western mountains. Starting, as we suppose, from the Great Plains at the head of the Saskatchewan River, they would follow it down to the spurs of the Rocky Mountain chain, which curve to the southeastward and offer a continuous area of vegetation to sustain them in their journey. The Big Horn Mountains next come in view, and by their contour tend to place them well to the south by the time they reach the southern end.

The next objective point in their flight would be the Black Hills, which are densely timbered, and would naturally attract them from a distance. After leaving this latter region there are no prominent elevations to guide them in their flight, and they consequently follow the drainage of the Missouri Valley, stopping when the bright green fields of our farming communities are reached and suitable food obtained. The short prairie grasses at the season of their migratory flight have lost their freshness and begun to turn yellow. The prairies are consequently not attractive to them, and they only halt briefly for rest. But when the tall, luxuriant vegetation of the east is reached, they instinctively realize that they have arrived in a land of plenty, and accordingly leave their eggs where their young will find abundance of food upon hatching out.

In the southward flight of these great swarms, I believe that they never extend as far as Laramie Plains. The valley of the Upper North Platte appears to be the southern limit of their migration, although they cross the Platte farther to the eastward and overrun Eastern Colorado and Kansas. The Upper North Platte Valley is a region of very high winds and perhaps unsuited for this reason as a highway of travel; while the line of flight chosen by them is through a country unusually free from atmospheric disturbances.

The grasshoppers which visit that part of Colorado extending for some distance eastward of the mountains, I believe, take their flight from Utah, and travel nearly due east over the vast intervening mountain-ranges. The members of Professor Hayden's Geological Survey of Colorado observed them in 1873, on the summits of all the highest peaks, in vast numbers. I have never heard of a flight crossing the Union Pacific Railroad near Cheyenne, Wyo., and moving due south into Colorado along the mountain-range which here runs north and south. And this would have been observed if they entered Northern Colorado from the north instead of from the west. The main range of Colorado, from its great altitude, offers a formidable barrier to their eastward progress, causing myriads to perish from the cold which pervades these elevated regions.

If the country between the Big Horn Mountains and the Black Hills and the Upper Missouri and North Platte Rivers were a thickly-settled farming region, the great swarms on their eastward journey would stop here, and never reach the Lower Missouri Valley. The westward progress of civilization must ever decrease the amount of damage done to eastern agriculture; and finally when the entire West shall be settled, the cultivated fields will be extended over such a wide area that the swarms will be proportionately arrested and scattered, and the destruction of crops in any particular State be inconsiderable.

Under date of March 4, 1877, Lieutenant Carpenter writes me from Camp Robinson, Nebraska: "The warm weather has hatched out the eggs in Western Nebraska and a snow-storm has since destroyed the young."

In Montana the Monthly Weather Review reports locust as hatching out by millions in valleys about Virginia City. May 28 they were numerous throughout the Territory; 27th, began to fly. In July they were seen flying southwest 11th to 20th, and southeast 27th to 31st; much damage done in some localities. In August millions flying southeast 1st to 5th at Virginia City; decreased in numbers until 29th; no eggs deposited. According to the Monthly Agricultural Report for July, grasshoppers were abundant in July at Jefferson, and threatened to greatly reduce the wheat-crop. It should be noticed that the summer of 1876 was a hot and dry one throughout the West.

I quote further information regarding the locust in Montana from Mr. Whitman's report for 1876. Besides the region named in the article above quoted from the Winnipeg Standard, various parts of Montana are known to have been considerable hatching-grounds during the past spring. In the Bismarck Tribune of June 14 is found the following, which is quoted because it gives an idea not only of the place but of the nature of a breeding-ground:

IN THE FIELD, NEAR ROSEBUD BUTTES, *May* 29, 1876.

As we move westward the grazing improves, and here in the Little Missouri Valley the season is at least a month in advance of the season on the Missouri. This would be a splendid grazing region were the water good. The grass is heavy and nutritious, but the water is strongly impregnated with alkali. Millions of locusts are just now making their appearance in this region. Too young to fly or do much harm, in a few days, should the winds favor them, they will sweep down upon the defenseless agriculturists on the border, doing untold damage.

Officers who passed over the country between the Little Missouri and the Yellowstone Rivers during the spring state at various points in that region young locusts were found in immense numbers. Shortly before the 23d of July migrating swarms of locusts appeared in the vicinity of General Crook's camp; "myriads of grasshoppers filled the air, appearing like an immense drifting snow-storm, tending toward the southeast, and apparently taking advantage of a northwest wind to favor their flight to the same fields that they have effectually devastated for two consecutive seasons."—(Extract from a letter of July 23, quoted in the Pioneer Press and Tribune.)

HABITS OF THE LOCUST.

The following account of the habits of the locust, its mode and time of egg-laying, and its time of hatching, is compiled from the statements of others, as I have only been in the West during midsummer after the young had hatched and before the eggs were laid. Having, however, obtained the eggs of *C. spretus* from Iowa and Minnesota, and studied the habits of *Caloptenus femar-rubrum* of the East, so closely allied to *C. spretus*, and having observed the movements of *Œdipoda sordida* and *carolina* during the process of egg-laying, I can more intelligently describe the process in *spretus*. Indeed, all the different species of grasshoppers are very similar in their habits, nearly all laying their eggs in the ground, others (as in *Chloëatis*) inserting them in rotten wood. When about to lay her ripe eggs, the female selects a dry field, either in upland pasture or plowed lands, or even hard roadsides and paths. In the latter place they are more frequently observed; but from being interrupted when beginning their holes, they often leave smooth round holes, a little smaller than a lead pencil, and without any egg-sac. Immediately after

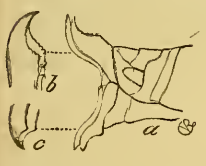

FIG. 1.—Rocky Mountain Locust. Egg-laying appendages of female. *a*, end of abdomen; *b*, upper; *c*, under hooks.

sexual union, the female (the males being distinguished from the other sex by their smaller size and blunt rounded hind bodies) proceeds to deposit her eggs. Selecting a suitable place, she forces her hind body or abdomen nearly or quite vertically downward into the earth for about an inch. During the process she opens and shuts the solid horny appendage (Fig. 1), forming four stout hooks, by means of which the soil is displaced, while a small bore is formed by the movements of the abdomen, which now elongates nearly double its original length, until the hole is an inch or more in depth. "Now, with hind legs hoisted straight above the back, and the shanks hugging more or less closely the thighs, she commences ovipositing, the eggs being voided in a pale glistening and glutinous fluid, which holds them together, and binds them into a long cylindrical pod, covered with particles of earth, which adhere to it. When fresh, the whole mass is soft and moist, but it soon acquires a firm consistency. It is often as long as the abdomen, and usually lies in a curved or slanting position." The figure from Dr. Riley's report, (Plate LXII, Fig. 1,) from whose account we have quoted, will give a good idea of the act of egg-laying or oviposition. Riley says that "the eggs which compose this mass are laid side by side to the number of from 30 to 100, according to size of mass."

Mr. Whitman, under date of February 18, 1877, further writes me regarding the breeding-habits of the locust in Minnesota:

In regard to this year, in addition to what I have written in my report, I found, September 7, a large number of females with from one to fifteen eggs in the abdomen, evidently ready to be deposited. Almost every female contained eggs. A few were found evidently totally exhausted of ova (or ovaries). All these had flown in from somewhere to the west late in August. So far as I have seen heretofore, the female, in July, before laying, has the abdomen largely distended with eggs. The female locust that I experimented upon was in such condition; then her abdomen decreased in size after laying; then increased again. But the females that I found in September, although having eggs in them, were not distended at all; in fact, there were some noticeable differences in appearance between those that flew away from us last July and those that flew in later in the season; and one difference was in the size of the body (or abdomen), and possibly this was what made the farmers say that the incomers were "smaller and not fully grown." I might go on to write considerably more in regard to the ovarian differences in appearance, but I don't know that it is worth while. I think I can sum it all up by saying that the locust which hatched in this State last spring could be very easily mistaken for the red-legged locust (as it appears about Saint Paul), while the new-comers were strikingly different in shape and somewhat in color. By the way, I have never been able to find any such thing as a red-legged locust down in the country where *spretus* was abundant. I have found a specimen or two of *spretus* in Saint Paul.

As for copulation, I think it takes place several times before laying. I judge so from what I have seen myself and what others have told me. I have been also told that the same female may receive two or more males. I had some two-striped locusts caged, and thought I could observe selection between males and females. I found in a large two-striped locust (in August) sixty-five eggs.

Regarding the breeding-habits of the locust while in confinement, I quote as follows from Mr. Whitman's report for 1876:

On the 25th of June I shut up in wire-gauze cages nine pupæ of the Rocky Mountain locust. The bottoms of the cages were filled with earth packed hard, and the insects appeared to thrive in confinement. By the 2d of July they had all become perfect insects. By the 8th of July they commenced coupling, and were seen repeating the act for several days. On the 15th and 16th, two of the females went through the form of depositing eggs, and I marked the place of deposit on the edge of the cage. The coupling was repeated again as before, until the 3d of August. At that date the coupling ended, and the locusts became almost inactive, and were seen to eat very rarely afterward.*

* The early part of this coupling-season was one of the greatest activity on the part of these insects. They dashed themselves against the wire of their cages as though all space would be too small to contain them. There would be a flash of the wings, extended and closed again in an instant, or that movement of the hind-legs known as "fiddling," which seemed to be a well-known signal between the male and female. In cages where several pairs were confined together, the male, while in the act of coupling, would repeat this movement if brushed against by another.

On the 14th of August one of the males died. The female died on the 9th of September, and was found to contain fourteen full-sized eggs; but I found, on examining the cage, that there was also a full-sized egg-cone where she had already appeared to deposit on the 15th of July. Of the rest of the Rocky Mountain locusts, the males were caged with some female red-legged locusts caught in my garden, and although the two species did not seem inclined to have much commerce with each other, I saw one pair coupling. These observations are very slight and imperfect, but are given for whatever they might be worth. That the male dies first may be inferred, not only by the above experiment, but from the fact that in September it was common to find many pairs coupled, of which the female was alive, but the male had died without releasing himself.

The time required from hatching till the wings are obtained averages about two months. The high and long flights characteristic to the species after the wings are acquired are seldom indulged, except when there is a fair wind.

Just as the mature insects fly, as a rule, in a southeasterly direction, so the young, soon after they hatch, manifest the same desire to move toward the southeast. They are most active in the heat of the day, but are perhaps more ravenous at night. They migrate short distances every clear day, but do not like to cross a stream unless they can jump it. If driven into water, however, they kick about, making considerable progress, and donot easily drown. Such, at least, are the habits of the young hatched in the Mississippi Valley, though it is very probable that in their native table-lands of the mountain region the migrating habit is not developed till they have acquired wings, and are forced from hunger to seek new quarters.

I copy the following letter from Mr. J. L. Cabot, dated Currie, Minn., July 20, 1875, which gives a good idea of the fecundity of the insect:

This is the third season that we have had hoppers. The first year they came on the 12th of June and deposited their eggs, and went away in four days, leaving the country almost totally cropless. The next season, 1874, they hatched in the last part of May, and staid here until about the 4th of July. They left the county totally stripped of all domestic vegetation, with the exception of about a tenth part of a crop of potatoes. The State furnished the county with seed-wheat this spring, and our land was all sown and planted again. Until the 4th of July crops bid fair for one of the largest yields ever known in the State. But on that day about noon the grasshoppers began to come down in such numbers that in some places they destroyed the crops in two days. They were very large ones, and left in two or three days, but had no sooner gone than other hordes of smaller ones came, and in double the number, and began to lay their eggs and leave. More came and took their places, and laid more eggs, and passed on southwest, rolling over the prairie like heavy clouds of mist on a foggy day. And still they come and go.

Another man and myself selected an average spot in a field and dug from a foot square 300 cones, each cone containing an average of 30 eggs, which would make 392,040,000 eggs to the acre.

We then caught about a pint of the grown hoppers and found it to contain 320 insects, which would make 20,480 to the bushel. And calculating each egg a hopper, we found that next spring when they hatch out we will have 19,000 bushels to the acre, and 3,200,000 to the quarter-section, or 14 quarts to the square foot. And still they are laying their eggs. But if they will go away to-day or to-morrow they will leave us enough to live on. I can't describe the feelings of the people. We think that if the State and General Government would help us to protect the grass on the prairies until next June, the hoppers might be exterminated by fire.

A few of the eggs hatch in the autumn. This has been noticed in Colorado by Mr. Byers,* and in Missouri by Professor Riley, who states that in this State "in most counties, even in the northern ones, some of the earlier eggs hatched, especially those laid on hill-sides and other high ground exposed to the rays of the sun. The young hoppers attained a size of one-fourth to one-half of an inch, and were active during the middle of the day, even into December. These young hoppers disappear and seek winter shelter; but it is doubtful whether many, if any, survive the winter." (Seventh report.) In his eighth report he says that in Kansas certain experiments made the following spring demon-

* In November a correspondent of the Colorado Farmer wrote that "the young locusts were hatching out in great numbers, and that the eggs deposited during the present season were so far advanced toward hatching that large numbers would be destroyed by frost during the winter and spring."—(Riley's Eighth Report.)

strated tne fact that a temperature of 2° degrees below zero was fatal to them.

The embryos evidently get their growth in the autumn and lie dormant until the spring before hatching. Mr. Whitman writes me under date of February 3, 1877, from Saint Paul, Minn., "We are interested here to know how near the eggs can reach hatching and still remain uninjured by feezing, and I have some eggs that were just taken from ground frozen solid, and were hatched after being kept moist and warm three days. I heard yesterday of a gentleman who started for Chicago with some eggs in his pocket and found them hatched on reaching that place."

In Missouri, the eggs mostly hatch in the middle of April and early in May, while some continue to hatch until June 1. The young acquire their wings in about seven weeks.—(Riley.)

In Kansas, the eggs hatched the first week in April, and the young first became winged May 28 and 29, and began to fly away then, until June 22.

The locusts leave Kansas, Nebraska, and Missouri about the middle of June, and are said to fly in a general northwestward course, while the fresh broods from the Rocky Mountains enter these States from about July 20 until the middle or last of September.

In Nebraska, they were fledged in 1874, about the 7th of June, and then began to fly away, and by the 6th of July they had about left the State. These dates will approximately apply to Minnesota and Iowa for the swarms from the Rocky Mountain region. In Iowa the grasshoppers in 1874 entered the State from the south and west about the 10th of June; these were the swarms from Kansas, or "probably deflected from their usual course by adverse winds." In Minnesota the young hatch in April and May, and get their wings and begin to depart about July 1, the departure becoming general about the 10th, and total by the end of August.

In Colorado, on the plains at the elevation of Denver, the eggs begin sometimes to hatch in March and continue doing so until early in May. The locusts acquire their wings and fly off about the first or middle of June. The swarms from the north and westward appear about the 20th of July, and continue to arrive until early in September. Among the foot-hills the eggs hatch in May, and at an elevation of 8,000 or 9,000 feet in June and even July the young in the subalpine elevations among the mountains in may cases perishing from the cold before acquiring wings. In Dakota, in 1874, they became winged during the first week in June and disappeared by the middle of July.

It is not generally known that the great powers of flight in the grasshopper as well as most other winged insects is due in part to the presence of large air-sacs. These sacs are expansions of the air-tubes which ramify throughout the interior of the body. They are found in the head and thorax, but are largest (especially in the honey-bee) in the base of the hind body. They do not occur in insects which simply crawl or walk. In the grasshoppers (*Acrydii*), most of the transverse anastomosing tracheæ in the abdomen have large air-reservoirs, greatly assisting in lightening the body and sustaining it in their long flights. It is from their development, probably, in the western locust (I have found them well developed in several eastern allied forms) that this insect is enabled to sail so lightly and easily for hours at a time in the air hundreds or even thousands of feet above the ground, as well as to spend days, perhaps, in its long flights during the migratory season.

The following valuable notes on the natural history of the grasshopper (*Caloptenus spretus*) have been kindly sent me by Prof. Samuel Aughey, of the University of Nebraska:

1. It is a mistake to suppose that the grasshoppers never fly at night. In August, 1866, I was camped on the Bow River, on an open prairie, in Cedar County, Nebraska. I was lying on a robe outside of the tent, the moon shining brightly. In the evening not a grasshopper could be seen or found. At 1 o'clock at night the wind shifted from the west to the north, and soon the atmosphere became perceptibly cooler. Suddenly grasshoppers commenced to drop, and continued to fall for nearly half an hour. In the morning the prairie was covered with them. I had a similar experience on two other occasions. On the Verdigris, a tributary of the Niobrara, and on the Upper Elkhorn in August, 1867. These experiences are a demonstration to me that they do sometimes, at least, fly on warm moonlight nights.

2. It appears doubtful to me whether these migrating grasshoppers ever move faster than the wind carries them. In August, 1867, when they were moving over Northern Nebraska, I climbed tall cottonwood trees, and let loose among the flying grasshoppers bits of cotton. These bunches of cotton moved or were carried forward as fast by the wind as the grasshoppers flew, and in the same direction. In June, 1875, I did the same thing from the cupola of the State University on four different days. When they were flying thickest the bits of cotton would keep even with them as far as they could be seen with a field-glass. And while these few experiments are not conclusive, it appears to me that, until some one sees them move faster than the wind, we have a right to presume that they do not. The only physical exertion, then, that the grasshoppers need to make in order to migrate is to raise themselves into the air and to keep suspended. The winds waft them into (to them) unknown regions. The height to which they often rise is very great. On the 18th of June, 1875, the column that passed over Lincoln, Nebr., was within 50 feet of being one mile in height. This I ascertained by trigonometrical determination.

3. It is probable that their constitutional vigor decays or declines in regions moister than their native habitats. I have attempted to ascertain this by various methods. One experiment was to attach the limbs of mature grasshoppers that were hatched in Nebraska to a delicate spring-balance, and ascertain in this way the degree of their physical strength. As they varied a great deal in strength, I averaged the strength of ten at a time. The following is an example of such an attempt, the first being taken from Nebraska, and the second from Northern Utah and Wyoming:

	Nebraska.	Utah.
The first grasshopper drew	1.50 ounces.	1.75 ounces.
The second grasshopper drew	1.50 ounces.	2.00 ounces.
The third grasshopper drew	1.25 ounces.	2.00 ounces.
The fourth grasshopper drew	1.75 ounces.	1.75 ounces.
The fifth grasshopper drew	1.50 ounces.	1.75 ounces.
The sixth grasshopper drew	1.75 ounces.	1.75 ounces.
The seventh grasshopper drew	1.75 ounces.	2.10 ounces.
The eighth grasshopper drew	1.50 ounces.	2.00 ounces.
The ninth grasshopper drew	2.00 ounces.	2.25 ounces.
The tenth grasshopper drew	1.50 ounces.	1.75 ounces.
	15.80 ounces.	18.80 ounces.

I have ten more tables of the same general character and results. Only in one did the two approach each other. The highest of the Nebraska columns came within half an ounce of the strength of the lowest of one set of ten from Wyoming. These tests were mostly made during July, 1875. I cannot think that the difference in strength between the Nebraska and Utah grasshoppers could have been accidental. I reached the same results by the experiment of ascertaining the length of time that the grasshoppers from the two localities could live without food. Omitting the columns of figures, the average result reached was that the Utah and Wyoming grasshoppers could live three and one-fourth days longer without food than those from Nebraska. Vivisection produced the same results. These and similar experiments satisfied me that away from their natural habitats the constitutional vigor of the grasshoppers becomes impaired, and that in a few generations they must tend to run out.

4. Confirmatory of the preceding conclusion is the following observation: As early as the spring of 1865 I noticed that probably not more than about 50 per cent. of the grasshopper-eggs that were laid the autumn previous hatched out. Almost daily from April till far into June I dug over some small portion of the ground where the eggs were thickest. Only an occasional *entire* nest of eggs hatched out. Some nests would hatch out in part and some not at all. Late in the season many entire nests of eggs could be found changed into an apparently gelatinous mass. In the spring of 1867 a still larger proportion of eggs seemed to be injured. Segmentation in many eggs had commenced in the fall and during the warm weather of February, and in many nests

the entire grasshopper had formed in the egg. The oscillations between thawing and freezing, wet and dry weather, seemed to have destroyed great numbers. The damage done to the eggs was greatest in low grounds. In both these years, also the spring of 1875 and the present spring (1876), there were an exceptionally large number of eggs in the ground. In digging over the spots where the most eggs seemed to be laid, the number ranged between 100 and 15,000 to the square foot. Isolated spots could always be found where the number was much greater. If, indeed, all would hatch out, no green thing could ever escape.

5. Among the curious things about their natural history is the following: Rainy days in some way are connected with the rapid development, or at least appearance, of the little red parasite, *Astoma gryllaria*. On June 1, 1875, the university grounds in Lincoln, Nebr., were covered with grasshoppers, and about two in a hundred contained these parasites, located mostly under or near the wings. On that day and night it rained, though it remained warm. Immediately after it cleared up the next day three out of every four grasshoppers were full of these parasites. Twice I have known this to occur. The cause or connection between the rain and the development of these parasites I have not ascertained.

The power of adaptation to varying circumstances which this migratory grasshopper seems to have is simply wonderful. Perhaps naturalists, in studying them, have been overhasty in drawing conclusions from a narrow range of facts. As to myself, after watching and experimenting for so long a time, I am not so sure that I understand them as I was ten years ago.

As an example of how high the grasshoppers may fly and the enormous number comprising a swarm, I quote the following statement from the signal-service observer station at Fort Sully:

June 15. [Direction of wind, as ascertained by the records: 6 a. m. to 7 a. m., northeast; then east till 10 a. m.; then south till 3 p. m.; southeast remainder of day.] Several days previous to this date had been hearing of the approach of locusts along the line of telegraph from Omaha, upward, to northwest; and at 4 p. m. of the 14th the operator at Fort Thompson (85 miles south, 25° east from Fort Sully) reported their advance flying northwest and northwardly. At noon a large cloud of the insects passed over until night, when they were no longer visible. Roughly estimated, the swarm may have been about 50 miles long, 25 wide, and one-quarter to one-half mile in height. A hail-storm the following day may have dispersed them.

June 23. [Direction of wind: 6 a. m., southeast; 7 a. m., southeast; 10 a. m., southeast; 2 and 3 p. m., east; rest of the day calm.] Large flights of locusts passing over during the morning, going north and northwest, at an estimated elevation of about 50 feet to as high as they were visible with field-glasses, possibly a mile; none alighting. This swarm, as near as could be ascertained by telegraph at the time, came from the Minnesota infested region, along the line of the Sioux City and Saint Paul Railroad, in a continuous cloud, probably 1,000 miles long from east to west, and 500 miles from north to south. How much farther north of this post unascertained, and not conjectured.—(Riley's Eighth Report.)

At Virginia City, in Southwestern Montana, the weather-signal observer states that "the locusts were thickest on July 20 and 21, giving the sun a hazy appearance. These 'emigrant' locusts came from the plains of Dakota, and were here, the largest bodies on the above-mentioned days, at least half a mile in thickness, and, as I learn from reliable authority, they presented an unbroken width of 20 miles, being even more numerous on the wings than here near the center."

In Indian Territory and Northern Texas they become winged, and migrate during the second and third weeks of May.

Habits of the young.—The Rocky Mountain locust casts its skin, or molts, five times after hatching. The figure (Fig. 4, Plate LXII) from Mr. Riley's eighth report graphically illustrates the process of molting. It should be borne in mind that the locust, like all grasshoppers, is born without wings, and during this period is called the *larva*. Soon the wings begin to grow, appearing as little pads (Fig. 4, *a*.) When these appear it is called a *pupa*, while the winged adult is the *imago*. When the larva is about to molt, the skin, which had become too small for it, splits open on the back of the head and thorax, and the larva withdraws itself through the rent, the body at first soft and flabby. With each molt the wings, at first very small, increase in size. Mr. Riley describes minutely the molt of the pupa into the fully-winged state.

When about to acquire wings the pupa crawls up some post, weed, grass-stalk, or other object, and clutches such object securely by the hind feet, which are drawn up under the body. In doing so the favorite position is with the head downward, though this is by no means essential. Remaining motionless for several hours in this position, with antennæ drawn down over the face, and the whole aspect betokening helplessness, the thorax, especially between the wing-pads, is noticed to swell. Presently the skin along this swollen portion splits right along the middle of the head and thorax, starting by a transverse-curved suture between the eyes and ending at the base of the abdomen. Let us now imagine that we are watching one from the moment of this splitting, and when it presents the appearance of Fig. 4, *a*, Plate LXII. As soon as the skin is split the soft and white fore-body and head swell and gradually extrude more and more by a series of muscular contortions; the new head slowly emerges from the old skin which, with its empty eyes, is worked back beneath; the new feelers and legs are being drawn from their casings, and the future wings from their sheaths. At the end of six or seven minutes our locust—no longer pupa and not yet imago—looks as in Fig. 4, *b*, the four front pupa-legs being generally detached, and the insect hanging by the hooks of the hind feet, which were anchored while yet it had that command over them which it has now lost. The receding skin is transparent and loosened, especially from the extremities. In six or seven minutes more of arduous labor, of swelling and contracting, with an occasional brief respite, the antennæ and the four front legs are freed, and the fulled and crimped wings extricated. The soft front legs rapidly stiffen and, holding to its support as well as may be with these, the nascent locust employs whatever muscular force it is capable of to draw out the end of the abdomen and its long hind legs (Fig. 4, *c*). This in a few more minutes it finally does, and, with gait as unsteady as that of a new-dropped colt, it turns round and clambers up by the side of the shrunken cast-off skin and there rests, while the wings expand and every part of the body hardens and gains strength, the crooked limbs straightening and the wings unfolding and expanding like the petals of some pale flower. The front wings are at first rolled longitudinally to a point, and as they expand and unroll, the hind wings, which are tucked and gathered along the veins at first, curl over them. In ten or fifteen minutes from the time of extrication these wings are fully expanded and hang down like dampened rags (Fig. 4, *d*). From this point on, the broad hind wings begin to fold up like fans beneath the narrower front ones, and in another ten minutes they have assumed the normal attitude of rest. Meanwhile the pale colors which always belong to the insect while molting have been gradually giving way to the natural tints, and at this stage our new-fledged locust presents an aspect fresh and bright. (Fig. 4, *e*.) If now we examine the cast-off skin, we shall find every part entire, with the exception of the rupture which originally took place on the back, and it would puzzle one who had not witnessed the operation to divine how the now stiff hind shanks of the mature insect had been extricated from the bent skeleton left behind. They are in fact drawn over the bent knee-joint, so that during the process they have been bent double throughout their length. They were as supple at the time as an oil-soaked string, and for some time after extrication they show the effects of this severe bending by their curved appearence.

The molting, from the bursting of the pupa-skin to the full adjustment of the wings and straightening of the legs of the perfect insect, occupies less than three quarters of an hour and sometimes but half an hour. It takes place most frequently during the warmer hours of the morning, and within an hour after the wings are once in position the parts have become sufficiently dry and stiffened to enable the insect to move about with ease, and in another hour, with appetite sharpened by long fast, it joins its voracious comrades and tries its new jaws. The molting period, especially the last, is a very critical one, and during the helplessness that belongs to it the unfortunate locust falls a prey to many enemies which otherwise would not molest it, and not unfrequently to the voracity of the more active individuals of its own species.—(Riley's Eighth Report.)

The egg (Plate LXII, Fig. 1, *c*) is curved, cylindrical, .21 inch (5½ millimeters) in length, more pointed at the posterior than the anterior end. The posterior end is contracted just before the extreme tip, which is smooth, the more or less regular pits which cover the chorion, or egg-shell, being here obsolete. I have been unable to discover any micropyle, or passage for the spermatozoa. The posterior end points downward in the egg-moss, so that the exit of the young locust from the anterior end is thus rendered easier. Although I have not seen the larva actually burst its way out of the egg, yet on the examination of between fifteen and twenty deserted egg-shells, I have, without an exception, noticed in them one, more usually two, slits extending from the head-end to the middle of the egg. The egg-shell is without doubt burst open by the puffing out or expansion of the membrane connecting the head and prothorax, just as the common house-fly or flesh-fly bursts off the end of its pupa-case by the puffing out of the front of the head. I have seen the embryo make its exit in two or three instances. In one case I saw a large piece of the egg-shell (chorion) fly off from in front of the face while the face of the embryo puffed slightly out, and in another instance the whole anterior end of the shell came off. In the locust I have observed, as will be seen farther on, that the amnion is ruptured by the forcible expansion of the membrane behind the head, the larvæ before walking lying on their backs or sides and forcing this membrane outward. This action probably begins before the shell is burst and seems amply sufficient to burst the brittle chorion, which is easily broken and peeled off by rubbing the egg between the fingers, leaving the serous membrane beneath. The pressure thus exerted must be a lateral one, and sufficient to rupture the chorion.

In his ninth report on the injurious insects of Missouri, Professor Riley maintains that besides "a continuation of undulating contractions and expansions of the body," the tips of the jaws and "sharp tips of the hind tibial spines," the shell is ruptured, and then "splits up to the eyes or beyond, by the swelling of the head." I think the swelling of the space between the head and thorax is sufficient to accomplish the rupture of the shell. It may be objected to Mr. Riley's account of the supposed action of the jaws and spines that, as may be seen by my Fig. 2, the position of the legs is such that the tibial spines do not point outward, the tibiæ being placed between the femora, and the legs are not displaced until after the amnion is shed. Moreover the spines are soft and flabby, as well as the legs; besides this the legs and the entire body are covered by the amnion, the tibiæ being smooth. Did the spines saw through both the chorion and serous membrane, the amnion would, of course, be ruptured. I also do not think that the jaws would be available until after the amnion has been cast. That the jaws are not moved out of their place until after the embryo leaves its egg-shell and throws off its amnion, I was able to plainly see in a specimen, which the moment after the amnion was forced back from the head opened the jaws and thrust out the palpi and antennæ. The amnion is sometimes nearly shed before the embryo has entirely extricated itself from the egg-shell. The outer embryonal layer, or "serous membrane" of Kowalevsky, may be detected by rubbing off the chorion.

I have found six stages in the life-history of the Rocky Mountain locust, with consequently five molts, with the following characters as seen in the female sex of each stage:

1. First larval. Head very large, and abdomen short and small; antennæ 12-jointed. Length, $14\text{–}15^{mm}$.

2. Second larval. Head smaller; antennæ 16-jointed; lower edges of tergum of meso-thoracic ring and especially meta-thoracic full and rounded. No difference from the first stage seen in a dorsal view; colors deeper, markings more distinct. Length, $7\text{–}8\frac{1}{2}^{mm}$.

3. Third larval. Head about the same size proportionally as in the second stage; lower sides of meso- and meta-thoracic rings subacutely produced, evidently the rudiments of the wing-pods of the pupa. The proportion of the prothorax to the two posterior segments is the same as before. Length, $9\text{–}11^{mm}$.

4. First pupal. Antennæ 20-jointed; prothorax much produced backward, wing-pods well developed, covering the tergum of the meso- and meta-thoracic segments, so far as they are not concealed by the overlapping of the prothorax; outer pair twice as large as the inner pair; the hinder pair $2\frac{1}{2}^{mm}$ in length, or two-thirds as long as the prothorax. Length, 15^{mm}.

5. Second pupal. Antennæ 22-jointed; prothorax still larger; hind wing-pods as long as the prothorax. Length 20^{mm} (1 inch).

6. Imago, or adult, with wings fully developed. Antennæ 23–24-jointed; eyes more rounded than in the pupa; hind femora slenderer. Length of body, 25^{mm}.

It will thus be seen that there are three larval and two pupal stages besides the adult stage.

The embryo locust.—On removing the living embryo from the egg-shell under (Plate LXII, Fig. 2), it is found that it lies with the legs folded on the side of the body, the fore and middle pair folded directly across the thorax, while the hind pair are laid along each side of the abdomen. The antennæ lie on the face each side of the clypeus and labrum, or upper lip. The eyes are dark reddish, and the head, limbs, and cross-lines on the back of the body are reddish mixed with yellow. Beneath, the body and legs are white. By putting the eggs in alcohol the shell becomes more transparent, so that the head, eyes, limbs, and reddish portions of the body become visible. Length of embryo at time of hatching 0.21 inch. Described from living specimens received from Mr S. D. Payne, Kasota, Lesueur County, Minnesota, March 1, 1877.* Either during the night of the 13th or early in the morning of the 14th of March nearly all the larvæ (the eggs having been kept in a warm room) hatched at the same time. The egg-shell bursts open at the head-end, when the larva immediately after extricating itself from the egg casts off a thin pellicle (the amnion or *faltenblatt*), as I have seen in the larvæ of the flea, currant saw-fly, and other insects. Before the skin is cast it is almost motionless, and by slight movements of the body in about five minutes draws itself out of the amnion. The pro-

* This shows that the embryo locust develops in the autumn immediately after the eggs are laid, and that it lies dormant (a few occasionally hatching in the autumn) during the winter, ready to burst its egg-shell in the spring.

cess of extrication is as follows: While it lies nearly motionless it puffs out the thin, loose skin connecting the back of the head with the front edge of the prothorax. The distension of this part probably ruptures the skin, which slips over the head, the body meanwhile curved over until the skin is drawn back from the head; when the latter is thrown back it withdraws its antennæ and legs, and the skin is in a second pushed back to near the end of the abdomen; finally it draws its hind tarsi out of the skin, and in a moment or two more the young locust frees itself and walks actively off, sometimes, however, with the cast skin adhering to the end of the abdomen.

Before the molting of the amnion the body and legs are soft and flabby; immediately after, it walks firmly on its legs. At 11 a. m. most all, one or more hundred, had hatched. They are pale-reddish, however, as in the embryo; by 3 p. m. they had begun to turn dark, and by 9 of the next day all were dark colored, as in the following description:

Description of the larva. (Plate LXII, Fig. 3).—The following description is taken from living young as they had just hatched in Salem, Mass., January 22, 1877 from eggs received from Mr. A. Whitman, of Saint Paul, Minn. The larva has a larger head and smaller abdomen than the pupa and has no rudiments of wings. They were blackish, marbled with flesh-color, with a dorsal white line behind the head. Legs flesh-colored, spotted irregularly with black. Hind thighs (femora) spotted with black, much as in the adult; toe-joints (tarsi) black. Head very large in proportion to the rest of the body; abdomen small, tapering rapidly toward the tip. Length, 0.17 inch. In another specimen (three living ones only examined) the back of the body had a reddish tint, as in older specimens observed living in Colorado.

Pupa (Plate LXII, Figs. 3, 4).—Ground-color, a deep reddish salmon-color on the head, body, and legs. Front of head below the antennæ black, marbled with white lines. Prothorax with a curved, broad, black longitudinal band on each side of the median line, and below a squarish black spot separated from the black band above by a conspicuous white stripe, and with two white spots on the lower edge. Rudimentary wings black, with fine pale lines and reddish flesh-colored along the costal edge. Hind legs blackish on the outside of the thighs (femora), interrupted by fine, salmon-colored lines. Abdomen whitish above and on the sides, spotted and marbled with black, forming broken lines; ventral side flesh-colored, not spotted. Hind shanks (tibiæ) black beneath, above flesh-colored, with the spines black. Length, 0.65 inch. Described from several living specimens taken at Manitou, Colo., July 16; hundreds of others seen in different parts of Colorado not apparently differing on casual examination.

In addition I may quote Mr. Riley's description based on living specimens observed in Missouri:

The pupa is characterized by its paler, more yellow color, bringing more strongly into relief the black on the upper part of the thorax and behind the eyes; by the spotted nature of the face, especially along the ridges; by the isolation of the black subdorsal mark on the two anterior lobes of prothorax, and by the large size of the wing-pads, which, visible from the first molt, and increasing with each subsequent molt, are now dark, with a distinct pale discal spot, and pale veins and borders. The hind shanks incline to bluish rather than red, as in the mature insect.

ADULT (Plate LXII, Figs. 1, 4, *e*, 5, 6).—After repeated examination of the variations of this species as compared with those of *C. femur-rubrum*, the only reliable characters I have been able to find are the following: The male and female *C. spretus* (normal Rocky Mountain form) differs from *C. femur-rubrum* in its much larger size, its proportionately longer and larger wings and usually lighter tints, and the larger, more distinct spots on the wings. I can see no difference in the ovipositor of the female. The most constant difference is in the form of the end of the male abdomen, which is narrow, elevated, and more or less deeply notched (see Plate I, Fig. 6), while in the male of *C. femur-rubrum* it is well-rounded, full, swollen, and the edge entire, with very rarely a slight tendency to a notch. The largest male from Colorado in my collection measured 1.30 inches. The small variety *Atlanis* I regard as a variety of this species, and not *femur-rubrum*, because it has the well-defined notch in the narrow, high abdominal tip. My Iowa specimens are darker than those from Colorado, Missouri, and Kansas, but a fine male from Arapahoe Peak, Colorado, is full as dark as those from Iowa.

The young do not leave the place of their birth until after the first month, but huddle together, not scattering, as most young insects do, they being gregarious at the outset. The small bands then unite into larger ones, and these mass into enormous armies. They are exceedingly ravenous, feeding upon each other when other food is exhausted. Riley says that "the young insects move, as a rule, during the warmer hours of the day only, feeding, if hungry, by the way, but generally marching in a given direction until toward evening. They travel in schools or armies, in no particular direction, but purely in search of food, the same school often pursuing a different course one day to that pursued the day previous." In Missouri, the young moved in a general northerly direction. They seldom move, when half-grown, "at a greater rate than three yards a minute, even when at their greatest speed, over a tolerably smooth and level road, and not halting to feed. They walk three-fourths of this distance and hop the rest." It is in the young wingless condition that the locust is most to be feared, and, on the other hand, most easily subdued.

THE ROCKY MOUNTAIN LOCUST NOT PERMANENTLY ABUNDANT AND INJURIOUS EAST OF THE PLAINS.

It has been abundantly proved by Professor Riley and others that the locust will not be destructive east of longitude 93° or 94°, namely, the western edge of the Mississippi Valley. We have seen that the progeny of the swarms from the plains lying on the flanks of the Rocky Mountains which at intervals infest the western border of the Mississippi basin generally return northwestward. The cause of their northwestward migration is in all probability due to the prevailing southerly and easterly winds of June and early July; but those that are left are said to be enfeebled and degenerated. Mr. Riley attributes this to the low altitude and moisture of the Mississippi Valley, the locust flourishing and most prolific in the dry elevated plateaus of the Rocky Mountains. Professor Riley thinks that the length of the summers of the western Mississippi States as compared with the short hot summers of the plains another cause of its inability to live permanently east of the plains in large numbers. To use Riley's own words:

Assuming that I have correctly placed the native home of the species in the higher, treeless, and uninhabitable plains of the Rocky Mountain region of the northwest, and that it is subalpine, we may perhaps find, in addition to the comparatively sudden change from an attenuated and dry to a more dense and humid atmosphere, another tangible barrier to its permanent multiplication in the more fertile country to the southeast in the lengthened summer season. As with annual plants, so with insects (like this locust), which produce but one generation annually, and whose active existence is bounded by the spring and autumn frosts, the duration of active life is proportioned to the length of the growing season. Hatching late and developing quickly in its native haunts, our Rocky Mountain locust, when born within our borders (and the same will apply in degree to all the country where it is not autochthonous), is in the condition of an annual northern plant sown in more southern climes; and just as this attains precocious maturity and deteriorates for want of autumn's ripening influences, so our locust must deteriorate under such circumstances. If those which acquired wings in Missouri early last June had staid with us long enough to lay eggs, even supposing them capable of doing so, these eggs would have inevitably hatched prematurely, and the progeny must in consequence have perished.

The fact that some changes are undergone by the eastern progeny of the Rocky Mountain locust is substantiated by two good observers, quoted by Mr. Riley, as follows:

Mr. Riley is of the opinion that the grasshoppers run out in a few generations after they leave their native sandy and gravelly soil. My experiments, so far as they go, verify that opinion. For several years I have caught grasshoppers during early sum, mer that came fresh from the direction of the mountains, and by attaching their legs by fine silk threads to a small spring balance, found that their physical strength was from 25 to 50 per cent. greater than that of grasshoppers treated the same way that were hatched in Nebraska or in States farther eastward or northward. The same result was reached by caging them, and ascertaining how long they would live without food, and also by vivisection. In some places, also, the eggs that were laid in different years since 1864 did not hatch out. The changes from extreme wet to dry, and from cold to hot weather, or some other unknown causes, seem to sap their constitutional vigor. Were it not for this, long ere now these grasshoppers would, from their enormous numbers, have desolated the whole country as far east as the Atlantic.—Prof. Samuel Aughey, of the University of Nebraska, in the Lincoln (Nebr.) Journal.

I have observed hundreds of winged locusts fall to the ground during flight, either already dead or soon dying. These, upon examination, have generally proved to contain no parasites, and I judge that their death was in consequence of impaired strength; this second generation, raised in an unnatural climate, not equaling in vitality the first generations, and succumbing to the fatigue consequent upon extended flight.—Prof. F. H. Snow, of Kansas State University, in Observer of Nature.

This view is also held by Mr. Whitman, of Minnesota.

Mr. Riley states that in Missouri "the specimens which hatched in and left our western counties last spring were, on an average, somewhat darker and smaller than their parents." It thus appears that the Rocky Mountain locust is affected like most other animals or plants when removed from their proper geographical limits; but a few insects, such as the Colorado potato-beetle, &c., being able to withstand a change of climate. As will be seen below, a variety of *spretus* head is found in Northern New England, Illinois, and the Pacific coast. Though born and bred outside of the dry and elevated Rocky Mountain plains, are dwarfed and prevented by moisture and various natural causes, such as the presence of forests, &c., from increasing in large numbers and migrating. These dwarfed individuals are a climatic variety of *C. spretus*, which has been named *atlanis* by Mr. Riley, who, however, believes that it is a truly distinct species from *C. spretus*. But from a careful study of the geographical variations of a number of moths common to the Atlantic and Pacific States as well as the Rocky Mountain region, I have found that Rocky Mountain and usually Pacific coast specimens are larger and with longer wings than eastern examples.

(See my monograph of *Phalænidæ*, Hayden's United States Geological Survey, p. 584, 589.)

It appears that the var. *atlanis* collected in Illinois was first examined by Mr. Uhler and named *C. spretus*, but as Mr. Thomas's specimens of *spretus* came from the locust-area of the plains, and his description applies to the genuine *spretus*, his name should be regarded as the authority rather than Mr. Uhler, whose name was not accompanied by a description, so far as I am aware.

"It is somewhat strange," says Prof. C. Thomas, in the zoology of Lieutenant Wheeler's Survey, p. 892, "that the first specimen ever examined and named should have been found in Southern Illinois by the writer and sent to Professor Uhler, of Baltimore, about the year 1860, though previous to that time various scientific expeditions had penetrated the western plains; yet it is but seldom seen in the section where that specimen was obtained." It is not impossible that the few specimens of *C. spretus* said to have been seen east of the Mississippi have flown over from the eastern limits of the locust-area in Minnesota, Iowa, or Nebraska, and that it is not a permanent resident, just as the Asiatic migratory locust occurs temporarily in England and Sweden. The variety called by Mr. Riley *C. atlanis* is, however, common in Illinois, and extends west to central Missouri. This is a smaller form, with shorter wings, and markings more like the eastern locust, but differing decidedly in the notched end of the hind body of the male. There is great difference of opinion in regard to this form. Mr. Riley was the first to describe it fully, and I quote his description:

Caloptenus atlanis, n. sp.—Length to tip of abdomen, 0.70–0.85 inch; to tip of closed wings, 0.92–1.05 inches. At once distinguished from *femur-rubrum* by the notched character of the anal-abdominal joint in the male, and by the shorter, less tapering cerci; also by the greater relative length of wings, which extend, on an average, nearly one-third their length beyond the tip of the abdomen in the dried specimens; also by the larger and more distinct spots on the wings—in all which characters it much more closely resembles *spretus* than *femur-rubrum*. From *spretus*, again, it is at once distinguished by the smaller size, the more distinct separation of the dark mark running from the eyes on the prothorax and of the pale line from base of wings to hind thigh; also by the anal joint in the ♂ tapering more suddenly; and by the two lobes forming the notch being less marked. From both species it is distinguished not only by its smaller size, but by the deeper, more livid color of the dark parts, and the paler yellow of the light parts—the colors thus more strongly contrasting.

6 ♂'s, 7 ♀'s from New Hampshire. Just as the typical *femur-rubrum* is at once distinguished from the typical *spretus* by the characters indicated, so *atlanis*, though structurally nearer to *spretus*, is distinguished from it at a glance by its much smaller size and darker, more marbled coloring. The contrast is all the greater in the living specimens, and I have seen no specimens of *spretus* that at all approach it in these respects.

Whether this is the *femur-rubrum*, as defined by De Geer or by Harris, it is almost impossible to decide, though Harris's figure of *femur-rubrum* better represents it than the true *femur-rubrum* as subsequently defined by Thomas, and as found in Illinois and Missouri.

I have collected this grasshopper in Central Maine, and at Amherst, Mass., where it is not uncommon, and could be easily confounded with the eastern red-legged locust, (*C. femur-rebrum*). It is also common in Essex County, Massachusetts, and has been since 1864, as seen by specimens in the museum of the Peabody Academy of Science at Salem. Mr. S. H. Scudder has also specimens from New Hampshire, and it is not improbable that it is a widely-distributed form, with a range approximating to that given on the map. I am inclined to regard it as by no means a distinct species, but as an eastern variety of *C. spretus*, replacing that species on the Atlantic coast and in the Mississippi Valley. In this region it will probably never become injurious. Mr. Thomas regards it as a variety of *C. femur-rubrum* rather than *C. spretus*. In speaking of *Caloptenus femur-rubrum*, he remarks as follows:* "A few specimens taken in Iowa. These belong to the typical form, but they and all others obtained within the last two or three years appear to me to be slenderer and more like Riley's *atlanis* than in former years. That this species has been undergoing some modification in the Mississippi Valley within the last three or four years I think must be admitted. Although Riley's *atlanis* is certainly but a variety of *femur-rubrum*, yet it can be separated from the latter at a glance, and when the specimens are fresh without opening the wings or examining the posterior abdominal segments."

It should be borne in mind that the western *spretus* differs from the *femur-rubrum* in the much longer wings and its larger size. The legs are the same in both, while *spretus* is paler, with shades of dull yellow and red. The legs are of the same length in both, and the spines (ovipositor) in the end of the body are the same in the two species. These differences I find constant after careful examination of twelve specimens of each species, and of many others more superficially studied. The male of *spretus* differs decidedly from that of *femur-rubrum* in the characters already pointed out, namely, in the narrow, prominent, deeply-notched tip of the abdomen, as well as the short fork in the complete tergal piece of the abdomen. On the other hand the end of the body of the male of *femur-rubrum* is rounded, full, and entire, and not thickened, yet I have observed in one or two of the specimens of the male *femur-*

* Proceedings of the Davenport Academy of Natural Sciences, 1876, p. 260.

rubrum from Essex County, Massachusetts, a slight tendency of the abdomen to become notched, and I should not be surprised to find intermediate links connecting the variety *atlanis* with *femur-rubrum*, but with the evidence now before me, especially the occurrence in California of diminutive short-winged male *spretus*, scarcely distinguishable from the eastern *atlanis*, the two specimens agreeing well in the form of the abdominal tip. I am inclined to the belief that *atlanis* is simply a variety of *spretus*. Speculating on the origin of the two species, I should consider, that *femur-rubrum* being on the whole the more widespread species, that *spretus* originated from it after it (*femur-rubrum*) had attained its present distribution, and that *spretus* assumed its larger size and great length of wing on the hot and dry central plateau of the Rocky Mountains.

Practically considered the two injurious forms are the genuine *spretus* and the genuine *femur-rubrum*. It is the latter which is so abundant and destructive at times in the New England States and Canada. Having known the insect so well for twenty years in Maine and New Hampshire, I am surprised to find in Mr. Riley's seventh report the suggestion that the *femur-rubrum* "had been confounded" with his *atlanis*, and "had played the part of a migratory locust in the White Mountain region of Maine and New Hampshire." The form *atlanis* is a comparatively rare one in New England. During the summer of 1874, '75, and '76, in Massachusetts at least, it has been very rarely met with, compared with the ordinary red-legged locust, and must have been so in 1864, judging by the labels on the specimens in the museum of the Peabody Academy of Science, and I have little doubt but that it has always been a comparatively scarce insect, while the genuine *femur-rubrum* abounds in countless numbers each summer and autumn from Maine to Massachusetts, and I suppose all over its destructive limits as laid down on Map II.

I have received a male and female of *C. spretus*, var. *atlanis*, from Mr. Henry Gillman, of Detroit, who collected them "near Laughing Fish River, Michigan,* on the south shore of Lake Superior. This river falls into Traine Bay, an indentation of the coast to the eastward of Marquette. These specimens measured thus, from head to tip of wings when folded, male 1.08, female 1.10 inches; *atlanis* from Massachusetts, male 1.02, female 1.12 inches; *atlanis* from Illinois, male 0.92, female 0.95 inch; *atlanis* from California, male 0.99 inch. On the other hand a male *C. spretus*, normal form, from Iowa, measured 1.30, while an average male from Colorado was 1.34 inches in length. Ten specimens of Iowa *spretus*, the offspring of emigrants from the Rocky Mountains, were slightly smaller and considerably darker than specimens from Missouri, Kansas, and Colorado, approaching slightly but perceptibly var. *atlanis* and *femur-rubrum*. I have the idea that if the normal form of *spretus* were permanently acclimated in the Mississippi Valley, it would change to var. *atlanis*.

I should add that the conclusions regarding the varietal nature I have above stated are written out from notes made two years since after careful examinations, and in 1874, and again in 1875, while I have at the present time of writing re-examined the subject and come to the same conclusion as I held in 1874.

DOES THE ROCKY MOUNTAIN LOCUST INHABIT THE PACIFIC COAST?

Prof. C. Thomas remarks as follows in the Zoology of Lieutenant Wheeler's Survey, p. 892, 1876, concerning the westward distribution

* Riviere aux Poissons qui rit, of the French Voyageurs.

of this species: "So far as I can learn, it has not yet been found in California; but as it is found immediately east of the Sierra Nevada, it is quite probable that it reaches to the Pacific, though it may not be migratory on the west side of the range." Previous to this, in his Acrididæ of North America, (Hayden's Survey, 1873, p. 165), he remarked, "I have traced this species from Texas northward to the north shore of Lake Winnipeg, in British America, and from the Mississippi River westward to the Sierra Nevada range. It does not appear to be found in California, and but a short distance southward in Arizona. I am half-way inclined to the opinion that future investigations will show that this is really the destructive species in California, and not *Œdipoda atrox*, for it would seem impossible for the latter to sustain itself during a lengthened flight with its short wings."

Mr. Scudder thus writes me regarding the occurrence of *C. spretus* in California: "On looking over my cabinet I find two or three specimens, probably received from Mr. Edwards, with printed label 'California and Nevada,' which I should be very unwilling to separate from *spretus*."

In the autumn of 1875 I received from Mr. Edwards two specimens, labeled *C. spretus*, from California; one was a male, the other a female. The male I compared with a living male *spretus*, var. *atlanis*, caught at Amherst, and found no differences in size or length of wing, except that the wings were more clearly spotted and the body lighter colored. I then considered it as *C. spretus*, and published a note to that effect in the American Naturalist for October, 1875, vol. ix, p. 573.

On sending the two specimens to Mr. Scudder for identification, he writes me that the female "is apparently *femur-rubrum* and the other probably *bilituralis* Walker, though it is pretty hard to be sure of Walker's species. I have both of these from Vancouver's Island (Crotch).".

On a fresh comparison of Mr. Edwards's male, which he and I refer to *spretus*, I found it to be of the same size and length of wing as Massachusetts *atlanis*, but on comparing it with *C. spretus* from Northern Missouri, it does not seem to me to differ, except in being considerably smaller and in having shorter wings; in coloration and style of markings, particularly the general pale-reddish and dull-yellowish tints, and especially the distinct spots on the wings, it is a true *spretus*. Some observers may call it variety *atlanis*. I should prefer to regard it as a small subvariety of *spretus*, and regard *atlanis* as confined to the Eastern States. However, as far as our present knowledge goes, I should conclude that *spretus* occurs west of the Sierra Nevada as well as east, but have not extended its range on the map beyond Utah and Idaho, except conjecturally. It is to be hoped that collectors in California will settle all doubts as to the range of this species in the Pacific States, and collect it in such numbers that satisfactory comparisons may be instituted between the Pacific coast form and the genuine *spretus* and the form *atlanis*. Meanwhile, Mr. Henry Edwards, so well known for his extensive entomological researches in Oregon, California, and Nevada, sends me the following notes under date of September 10, 1876: "Now as to *Caloptenus spretus*, I first found this species in large numbers about 20 miles north of San Francisco, in Marion County, in May, 1875. Previous to that time, though known to me by a few scattered individuals, it had never appeared in great abundance, but at the above date it was in immense quantities in the locality indicated, though it appeared to prefer the dried-up grass to the green and growing corn and other cereals which were close at hand. I have heard of no serious complaints whatever of the destructive qualities of this insect, and am inclined to think that it is not yet much to be dreaded in California. We have no other species that I am aware of in large numbers. *Spretus* has been taken by me near Portland and at the Dalles, Oregon, and still more abundantly at Victoria, Vancouver's Island, but I have never seen it in the Sierras; my idea being that it is always (here at least) confined to the valleys and plains. In proof of this, the locality in Marin County to which I have alluded is at the base of Mount ———, and on the sides of the mountain itself the grasshoppers were not found at all. I do not think it goes far south of San Francisco. I have seen one or two from Santa Barbara, but none from below that point. Perhaps it may be replaced by another species. We have no literature that I know of on the subject, save a few newspaper notices, which I will try to find and send to you. At present, we are strangely exempt from all destructive insects."

California in former years has had its locust invasions, although we are entirely uncertain as to the species forming the swarms. In different parts of California they have appeared in the following years, according to Mr. A. S. Taylor (Smithsonian Report for 1858): 1722, 1746–1749, 1753 and 1754, 1765–1767. In the present century they have been abundant and destructive about 1827 or 1828, about 1834 or 1835, and in 1838, 1846, and especially in 1855.

THE GEOGRAPHICAL DISTRIBUTION OF THE ROCKY MOUNTAIN LOCUST.

A glance at the accompanying map, showing the distribution of the Rocky Mountain locust (*Caloptenus spretus*), will show the probable limits within which it will be found. At least there is no probability that the locust will ever afflict farmers east of the limits assigned.

The eastern limits have been defined by Professor Riley for Texas, Indian Territory, Missouri, Kansas, Nebraska, and Minnesota, while the northern and northeastern limits have been indicated by Prof. G. M. Dawson. The southestern limits are somewhat conjectural, but have been indicated to me by Maj. J. W. Powell. The western limits in Nevada and Idaho have been pointed out to me by Prof. Cyrus Thomas.

The range of the small variety (*atlanis?*) in California and British America (Vancouver Island) has been indicated by Messrs. H. Edwards, S. H. Scudder, and myself; while the eastern range of the eastern variety *atlanis* has been indicated by Messrs. Riley, Thomas, Scudder, and myself.

The locust area is divided into two regions, one the permanent breeding-places, on the elevated plains among the Rocky Mountains and the great plateau lying east and extending approximately to longitude 102°. Beyond the edge of the great plains are found the temporary breeding-places of the locust, which comprise the prairie-lands of the border States as far east as longitude 93° or 94°. The arrows with simple shafts indicate the course of the migrations from the original, usually permanent, breeding-places, and the arrows with a feathered shaft the return migrations from the temporary breeding-places periodically visited.

THE MIGRATIONS OF THE ROCKY MOUNTAIN LOCUST OF THE WEST.

In dealing with this fearfully-destructive insect, which has attracted so much notice from the public, and in seeking for remedies against its devastations, it is of prime importance to have a thorough knowledge of its breeding-places, the frequency and extent of its migrations, and to seek for the connection between the direction of the winds and other meteorological phenomena and the flights of the locust.

The locust is quite or nearly as destructive in Africa, Asia, and Southern Europe as in this country, but the laws of their migrations and their connection with meteorological phenomena have never been studied in those regions, and it remains for the United States, with its Weather Signal Bureau, to institute, in connection with the scientific surveys of the West, investigations regarding the nature of the evil and the best means to overcome it.

In endeavoring to trace the connection between the migrations of the locust and the course of the winds at different months, the writer has been led into some theoretical considerations which seem to be supported by the facts presented in the unpublished report, and which may be confirmed or disproved by future investigations.

History of the migrations of the locust.—The following table, compiled from the reports of A. S. Taylor, the late Mr. B. D. Walsh, Prof. C. V. Riley, Prof. C. Thomas, Mr. G. M. Dawson, and the observations of Mr. W. N. Byers, together with the reports in the Monthly Weather Review, will show the years when the locust was excessively abundant and destructive in the different Territories and States, and also serve to roughly indicate the frequency and extent of the migrations of the destructive locust of the West. The dates which are starred are years when the progeny of the locusts of the preceding year abounded, and when in most cases there were no fresh incursions from the westward. The species referred to under the head of California, Washington, and Oregon may be some other than *Caloptenus spretus*.

Manitoba.	Minnesota and Western Iowa.	Montana and Dakota.	Wyoming and Idaho.	Utah.	Colorado.	Nebraska, Kansas, and Western Missouri.	Indian Territory and Texas.	California.	Washington and Oregon.
1818	1818	......	......	......	......	......	......	1827 or 1828	......
1819	1819	......	......	......	......	......	......	1834 or 1835	......
......	1820	......	......	......	......	1820 or 1821	......	1838	......
......	......	......	1845	......	......	......	1845	......	......
......	......	......	......	......	......	1846 ?	......	1846	......
......	......	......	1852	1852	......	......	1849	......	1852
......	......	1855 ?	1855 ?	1855	1855 ?	1855	1855	1855	1855
......	1856	......	......	1856*	......	......	1856*	1856*	......
1857	1857*	......	......	1857	......	......	......	......	......
1864	1864	1864	......	......	1864	......	......	......	......
......	1865*	......	......	......	1865*	......	......	......	......
......	......	......	......	1866	......	1866	1866	......	......
1867	1867	......	......	1867	1867	1867	1867	......	......
1868*	......	......	......	1868*	1868	1868*	......	......	......
1869	......	......	......	1869	......	1869*	......	......	......
1872	......	......	......	1870	......	......	......	......	......
......	1871	......	......	1871	......	......	......	......	......
......	slight.	......	......	1872	......	......	......	......	......
......	1873	1873	1873	......	1873	......	......	1873	......
1874	1874	1874	1874	......	1874	1874	1874	Southern	......
1875	1875	1875	1875*	......	1875*	1875	1875	California.	......
......	1876	1876	1876	1876	1876	1876	1876	......	......

This table and the data on which it is based are necessarily very imperfect, owing to the vast extent of the territory over which the locust swarmed, and the fact that the greater portion is uninhabited, while the inhabited portions have been settled only within comparatively few years. It will be seen, however, that since 1873 the evil has been greater and more wide-spread than ever before.

The theory of the migrations.—(1) *The immediate cause of the migrations of the locust from its original breeding places is the unusual abundance of the species during certain years.* It has been found in some cases that the exceptional years when the locust migrates are periods of unusual heat and dryness, conditions unusually favorable to the excessive increase of insect life. As may be seen in the accounts of the eastern locust, the grass army-worm, the grain-aphis, the chinch-bug, and other less destructive insects, when the early part of the season, the spring and early weeks of summer, are warm and dry, without sudden changes of temperature, insects abound and enormously exceed their ordinary numbers. When two such seasons occur, one after the other, the conditions become still more favorable for the undue development of insect life. Now it is well known that in the Eastern States the summers of 1860 and 1874, preceding the appearance of the army-worm and grain-aphis, were unusually warm and dry, and favorable not only for the hatching of the eggs laid the year previous, but for the growth and development of the larvæ or young. Look now at the conditions for the development of locust life on the hot and dry plains, chiefly of Dakota, Montana, Wyoming, and Idaho. We have no extended meteorological records from these regions at hand, but it is more than probable that the years preceding the migrations of the locusts were exceptionally warm and dry, when the soil was parched with long-sustained droughts, as we know that the corresponding species east of the Mississippi River abounds during dry summers following dry and warm springs.

Given, then, the exceptional years of drought and heat and the great extent of territory, and we have as the result vast numbers of young hatched out. The year previous having perhaps been warm and dry, the locusts would abound, and more eggs than usual would be laid. These would with remarkably few exceptions hatch, and the young soon consume the buffalo grass and other herbage, and move about from one region to another, following often a determinate course in search of food. In this way large broods may migrate a long distance, from perhaps twenty to fifty miles. In about six or seven weeks they acquire wings. Experience shows that the western locust as soon as it is fledged rises up high in the air, sometimes a thousand feet or much higher. They have been seen to settle at night on the ground, eat during this time, and toward noon of the next day fill the air again with their glistening wings. As more and more become fledged, the vast swarm exhausts the supply of food, and when the hosts are finally marshaled, new swarms joining perhaps the original one, the whole swarm, possibly hundreds of miles in extent, begins to fly off, borne by the prevailing westerly and northwesterly winds, in a generally easterly and southeasterly course.

(2.) *The secondary cause of the migration is the desire for food, and possibly the reproductive instinct.* The fact that in their migrations the locusts often seem to select cultivated tracts, rapidly cross the treeless, barren plains, and linger and die on the prairies and western edge of the fertile valleys of the Missouri and Mississippi, indicates that the impelling force is due primarily to the want of food, and that the guiding force is the direction of the prevailing winds, for they have no leaders, and we do not believe in the existence of a "migratory instinct" in the locust any more than in the grass army-worm, or the cotton army-worm, which it is sufficiently evident migrate from field to field, simply in search of more abundant food.* Meanwhile the reproductive system of

*The simple fact that the more extensive migrations of the locust both in the New and Old World are periodical, long intervals existing between them, suggests that the development of a migratory instinct would be impossible. If once partially implanted, the long succession of non-migratory years would effectually break up the germs of such an instinct. It may be quite different with birds, which perform their annual migrations for years and perhaps centuries without fail.

the locusts is maturing, the eggs ripening, and the uneasiness of the locusts during the course of their travels may be unconsciously stimulated by the sexual instincts and the desire to discover suitable places for egg-laying, a long and tedious operation.

It has been sufficiently shown that a swarm of locusts observed by Professor Robinson near the entrance to Boulder Cañon, Colorado, traveled a distance of about six hundred miles to Eastern Kansas and Missouri. Though the swarm was first observed at some distance north of Denver, Colo., it was then on its way from the north, and may have come from some part of Wyoming two or three hundred miles northwestward or northward. Though the winds may vary and counter-currents exist, and storm-gusts from due north, such as often sweep over the plains, and local southerly breezes may retard their flight, the course is either eastward or southeasterly. We know enough of the winds in the Western States and Territories to lay down the the law that the general direction of the winds in July and August, along the eastern slope of the Rocky Mountains and on the plains, is from the west and northwest, and accords with the eastward course of the locust swarms. The relations between the average direction of the winds and the migrations of the locust have, however, never been sufficiently studied, either, so far as we are aware, in Europe or in this country. And yet, if we would intelligently study the causes of the excessive increase and migrations of the locust, we must examine the meteorological features of the country, ascertain the periods of drought and undue rain-fall, the average direction of the wind for the different months, in order to learn how far they correspond with the phenomena of insect-life. That there are meteorological cycles, dry and hot seasons recurring at irregular intervals, while the general average may remain nearly the same century after century, is supported, though it may be vaguely, by observed meteorological facts.

The question then arises, *Can meteorologists predict the coming of seasons of undue heat and drought, and consequently can we predict insect-years? That is, the migrations of locusts and the undue increase of the chinch-bug and army and cotton worm?* I believe that we shall, after the lapse of years, be able to foretell with a good degree of certainty locust invasions, and be able to provide against the losses thus incurrred.

On the frontier of the Western States, in Colorado, or in the Territories of Wyoming, Montana, and Utah, where the losses from the ravages of the locust cannot easily be made up by importations from contiguous Territories, it seems the most practicable mode to provide in years of plenty against years of want. We should imitate on a grand scale the usage of the ancient Egyptians under Pharaoh, who laid up in times of unusual harvest stores of grain for times of famine. It is said that this has been done on a small scale by the Mormons. If this were done in the far West, in seasons immediately preceding insect-years, which had been predicted by entomologists in conjunction with the meteorologists, we should be saved the distress, destitution, and even loss of life from starvation, which have resulted from ignorance of the laws regulating the appearance of destructive insects, especially the western locust.

The return migration.—By simultaneous observations for a number of years over the region liable to be visited by migratory hordes of locusts, added to the knowledge we already possess, it will not only be possible to predict the course of certain swarms from their breeding-places, and their probable destination, so that when a swarm starts from Montana or Wyoming, its arrival in Colorado a week or a fortnight later may with some certainty be predicted, and, again, its arrival in Kansas and adjoining States be announced with a certain amount of precision, as has already been done by Dr. Riley, but we shall be able to foretell the course taken in the return flight of their progeny in the succeeding year. I will confess that previous to my visit to Kansas and Colorado, in 1875, I was skeptical as to Dr. Riley's opinion that there was a general movement in a northwest course of the young of the previous year, broods from Missouri and adjoining regions northwestward. The facts and resulting theory have already been stated in full by Dr. Riley and others. It remains to determine the causes of this return migration, this completion of the "migration-cycle," as Professor Dawson terms it. It is evident that in this case the desire for food is not the cause, for food is many times more abundant in the Mississippi Valley than on the plains whither they return. The solution of the problem, I think, must be sought in the direction of the prevailing winds during the middle of June, the time when they become winged. It may be found, after a series of careful meteorological observations, that the prevailing winds at this early season are southerly and southeasterly. It has been shown by meteorologists, as I learn from Prof. C. Abbe, that during May and June the winds blow inward toward the heart of the continent from the Atlantic Ocean and Gulf of Mexico. On application to General A. J. Myer, Chief of the Signal-Service of the United States Army, for the meteorological data necessary to confirm this hypothesis, I promptly received a full summary of data observed by the officers of the Weather Signal Bureau, for periods of from two to five (usually the latter) years between 1871 and 1876, which show that the prevailing winds in June, in Davenport, Dodge City, and Keokuk, Iowa; Saint Paul and Breckenridge, Minn.; Yankton and Fort Sully, Dak.; Omaha, Leavenworth, and Fort Gibson, Ind. T.—all within the locust area—are from the southeast and south. This fact may be sufficient to account for the prevailing course of the return migrations of the locust from the eastern limits of the locust area.

The accompanying table is taken from a synopsis of the meteorological phenomena of the Western States and Territories within the eastern limits of the locust area, which is appended to this chapter. It has been furnished me by Brig. Gen. A. J. Myer, U. S. A., Chief Signal-Officer, Washington, D. C., and my hearty thanks are due him for the labor and trouble involved in its preparation.

Station.	May.					June.					July.					August.					September.					
	1872	1873	1874	1875	1876	1872	1873	1874	1875	1876	1872	1873	1874	1875	1876	1872	1873	1874	1875	1876	1871	1872	1873	1874	1875	1876
Davenport, Iowa	NW	NE	SW	E	SW	SW	SW	SW	NW	SW	NW	SW	SW	E	SW	SW	SW	E	S	SE	SSE	SW	SW	SW	SW	.....
Dodge City, Iowa	....	....	....	N	E	....	....	...	S	SE	...	....	....	NE	SE	....	....	....	S	S	....	....	....	....	S	.....
Keokuk, Iowa	W	E	S	SE	S	S	SE	SW	SE	NW	NW	SE	SW	SW	E	S	SW	E	S	S	NE	S	NW	S	S	(?)
Saint Paul, Minn	W	N	N	SE	SE	SE	SE	SE	SE	NW	S	SE	SE	NW	SE	S	SE	SE	SE	SE	SE	NW	SE	SE	.....	(?)
Yankton, Southern Dak	NE	S	NW	SE	....	S	SE	SE	NW	.....	S	SW	SE	S	.....	E	SE	SE	SE	.....	....	NW	NW	NW	....	.....
Omaha, Nebr	SSE	N	S	SE	S	SSE	S	S	S	N	SE	S	S.W	SE	S	SSE	S	S	S	S	SE	SE	S	S	S	.....
Breckenridge, Minn	SE	SE	SE	SE	SE	SE	SE	SE	SE	NW	SE	SE	S	N	SE	SE	SE	SE	SE	SE	....	SE	NW	S	NW	.....
Fort Sully, Central Dak	NW	E	SE	NW	SE	SE	SE	SE	SE	NW	SE	SE	SE	SE	SE	SE	ESE	SE	N	SE	....	NW	NW	SE	N	(?)
Fort Gibson, Ind. Ter	E	SE	SE	SE	....	SE	SE	S	W	.....	SE	SE	S	E	.....	E	E	SE	SE	....	....	SE	SE	.....	.....	.....
Leavenworth Kans	SW	S	S	S	S	SW	S	S	S	S	SE	S	S	S	S	SE	S	S	S	S	E	SW	S	S	S	.....
North Platte, Nebr	.....	.....	.....	SE	SE	.....	.....	.....	SE	N	.....	.....	.....	NE	SE	.....	.....	....	SE	SE	.....	.....	.....	.....	SE	(?)
Bismarck, Mont	....	....	....	S	SE	.....	.....	...	E	NW	....	....	.....	NE	NW	...	.....	.....	NW	NW	....	.....	.....	.....	NW	.....
Cheyenne, Wyo	N	W	W	W	W	W	W	W	W	W	W	W	S	S	S	W	W	W	NW	NW	NW	NW	W	NW	.....	.....
Denver, Colo	N	NE	S	S	N	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	.....	S	S	S	S	.....
Colorado Springs, Colo	....	.....	N	S	SE	...	....	S	S	N	....	....	NW	SE	N	....	....	NW	N	....	....	.....	....	SE	N	.....
Santa Fé, N. Mex	N	SW	E	SW	SW	SW	N	SW	SW	SW	NE	SE	E	SW	E	S	SW	SW	SW	SW	....	SE	SW	E	SW	.....

Let us therefore grant this setting-in of southerly and easterly winds, which may last until the locusts are winged. When they rise on the wing into the air they are known to move in a general northwest direction. It is highly probable that they are borne along by these generally southeasterly winds, and pass over on to the plains. The cause is seen, then, to be entirely independent of subsistence; possibly the reproductive instinct causes them to become uneasy, restless, to assemble high in the air and seek the dry, hot, elevated plateau of the northwest. Should this be so, the cause of their migrations is probably purely mechanical. Abundant testimony is at hand to show that they are wholly at the mercy of the prevailing winds, and that as a rule the course of their migrations is quite dependent on the direction of the winds, while the course of the winds depends more or less on the season of the year. We may expect that future research over sufficient territory will show that the June migrations, from the eastern limits of the locust area, will be toward the northwest, and the July, August, and early September migrations, from the Rocky Mountain plateau, will be in a general easterly and southeasterly direction.

It is not only of great scientific interest, but of high practical importance, to collect all facts bearing on the return migrations, in order to know where the locusts go in their return migrations the second year, as we only know that they do fly a certain distance northwestward. We want to ascertain the extreme western limits of this return migration. We also want to learn whether they return to their original breeding-places on the eastern slopes of the Rocky Mountains, or whether the westerly winds, if they are westerly, drive them back and scatter them, so that they do not breed extensively.

It will be seen by the reader that all grounds for a reliable working theory of locust migrations are based on the work of our Signal Bureau and local observers, and that the observations of the meteorologists and entomologists must go hand in hand. The Government has provided a well-organized corps of meteorological observers, and we submit that a number of competent entomologists should take the field, under Government auspices. Not only should the border States, especially Texas, Kansas, Nebraska, Minnesota, and Iowa, employ competent entomologists, following the liberal policy of Missouri, which for eight years has had a State entomologist, whose reports have proved of incalculable practical value, as well as of great scientific interest, but the habits of the locust need first of all to be thoroughly studied in the Territories, particularly those of Wyoming, Montana, Idaho, Dakota, Utah, New Mexico, Arizona, and in the State of Colorado. A commission of entomologists should be appointed to make a thorough detailed study for several successive seasons of the habits of the locusts in the Territories mentioned. It would seem that the recommendations made at the recent meeting of western governors at Omaha, that an appropriation be made by Congress, and a commission be attached to the existing United States Geological and Geographical Survey of the Territories, is the most feasible and economical method of securing the speediest and best results.

Let us for a moment look at the losses sustained in the United States from the attacks of insects. The annual agricultural products of this country by the last census amounted in value to $2,500,000,000. Of this amount we in all probability *annually* lose over $200,000,000 from the attacks of injurious insects alone. Dr. Riley avers that the losses during 1874 in Missouri from locusts, and it will be remembered that only the western third was invaded, exceeded $15,000,000. This would make the losses in other parts of the West at least twice as much more, or $45,000,000 in all. The estimated money-loss occasioned by the chinch-bug in Illinois in 1864 was over $73,000,000; in Missouri, in 1874, it is estimated by Dr. Riley to have been $19,000,000. The annual losses from the chinch-bug are greater, Mr. Riley says, than from any other insect. The average annual loss to the cotton crop from the attacks of the cotton army-worm alone is estimated at $50,000,000. Adding to these the losses sustained by the attacks of about a thousand other species of insects which affect our cereals, forage and field-crops, fruit-trees and shrubs, garden vegetables, shade and ornamental trees, as well as our hard and pine forests and stored fruits, and it will not be thought an exaggeration to put our annual losses at $200,000,000. If the people of this country would only look at this annual depletion, this absolute waste, which drags her backward in the race with the countries of the Old World, they might see the necessity of taking effective preventive measures in restraining the ravages of insects. With care and forethought, based on the observance of facts by scientific men, we believe that from $50,000,000 to $100,000,000, or from one-quarter to one-half of this annual waste, could be saved to the country. And the practical, most efficient way is for the States to co-operate with the General Government in the appointment of salaried entomologists, and of a United States commission of entomologists, who should combine the results of the State officials, and issue weekly, or, if necessary, daily bulletins, perhaps in combination with the Weather-Signal Bureau, as to the conditions of the insect world, forewarning farmers and gardeners from week to week as to what enemies should be guarded against and what preventive and remedial measures should be used.

The Weather-Signal Bureau, first suggested and urged by the late I. A. Lapham, was not instituted without ridicule and opposition, but it has saved millions to our commerce and agriculture. The maintenance of an entomological commission and the appointment of State entomologists would involve comparatively little expense. Already, owing to the full information regarding the invasion of Missouri by the locust in 1874, contained in the reports of Prof. C. V. Riley, the people of that State will be well prepared, from the direful experience of the past, to deal more intelligently and efficiently with the locust in the future.

THE MIGRATORY LOCUSTS OF CENTRAL AND SOUTH AMERICA.

We have already referred to the fact that swarms of locusts of unknown species have occurred at different dates in Guatemala and other parts of Central America. The following notices are taken from an article by A. S. Taylor, of Monterey, Cal., published in the Smithsonian Report for 1858: "Throughout California, with its ante-1849 boundaries, throughout Lower California, New Mexico, and all the dry and the elevated mesas or plateaus of the republic of Mexico, their ravages have been noted by the old Spanish chroniclers from the first conquest and settlement of the countries." In 1632 the parishes of Mexico and Pinola, and other parts of the uplands of Guatemala, were overrun with locusts. Clavigero witnessed locust invasions in 1738 or 1739 upon the coasts of Xicayan, in Oaxaca. Afterward a famine occurred in Yucatan.

Regarding the injuries of a Guatemalan locust, we quote the following account from Squier's Honduras; descriptive, historical, and statistical, 1870:

The insect, however, which is most dreaded in Honduras, as indeed in all Central America, is the *langosta* or *chapulin*, a species of grasshopper or locust, which at intervals afflicts the entire country, passing from one end to the other in vast columns of many millions, literally darkening the air and destroying every green thing in their course. I once rode through one of these columns which was fully ten miles in width. Not only did the insects cover the ground, rising in clouds on each side of the mule-path as I advanced, but the open pine-forest was brown with their myriad bodies, as if the trees had been seared with fire, while the air was filled with them, as it is with falling flakes in a snow-storm. Their course is always from south to north. They make their first appearance as *saltones*, of diminutive size, red bodies, and wingless, when they swarm over the ground like ants. At this time vast numbers of them are killed by the natives. who dig long trenches two or three feet deep, and drive the *saltones* into them. Unable to leap out, the trench soon becomes half filled with the young insects, when the earth is shoveled back, and they are thus buried and destroyed. They are often driven in this way into the rivers and drowned. Various expedients are resorted to by the owners of plantations to prevent the passing columns from alighting. Sulphur is burned in the fields, guns are fired, drums beaten, and every mode of making a noise put in requisition for the purpose. In this mode detached plantations are often saved. But, when the columns once alight, no device can avail to rescue them from speedy desolation. In a single hour, the largest maize-fields are stripped of their leaves, and only the stems are left to indicate that they once existed.

It is said that the *chapulin* makes its appearance at the ends of periods of about fifty years, and that it then prevails for from five to seven years, when it entirely disappears. But its habits have never been studied with care, and I am unprepared to affirm anything in these respects. Its ordinary size is from two and a half to four inches in length, but it sometimes grows to the length of five inches.

Mr. Taylor remarks that "this statement is consonant with the accounts received from Honduras and Guatemala of the famine and pestilence of fever in those countries in 1855 and 1856, caused by clouds of locusts devastating the country, and confirms Gage's history of the same lands in 1632." In 1855 the valley of Colima, in Southwestern Mexico, was visited by locusts.

In 1856 their ravages extended along the first central mesas or steppes bordering eastward the Rocky Mountains, covering the dry soils of Texas, and down into the south of Mexico. In the vicinity of Cordova, in the State of Vera Cruz, the people made a regular campaign against them, and succeeded in destroying one hundred and ninety-two arrobas, computed as numbering four hundred million grasshoppers. In the State of Guerrero they also did great injury, particularly within the districts around Acapulco.

The treeless portions of South America are also not exempt from swarms of locusts, though we have no information as to the different species composing them. Taylor says that at the time of the visit of Darwin to Chile and the adjacent countries of South America he relates of the grasshoppers as follows, at the date of March 25, 1835, when he was crossing the dry country which lies between the city of Mendoza, in Buenos Ayres, and the opposite side of Chile. This country assimilates in every essential physical characteristic to that of the territories within the boundaries of Upper and Lower California prior to the American occupation:

"Shortly before arriving at the village and river of Luxan, we observed to the south a ragged cloud of a dark reddish-brown color. At first we thought it was caused by some great fire on the neighboring plains, but we soon found that it was a swarm of locusts. They were flying northward, and with the aid of a light breeze they overtook us at the rate of ten or fifteen miles an hour. The main body filled the air from a height of twenty feet to that, as it appeared, of two or three thousand feet above the ground. The sound of their wings was as the sound of chariots of many horses running to battle; or rather, as I should say, like a strong breeze passing through a ship's rigging. The sky, seen through the advanced guard, appeared like a mezzotinto engraving; but the main body was impervious to sight. They were not, however, so thick together but that they could escape a stick waved backward and forward. When they alighted, they were *more numerous than the leaves in the field*, and the surface became reddish instead of green. The swarm having once alighted, the individuals flew from side to side in all directions. Locusts are not an uncommon pest in this country. Already during this season several smaller swarms had come up from the south, where, apparently, as in all other parts of the world, they are bred in the deserts. The poor cottagers in vain attempted, by lighting fires, by shouts, and by waving branches, to arrest the attack. This species of locust closely resembles, and perhaps is identical with, the *Gryllus migratorius* of Syria and Palestine."

THE LOCUSTS OF THE OLD WORLD.

That the calamities which have befallen the farmers of the West are less grievous than those resulting from locust invasions in the Old World; that there is a general similarity in the habits of locusts the world over, and that the causes of their migrations are of the same general nature, may be seen by a perusal of the following statements, which I have taken from sources as a rule inaccessible to most readers. For brief popular accounts of the Old World locusts the works of Kirby and Spence, Westwood, and of subsequent compilers may be consulted. The following historical sketch of locust invasions in the Old World is condensed from an article by Rudolf Gottschall in "Unserezeit," (February, 1876, Leipzig). The first account after that of Joel, in the Bible, whose remarks apply to Egypt, Syria, Palestine, and Asia Minor, is the statement of Ororius, that in the year of the world 3800 certain regions of North Africa were visited by monstrous swarms; the wind blew them into the sea, and the bodies washed ashore "stank more than the corpses of a hundred thousand men." Another locust plague, resulting in a famine and contagious disorders, according to St. Augustine, occurred in the kingdom of Masinissa, and caused the death of about 800,000 men. Pliny states that the locusts visited Italy, flying from Africa. In Europe locust invasions have been recorded since 1333, when they appeared in Germany. Mouffit states that in 1478 the country about Venice was invaded, and 30,000 people died of famine. In 1725 the region about Rome was overrun by locusts.

In France, swarms appeared at the close of the middle ages. In 1747 there was a great invasion of Southern and Middle Europe, especially the shores of the Danube, Wallachia, Moldavia, and Transylvania. Before and after this date vast swarms were observed in Africa and Asia. Adansin in 1750 observed them in the Senegal. In 1799, Jackson, in his "Journey through Morocco," states that the whole country between Mogador and Tanger, on the borders of the Sahara, was covered with them, and they were in many cases borne into the ocean westward.

In Russia, whose southern steppes form the home of the locust, vast swarms in the time of Charles XII, who was then in Bessarabia, came there from the region of the Black Sea. Russia, Poland, and Hungary were often visited by them. In 1828 and 1829 enormous swarms invaded the coast of the Black Sea. In 1859, in the South Russian provinces of Cherson, and in Bessarabia, a tract 60 versts long and about one-third as wide was overrun by them. Taschenberg gives the locust years in Russia in the present century as follows: 1800, 1801, 1803, 1812–'16, 1820–'22, 1824 and 1825, 1828–'31, 1834–'36, 1844, 1847, 1850, and 1851, 1859 and 1861.

In August, 1384, according to Mr. J. Boll, they invaded portions of Switzerland.

In Germany the records go back to 1333. In this year, and until 1336, they abounded. Entering Hungary, they overflowed into Poland and Austria. They then divided into two great swarms, one of which flew southerly into Italy, the other into France, Suabia, Bavaria, Thuringia, and Saxony. In Germany they again occurred in 1543. In 1693 they invaded Thuringia, going from Hungary by way of Austria, Schlesia, and Bohemia, and invading the region about Jena, Gotha, Erfurt, and Weimar.

In Germany the locust years were as follows: 1333–'36, 1475, 1527 and 1543, 1636, 1686, 1693 and 1696, 1712, 1714, 1715, 1719, 1727–'31, 1734, 1746–'50, 1752–'54, 1759, 1761, and for the present century, 1803, 1825–'30, 1856, 1859. In 1873–'74 small numbers appeared in swarms about Genshagen, near Berlin; they laid their eggs, and in the middle of June of 1875 the larvæ appeared in millions, becoming fledged in July.

Köppen has published (Horæ Soc. Ent. Ross. iii, pp. 89–246) an elaborate memoir on the migratory locust of Southern Russia. He gives, in the first place, a biography of his subject, which includes several memoirs published in Russian journals. With regard to the species Köppen remarks on the various opinions of entomologists as to the relation between *Pachytylus migratorius* (Linn.) and *P. cinerascens* (Tab.), and comes to the conclusion that the two supposed species are to be regarded as varieties of one and the same, and that *Edipoda tatraica* (Motsch.) is identical with *P. cinerascens*. The form which he met with most abundantly in South Russia is the true *P. migratorius*.

The development of the insect is described by Köppen in detail. The eggs are deposited by the females, to the number of 60 to 100 together, in little nests surrounded by a membranous envelope. The eggs are laid in autumn and the young hatched in the following spring. The envelope is burst a little while before the exclusion of the young. The eggs display a great power of resistance to the influence of cold; they have been found to retain their vitality when the temperature reached 26° Fahrenheit when placed with earth in a large glass vessel.

The larvæ are said by Köppen to moult four times, and the fourth moult produces the winged insect. The different stages are described by Köppen. At the end of May (1861), eggs taken from the ground showed the eyes, antennæ, segments, and legs of the larvæ distinctly; and a little while before hatching, the larvæ could move within the egg. On its emergence the larva is yellowish-white, with a rosy tinge; in three to four hours its color is grayish-black. Before and during each moult the larvæ are sluggish. At the final moult, which always takes place in the hottest sunshine, the animals hang head downward, by the hind feet, upon the stalks of grasses, &c. This enables the insects to twist about in all directions, in order to free themselves from the skin. The expansion of the wings occupies about twenty minutes after the completion of the moult (twenty-two minutes according to Köste, who says that the moult itself occupies sixteen minutes); during this period Köppen observed that a dark yellow fluid was distributed over the wings in microscopic drops. The period which elapsed between the arrival of the insect at the winged state and the deposition of the eggs is uncertain; the statements of different authors vary between four weeks and two months.

Köppen describes the nearly indiscriminate voracity of these insects, but remarks that certain plants appear to be avoided by them, namely, flax and hemp, the *Cucurbitaceæ*, and, according to Petzholdt, dwarf garden-beans. The *Gramineæ* seem to furnish their favorite food. They prefer the leaves and other soft parts of plants and trees, but also sometimes gnaw the bark and even the wood of the latter. In time of scarcity they will attack straw-thatch and woolen clothes, and even devour each other. Köppen notices the statement made by various authors that the larvæ for the first ten days live upon dew, and treats it as an absurdity.

The perfect insects copulate almost immediately after the last change of skin. The union of the sexes continues apparently for a considerable time, from twelve to eighteen or even twenty-four hours, but sometimes only for an hour or two. The female carries the male about with her, and feeds as if alone; she is, however, unable to fly. The male sits quite motionless, only giving a sign of life by stridulation if another male should approach.

The eggs are deposited about seven days after copulation, according to Köste. The female digs a hole in the earth of about 1½ inches, by means of the hook-like horny organs of the apex of the abdomen, and the eggs are then laid in cylindrical masses, usually placed at an angle of about 45° to the surface. The eggs are united by a spongy mass (cement), which also envelopes the whole outside of the mass; here, by the adhesion of grains of sand, small stones, &c., it forms a sort of wall which protects the eggs from injurious external influences. The mass is sometimes formed wholly or partially of the frothy cement without eggs. Yersin ascribes this to a morbid condition of the female, and doubts whether the few eggs contained in such masses are capable of development. Köppen has found, on removing the female insect, that the pit which it had dug was filled with the frothy mass without any eggs. This seems to the recorder to indicate rather that the cement mass is first produced by the insect, and the eggs afterward laid in it. The nests found containing the spongy mass without eggs would then be easily accounted for, on the supposition that the females were disturbed or destroyed when just about commencing the actual business of oviposition. The number of eggs laid in each nest seems to vary from 50 to 90 or 100, and the ovary of the female contains from 100 to 150 eggs, according to Krünitz. The question whether the females copulate more than once has been much discussed in Russia, and from the author's statements it would appear that the popular opinion is that the act of copulation only takes place once. From Köste's observations, however, it is certain that the females copulate and deposit their eggs several times. He observed a female in confinement which copulated with six different males before laying her first batch of eggs; and afterward the same phenomena were repeated four times, the insect dying when engaged in oviposition for the sixth time. From his own observations, and those of other authors, Köppen regards it as most probable that copulation and oviposition are repeated usually at least three times by each female, perhaps at intervals of about a month, as stated by Yersin, the total number of eggs being from 160 to 170.*

Upon the rapidity of movement of locusts in the larval condition the

*In an article by V. Graber "on polygamy and other sexual relationships in the *Orthoptera*" (Verhandlungen der zool.-botanischer Gesellsch. in Wien, xxi, pp. 1091–1096, Zoological Record for 1871), the author details experiments regarding polygamy and repeated copulations in some orthopterous insects. A male and female were observed *in coitu* eight distinct times between May 21 and June 1; after the sixth connection the female began to deposit eggs. A second male, which had already fecundated several females, was then placed with her, and she paired at least five times with him. Analogous results followed experiments upon *Pezotettix pedestris,* and he believes that polygamy and polyandry exist in many species.

statements of authors are at variance. The observations of Sydon and Dönzingk give about a quarter of a German mile (*i. e.*, about 0.975 mile English) in the hour. Téchemewsky asserts that they only advance about 350 feet in the day upon grass land.

Of the senses of the locust, Köppen seems to regard hearing as the sharpest. The senses of smell and taste are exerted in the selection of food; and that of touch is displayed in the sensibility of the insects to changes of weather, especially temperature. Sociability is regarded by the author as characteristic of the locusts. The larvæ proceeding from one nest seem to keep together for a time; they afterward associate in larger masses which move together in search of nourishment. These migrations in mass commence in the second stage of larval life, but become more general after the second moult. The migration usually takes place in the morning and evening. The author remarks upon the direction of the migrations of these insects, which he regards as influenced to a certain extent by an instinctive perception of the direction in which abundant food or a suitable breeding-place is to be found, but modified or even sometimes caused by external agents, especially the winds. The author also discusses the primary causes of the great migrations of these insects and the phenomena observed during their flight.

In the south of Russia the hatching of the eggs takes place, according to the weather, at the end of April or beginning of May. A few larvæ are sometimes produced on warm days in October, but these soon die. The hatching occupies from two to three weeks, according to circumstances. The winged insects appear in the beginning and middle of July; copulation takes place early in August; and the oviposition extends from the middle of August to October. The dry steppes constitute the chief haunt of the locusts; damp places they seem to avoid. The females prefer for the reception of their ova the solid virgin soil, and rarely visit ploughed land for this purpose. Damp and cold are unfavorable for the development of the eggs. The author discusses in great detail the external conditions which act favorably or unfavorably upon these insects. The greater part of this section is devoted to the consideration of their enemies, of which Köppen gives a formidable list (pp. 151–166).

Leimé and other authors have given Tartary as the true home of the migrating locusts; but in Tartary no large swarms occur. In the author's opinion, the countries in which the swarms are seen are also the countries of their birth. He cites many facts in support of this opinion, and in illustration of the geographical distribution of the insect, the northern limit of their migratory or nomadic life being a line passing from Spain through the south of France, Switzerland, Pomerania, South Russia, and South Siberia, to the north of China. To the north of this line the insects generally occur only singly. Many interesting details as to their occurrence in vast numbers are given by the author (pp. 190–205).

Köppen also describes the injury done by the locusts when they occur in great numbers, and indicates the means adopted for their suppression (pp. 205–246).

Köppen also notices *Caloptenus italicus*, a congener of our *C. spretus*, which likewise occurs in South Russia, and at such times, as in other regions of Southern Europe, sometimes in injurious numbers. Other species which are also occasional devastators, especially when associated with the migratory species, are *Pachytylus stridulus*, *Œdipoda vastator*, *Stauronotus vastator*, *S. cruciatus*, and *Pezotettix alpina*.

Küntsler reports this insect as injurious to corn-crops in Austria in 1866 and 1867.

The ravages of the locust in Bavaria have been discussed by Jaeckel,* who cites various records of the visits of this species in swarms during the fourteenth century, one toward the close of the fifteenth, and one at the end of the seventeenth century, and gives a long account of a similar visitation in 1749. Since that year no swarms of locusts have occurred in Bavaria.

Gerstaecker in a recent work† on the European locust, which seems to be mainly, however, a compilation, writes as follows regarding the European locust:

That copulation can be accomplished very soon after emerging from the last larva-skin (he does not name a *cupa stage*), is shown by the fact that one occasionally finds individuals engaged in the act while the wings are still tender and have not attained their full color. But the act is as a rule performed in the course of several days (after becoming winged), or even after a still longer period.

The male lets the female free in the course of twelve to twenty minutes, after which the female, before proceeding to lay, employs herself in feeding again for several days. As soon as her eggs are ripe, which, according to Kösten, requires seven days on the average, she seeks a satisfactory spot to deposit them. (He then describes the act of laying much like Professor Riley.) The eggs are generally found at a depth of 4 centimetres, or more, below the surface. In this act, requiring considerable time, she by no means rids herself of her whole stock of eggs at once, but may pass several weeks even in perfecting them. Possibly for a second or third deposit of the egg-mass a renewal of copulation is necessary. At least such a repetition has been noticed in the case of females that had already been found laying, and has always been followed by a new deposit of eggs. In all cases, whether after a single or repeated coupling, which latter may depend upon the relative number of males, and the temperature of the season, a division is made of the egg-stock into several deposits as is shown by the fact that the larger egg-pods seldom contain more than one-half, and the smaller very generally a much smaller fraction of the whole mass of eggs produced by one female, which mass may amount to one hundred and fifty or more. With the last deposit the female has accomplished her destiny, so that she not seldom remains dead on the spot where the laying occurred. On the other hand the males even after repeated coupling, and with several females, appear to be able to prolong their life, and may be found alive as late as October.

From the comparatively long time during which the winged locusts may be found, extending very commonly from the end of July to the end of September, it must not be at once concluded that the life of an individual is correspondingly long.

In selecting a spot for the perfection of this egg (packet) dryness is of the first importance to the female, and besides this a certain degree of hardness. They prefer loamy and clayey ground to pure sand. Besides this, a spot is naturally selected which offers suitable and plentiful food to the hatching brood.

Fallow fields lying alongside cultivated fields and meadows appear to present an unusual attraction to the female when ready to lay. That the eggs, as such, winter over under the surface can be set down as a matter of common observation. The young brood generally do not hatch before the end of April.

The geographical distribution of the migratory locust of Europe and Asia (*Pachytylus migratorius*) has been discussed by Herr F. T. Köppen in Petermann's "Mittheilungen aus Justus Perthe's Geographischer Anstalt," (1871, p. 361,) his paper being accompanied by a map showing the range of the insect. I translate an abstract of it by M. Preudhomme

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* Correspondenz-Blatt der Zool. Mineralogisch Verein, Regensburg, xxi, pp. 83–93. See Zoological Record for 1867, Verhandlungen Zool. Bot. Gesellschaft, in Wien, xvii, pp. 930–932, Zool. Record for 1867.

† "Die Wanderheuschrecke. (Oedipoda Migratoria Lin.) Gemeinverstaendliche Darstellung ihren Naturgeschichte, Lebensweise, Schädlichkeit, und der Mittel zu ihrer Vertilgung. Im Auftrage des Königl. Preuss. Ministeriums für die landwirthschaftlichen Angelegenheiten verfasst von Dr. A. Gerstaecker, Prof. an der Universität in Berlin. Mit 9 Abbildungen auf 2 Tafeln in Farbendruck, Berlin, 1876. 67 pp."

For the above translation I am indebted to Mr. Whitman, who has kindly called my attention to the work.

de Borre, in the Comptr. Rendus of the Entomological Society of Belgium, 1871–'72, p. xviii:

The migratory locust is an *Orthopter* peculiar to the torrid zone and a large part of the north temperate zone of the Old World; but, in this last region, its northern limits is subject to some variations, the explanation of which is one of the principal objects of the work of M. Köppen.

In countries such as those of Arabia and Persia, where the mean temperature of the year, as that of the different seasons, is almost invariable, the abundance of the species in question does not vary; it is normally limited, both by the quantity of its nourishment and the natural enemies of the insect. But this is not the case in those countries which, like Southern Russia, may present, sometimes favorable seasons, sometimes years, or even simply seasons, unfavorable to the multiplication of *Pachytylus*. Thus, according to M. Köppen, the persistent prolongation of dry heat during a part of the autumn will exert an influence on the quantity of eggs laid in favorable places; and, on the other hand, a temperature less than 14° Réaumer, [63½° Fahr.,] prolonged for several days toward the end of May, will be indispensable to the hatching of the larva. There would result from the more or less perfect realization of these conditions, and their succession or their interruption during several years, those differences observed in the northern limit of the species, which alternately increase or diminish the area of distribution.

M. Köppen has distinguished and traced quite completely on the map for Europe and Siberia three different limits of the geographical area of *Pachytylus migratorius*: 1. The limits of its permanent distribution. 2. The limit of its temporary existence in all stages of development, a little more to the north. Finally, 3. The limits of its presence in the condition of bands of winged insects of a stated age, out of the regions where the species may live and propagate. It will be necessary still to establish the limits of accidental individual appearances, but that would be of questionable importance. The northern limit of the permanent geographical distribution of *Pachytylus migratorius* begins in Western Europe, from the coast of Portugal, near 40° latitude north, and extends from there toward the northeast as far as the mouth of the Bidassoa, thus leaving out all the northwest portion of Spain; it continues to rise obliquely in France up as far north as the lake of Geneva, and extends east, following more or less the forty-eighth degree of latitude, and embracing Valois, all of the north of Italy, Carinthia, and Hungary, it passes into Southern Russia, where it attains nearly the fiftieth degree, passes likewise across the middle of Siberia, whence it passes over the north of China, to end in Japan, at a latitude a little inferior to that of its point of departure in Portugal, leaving out the island of Niphon. M. Köppen remarks that all this limit does not deviate much from the isotherma of 16° R. [68° Fahr.] for the month of June. To farther circumscribe the area, so extensive, of this species, the line goes from Japan to the islands of Fidochi, to New Zealand and Australia, of which it only embraces the northern parts, passes from there to the island of Mauritius, then rises to the north, crosses Africa up to Madeira. But in this last part of the passage the limits are more hypothetical, from want of an exact knowledge of the existence of the species in the interior of Africa.

When, in a country comprised in this area, as has been frequently observed in Southern Russia, the locusts develop in a certain abundance, the want of food obliges them to migrate in part in different directions, and to break over their limits. If circumstances permit these emigrants to multiply for a certain period beyond their normal area, there results a temporary extension of this area, and occasionally new migrations to the north, until only a single spring, colder or more humid, comes to put an end to their invasion and to oblige them to go back to their natural limits. Temporary extensions like this of the area of distribution of *Pachytylus migratorius* took place in 1746 to 1749, and in 1822 to 1828; at these periods they appeared in Germany, and have multiplied themselves during several successive years. The northern limit of these temporary extensions may be also marked on the chart by a line which, taking its point of departure in the southwestern portion of Bavaria (where the *Pachytylus migratorius* has been observed from 1333 to 1339, and from 1748 to 1749), rises to the northeast by Jena and Halle toward Jûterbogk and Berlin, when it takes a nearly eastern course, following more or less the parallel of 52½° of latitude, near Müncheberg, Küstrin, Birnbaum, and Posen (regions which the species was known to have visited in 1730, 1752, and from 1827 to 1828); then the line passes across Southern Poland, at the fifty-second parallel, through the southern part of the government of the Mohilew, inclining gradually toward the south, and extending so as to reach the Wolga and the Ural. It is apparently to the humidity of the climate, injurious to the locust, likewise to the state of the eggs during the winter, that we should attribute the less extension of this limit toward the north in Western Europe.

To the north of the limits which have just been indicated, the *Pachytylus migratorius* has not the power of undergoing its whole cycle of metamorphoses, neither, consequently, to reproduce itself. This does not prevent its occasional appearance in swarms even in countries very northern; thus, it was observed in England (1693 and 1748), and even at the latter date, near Edinburgh; in Sweden (as far as Ostrogoth), at latitude 57° to 58° north, in 1748 and 1844, and finally on the Duna, near Dunabourg and at Polozk, in 1545. But these troops of voyagers did not hatch out in the same places where they were observed, nor did they leave any progeny in subsequent years. The only known example of an exception to this rule is the discovery made once by Boheman, in September, in the middle of Sweden, of a *Pachytylus migratorius* in the proper state. Evidently this is an exception wholly accidental, which does not prove anything against the rule. The more we advance toward the north, the less are large swarms of locusts observed, and we end by meeting only isolated individuals, as have been seen several times at St. Petersburg, and even near Wasa in Finland (latitude 63° north).

The want of facts prevents our extending these studies to the southern boundary of the area of distribution of *Pachytylus migratorius*. However, we can remark that in New Zealand, the extreme southern point of this distribution, the mean temperature of the warmer months is, according to Schmid (Lehrbuch der Meteorologie, p. 363), at 15°.5 R. (about 66° Fahrenheit), which does not differ much from the corresponding temperature of the northern limit of the area in Europe.

The localities out of Europe where the *Pachytylus migratorius* has been observed are as follows: Madeira, Algeria, Tunis, Egypt, Chartoum, Asia Minor, Syria, Arabia, Persia, India, Siam, China, Japan, Java, Luçon, Fidschi, New Caledonia, New Zealand, Northern Australia, and finally Mauritius island; but this last locality indicated by Serville needs confirmation. In Central Asia the species has been observed near Lake Aral, on the borders of Syr-Darja, on the upper side of Ischim and of Irtisch, and finally toward the lakes Kurgaldschin, Nor-Saisan, and Balchaasch.

According to M. Köppen, the great chains of mountains are a powerful obstacle to the diffusion of *Pachytylus migratorius*. The Alps especially play a large part in its distribution in Europe, and it is without doubt to them that we should attribute its relative rarity in the countries of the southwest of Europe and northwest of Africa, where it is almost completely replaced by other species of the same group, *i. e.*, the *Caloptenus italica* in Spain, Italy, and in the middle of France; the *Acrydium peregrinum* in Algeria.

It should be observed that this species, and in general all the *Acrydiidæ*, shun mountainous and wooded countries. They are most fond of the plains, of regions quite dry, and it is also a circumstance which influences necessarily their geographical distribution.

"The development of the organs of flight of the migratory locust," continues M. Köppen, "determines the facility and the amplitude of its flight, and consequently favors its migrations. They are evidently the cause of this colossal geographical distribution of the species. They remind us of the remark of Darwin, that species rich in individuals and with a wide habitat, which, owing to their organization, have had in their country the pre-eminence over many surrounding species, are those which, in the case of emigrations out of their area, should have the greater chances of overrunning new territories."

Köppen examines successively the causes which may determine the migrations of this orthopter in armies more or less numerous, and then the observed direction of these movements. It is said that they fly more often from east to west, but M. Köppen thinks that it is not necessary to attribute this circumstance, as has been done, to the predominance of the east winds at times when the sterility of the country that they inhabit, increased still by the prevalence of these same winds, forces them to seek places which can furnish them a more abundant pasturage. Numerous facts appear, he says, to contradict this explanation. In reality, the movements of these hordes is rather centrifugal, as M. Köppen establishes from observations made especially in the plains of Eastern Europe; that is to say, that all the migrations appear to radiate from countries where the species breeds most. In Europe they would consequently be directed to the west, while in China they should have a direction ordinarily toward the southeast.

M. Köppen thinks that the same centrifugal radiation has presided over the scattering of this species beyond its original limits, and that this radiation, propagating in waves, such as we still see produced at the limits of its geographical area, has carried the species from its center of creation or its original country to points where it is powerless to overcome the climatic conditions or that concurrence of vital forces which are opposed to it. The center of creation or the point of departure of the species will be found, then, in Central Asia. The complete absence of this species on the American continent shows that it only began to exist as a species after the epoch of the separation of America from the Old World.

M. Prudhomme de Borre adds, "In this study, so interesting, there is one point on which we should insist. It is this, that the observations of M. Köppen tend to confirm the principle of zoological geography, that the area of a species cannot be limited on the map by a simple curve, but between places where the species exist in a constant or normal manner and those where its absence is constant there is always a zone, often very broad, of temporary visitations, which is to the area properly so called what the penumbra is to the light, within the zone, of which the exterior limit is much more easy to trace than the inner; this last is subject to continual oscillations, with some undulatory movements, dependent on the centrifugal or expansive tendency of the species, and from the resistance which opposes it, and external circumstances, and evidently also the tendency of other species to spread out, with which it carries on a struggle for existence in endeavoring to maintain itself on an earth where the chances are divided, and even vary from year to year. M. Köppen has thus been enabled to figure on his chart three lines, as I may for the present call them, and the intermediate line represents the exterior actual limit of these oscillations of the true frontier line of *Pachytylus migratorius;* their amplitude may vary from two to four degrees."

The last thesis of M. Köppen that I shall draw attention to at this time, namely, that the absence of *Pachytylus migratorius* in America should prove that the species exists only as a species, since the separation of the two continents toward the north pole, seems to me scarcely necessary. A mere glance at the map which represents the area of distribution of this locust allows us to affirm without hesitation that that view is impossible. It is evidently not one of those species which we may call *circumboreal anteglacial*, because their presence in two forms (races, varieties, or species) on each continent indicates that they have had a common origin, a single area at that epoch, anterior to the glacial period, when the two continents were reunited in the Arctic zone by a bridge, so to speak, that is, a continuity of land, in conditions of climate which should allow the existence at that latitude of a fauna which only at present exists much farther south. The source of those species dispersed by the glacial period does not now probably exist in its integrity; but the two races confined, one in America, the other in the Old World, having undergone slow modifications each on its part, are to-day very analogous species, but as distinct by their external characters as by their separate geographical area.

Nothing like this applies to *Pachytylus migratorius;* it is one of those species which may be called *equatorial postglacial;* its expansion toward the north has been posterior to the glacial period, which would then have opposed it; and it can have no affinities in the New World, but degrees of consanguinity much farther removed than those unite the circumboreal species of the temperate zone. Thus, if, as some think, the northern hemisphere tends actually to retrograde toward a new period of cold, the *Pachytylus migratorius* is destined to see its area also retrograde toward the equator, and perhaps some day the western and eastern parts of this area may be completely disjointed, and, following this separation, its posterity may be so modified by isolation as to form two distinct species, as has occurred to circumpolar species.

In the discussion which followed, M. de Selys Longchamps speaks of the difficulty of separating *Pachytylus migratorius* (Linn.) and *cinerascens* (Fabr.), which he had at first regarded as varieties, but now considers as a distinct species, the latter being more sedentary and reproducing in Belgium year after year: "M. F. H. Köppen not speaking of *cinerascens*, it would be interesting to know whether he admits this species, and if in the affirmative, whether all his remarks apply alone to the true *migratorius* type, notably that which he says normally sojourns at Bayonne, where I have taken only *cinerascens*, variety *virescens*, whose characters are the same as in Belgium and Frankfort-on-the-Main. It is also *cinerascens* that M. von Heyden has taken."

Some notes on the Algerian locusts (*Acrydium peregrinum*, *migratorium*, &c.) by Coure, have been communicated to the Entomological Society of France by Giraud. In them, mention is made of a special work on the same subject, which the recorder has not yet seen. (Bull. Soc. Ent. Fr., 1867, pp. x, xiii.) The locusts visiting Algeria come from the south, and arrive in May. They lay their eggs soon after their arrival, and the young animals produced from these eggs usually become adult in July. In August all usually disappear. Coure also notices the arrival in Algeria in the early part of January, 1867, of a flight of locusts. The color of these was stated to be reddish. It appears that on first attaining their adult form, these insects are of a rosy tint, and afterward change; and Coure thinks that it is not until after their change of color that they are fitted for reproduction. Lallemant states (*l. c.*, p. xiii) that the locusts, which live for a long time in the adult state, are at first rosy, then emigrate southward, and return in winter of their mature color.

In Spain, during the summers of 1875 and 1876, *Decticus albifrons* (Fabr.) was abundant and injurious, but less so in 1876 than the year previous, as the soldiers assisted the inhabitants of the district infested in destroying them.

In China records exist of the appearance of locusts in devastating numbers one hundred and seventy-three times during a period of nineteen hundred and twenty-four years, as stated by Andreozzi,* who has translated, from a Chinese work on agriculture, notes respecting the ravages of locusts in China, and the superstitious existing among the Chinese with regard to their origin. The three great causes of famine in China are placed as flood, drought, and locusts.

In Southern Australia locusts of an unknown species committed ravages in 1872. (See Proceedings of the Entomological Society of London, 1872, pp. xii–xvii).

EXTERNAL ENEMIES AND PARASITES OF THE ROCKY MOUNTAIN LOCUST.

When any insect abounds to an unusual extent, it has been found that not only its peculiar parasites abound in a corresponding ratio, but parasitic insects which prey usually on various other insects leave their ordinary hosts and attack the new-comers. Among the most important agencies which diminish the numbers of locusts, especially in the Mississippi and Missouri Valleys, are the insect-parasites. The birds destroy many, but the natural insect-enemies still more. The blackbirds, quail, prairie-chickens, and grouse were said to destroy many of the eggs in Minnesota. As samples of the accounts given by different writers, I give the following by Uriah Bruner, contributed to the "Inter-Ocean:"

> Quails, paririe-chickens, and grouse, if sufficiently numerous, alone are sufficient to pick up every embryo grasshopper long before he can have wings. This I know from actual observation.
>
> Seven years ago large areas of eggs were deposited on my farm near Omaha. I then was fortunate enough to have about fifty quails on my place. As soon as the hoppers were hatched, and while yet almost microscopic in size, I venture to say that each one of the quails picked up, every day, enough of them to fill a bushel-measure if grown to full size. They devoured all my grasshoppers long before their wings had developed; but the grasshoppers devoured no one's crops that year, and very few escaped to migrate. It seems, however, that that spring the young grasshoppers were destroyed everywhere where their eggs were deposited among us, and most persons will tell you that the cold spring rains killed them off. This is possible, where the rains were heavy enough to carry them off and drown them. But at that time quails, prairie-chickens, and grouse were plenty everywhere, and I suspect that rain-storms got credit for what the birds did.
>
> Within the last six years we have had sporting-clubs in all our cities, towns, and villages, and very few birds survive the skill of the sportsman. Should any be fortunate enough to escape the sportsman, farmers' boys will trap and snare what are left during the winter and send them off to market. Was it not last winter that the report came back from Chicago, Saint Louis, New York, and other large cities that the market was glutted with quails, prairie-chickens, and grouse?
>
> If my position is correct, is there any wonder that the grasshoppers that hatched in Missouri, Kansas, and Minnesota last spring have done so much damage before and after their migration? The wonder is that they did not more damage. If God in his mercy had not sent deluging rains throughout Missouri and Kansas, that swept most of them down the waters of the Missouri, and if in Minnesota herculean efforts had not been put forth to destroy them in their pupa state, the great Northwest might not to-day rejoice in the great harvest that is now ready to take in.
>
> There can be no excuse for us to be eaten out by the grasshoppers, when hatched out among the settled parts of our country; and if we don't destroy them in their

* An extract from this translation is given by Stefanelli in the Bulletino Entomologia Società Italiano, 1870, pp. 70–82.—(Zoöl. Record for 1870).

embryo state we must lay the blame to ourselves if our farms are ravaged by them. Those hatched beyond the borders of civilization are not likely to visit us often nor do us much injury. We must protect quails and prairie-chickens. All of the Northwestern States must have statutory provisions against killing them for ten years, at least, and railroad companies must refuse, and by law must be prohibited, from carrying them over their roads for the same period. We must act and put in operation the knowledge we possess, or permit ourselves to be overcome by our insect enemies. It is for us to choose.

In "The Chicago Field" for March 17, 1877, Dr. Elliott Coues, United States Army, is inclined to place the sharp-tailed grouse (*Pediœcetes columbianus*) "if not at the head, at least in the very front rank of all the natural grasshopper-staying agencies. *These birds yearly destroy millions of grasshoppers*, and *at certain seasons eat very little else.*" As his article is a brief one and much to the point I insert it nearly entire:

I observe, in a late issue of the Chicago Field, that the question of the grasshopper-preying disposition of the prairie-hen is re-opened, though it is only through ignorance that any doubt on the subject can arise. Some three or four years ago I prepared and caused to be somewhat extensively circulated in the Northwestern States a brief reply to a question I found asked in one of the papers, "What will destroy grasshoppers?" stating in brief, "Prairie-hens will," and giving some facts bearing on the case. I never meant that these birds were a complete cure for the plague, but I endeavored to show what incalculable numbers of the pests the chickens destroyed, and to set their grasshopper-eating habits in the proper strong light. Probably few persons, outside the ranks of practical ornithologists are aware how extensively the so-called granivorous or seed-eating birds, such as sparrows, buntings, and finches, feed upon insects at certain seasons; and the same is true of the graminivorous birds, like grouse and partridges of all kinds. As for the peculiar insects now in question, namely, the grasshoppers, they furnish food to an immense array of quadrupeds and birds which inhabit the western prairies. The wolves, foxes, badgers, skunks, and various species of spermophiles or "gophers," all eat them. Among birds, the cranes, ducks, hawks, owls, grouse, and a great variety of small sparrow-like birds eat them. To just what extent these furred and feathered natural enemies make an impression upon the devastating hosts, cannot, of course, be known, for they have always been at work; but we may logically infer, from known facts, that the destruction is incessant, decided, and important to the last degree. Since, also, we do not know how delicately the contending forces of nature may sometimes be balanced in the perpetual "struggle for existence," it would be unsafe to assert that the diminution of the numbers of prairie-grouse by the incessant persecution to which pleasure or profit subjects them, is one of the principal causes of the late perilous swarming of the grasshoppers, but that there does exist to some degree a causative connection between the two circumstances, there can be, I think, no doubt.

With the prairie-chicken proper, or pinnated grouse, *Cupidonia cupido* of the books, I have had very little experience. There is, however, in its general habits, tastes, and proclivities, nothing materially different from what is the case with the sharp-tailed grouse, *Pediœcetes columbianus*, and this is a bird which I have had ample opportunities of studying for several years. I am inclined to place it, if not at the head, at least in the very front rank of all the natural grasshopper-staying agencies. *These birds yearly destroy millions of grasshoppers*, and *at certain seasons eat very little else*. Such a seemingly extravagant statement is supported, nevertheless, by actual observation and personal experience. I lived in Dakota in 1874, during the grasshopper invasion of that year, and was among the sharp-tails continuously from June until October, killing a great many of them "out of season" for scientific purposes, and in season for sport and food. In the latter part of summer, and in September, I invariably found grasshoppers in the crops of those I examined; and almost invariably I found the craws crammed with the insects, almost to the exclusion of other articles of diet. As I took occasion to say in the "Birds of the Northwest," 'At this season their food appears to be chiefly grasshoppers. I have opened numbers to find their crops crammed with these insects, only varied with a few flowers, weed-tops, succulent leaves, and an occasional beetle or spider.'

I don't pretend to say that the business of staying the ravages of the grasshoppers may be safely and confidently left to the grouse, or to any other natural agency—the hoppers have waxed too many for that; but I do assert, without fear of reasonable contradiction, that these birds are the natural means by which, in certain sections of the country, the greatest numbers of the insects are destroyed.

Among the many experiments which might be made with the hope of staying the ravages of this plague, the absolute, unqualified, and long-continued protection of the grouse might be tried. The denial of the sportmen's pleasures, and the stoppage of one particular source of food-supply, which such course would entail, would go for nothing in comparison with the advantages that might result. I do not make the suggestion hastily, nor without due consideration, backed by personal observation, and fortified by logical induction.

We are always slow to acquire exact and full information respecting the food of the animals which surround us, notwithstanding that many or most of our quadrupeds, birds, and insects hold toward us relations of the utmost economic importance, and in spite of the unquestionable fact that all agricultural interests hinge upon the solution of the problems involved. A few years ago the cock-of-the-plains (*Centrocercus urophasianus*) was supposed to feed chiefly, if not exclusively, upon wormwood. I have killed them to find nothing but insects in their crops. Hawks, particularly of the genus *Buteo*, presumed to feed mainly upon small quadrupeds and birds, are immense consumers of grasshoppers in the West, at certain seasons.

One thing is certain, that if we are to use birds in our war against the invading hosts, we must employ our own, and no imported ones. The expensive, uncertain, and difficult experiment of introducing any alleged "acridophagous" species of the Old World will never, I suppose, amount to much. Moreover, it is not to the technically considered "insectivorous" birds that we may turn our attention hopefully. Though many of these small species feed habitually upon grasshoppers in season, their collective efficiency in the work of destruction appeared to be, and I have no doubt is, comparatively insignificant. At present I know of no birds capable of rendering more efficient service than the grouse.

Young locusts have been found by Professor Green, of Lawrence, Kans., in the stomachs of various birds, such as the red-eyed woodpecker, yellow-billed cuckoo, cat-bird, red-eyed vireo, great crested flycatcher, and crow-blackbird. The hair-worm (*Gordius*) is a common parasite of the locust as of other species of grasshoppers. Mr. Riley states that many predaceous beetles attacked them, but few, if any, ichneumon-flies have been found in them, these beneficial insects confining their attention chiefly to caterpillars, such as the northern army-worm, &c. But the mite and Tachina flies are universally prevalent, and all writers agree are useful in reducing the number of locusts in the eastern border of the locust district.

June 2, before reaching Kansas City, I found on stepping off from the cars at different stations that the weak, feeble locusts were infested by large red mites attached to the base of the abdomen and to the under side of the wings.

The little red mite, which has proved to be such a benefactor to the people of the West, does not apparently differ from those found on the red-legged locust of the Eastern States in size or form. It is the six-legged young of some four-legged garden-mite, and has not yet been reared to adult life, and may be called *Trombidium gryllaria*.*

The scarlet silky mite.—Another mite, which is possibly the parent of the minute red six-legged parasitic mite, is the scarlet silky mite (*Trombidium sericeum* Say, Plate II, Fig. 4). It is about 2 lines in length, and has been abundant for two years in Minnesota, eating the eggs of the locust. As proof of its beneficial nature, I insert the following extract from a western paper:

Governor Miller, in a letter from Windom, says:

"Last evening, when we reached Worthington from Lake Shetek, there was quite an excitement in Worthington, owing to the fact that the citizens were generally convinced that a red parasite was destroying the grasshopper-eggs. I examined the matter carefully myself, and became convinced that the destruction of the eggs in that immediate vicinity was well assured; but I determined not to write you and excite any hopes until a further and more complete examination could be had. We therefore furnished our Bohemian friends with a bottle of the eggs, and their pests, and the commission left in high spirits. We postponed further investigation until this morning, when I left and prosecuted the examination with vigor. The farmers in the vicinity knew nothing of these signs of deliverance until the visitors from Worthington

*Astoma locustarum of Walsh (no descr.); *Astoma gryllaria* of Le Baur; *Astoma gryllaria* of Riley.

reached them, and I feel safe in saying to you that in a circle of ten miles from Worthington there will scarcely be an egg left by to-morrow night. I send you a bottle herewith containing the cones and the parasites. We could scarcely find a cone, or sack, except as they were indicated by the parasite on the surface; and each cone which was not entirely destroyed had from five to fifty of the red laborers at work upon the eggs. We found scores of cells with no eggs left except the shells. As fast as the bug finishes one cone, it starts upon an expedition for new worlds to conquer, and it instinctively finds and conquers the new world. I, of course, informed our station-agents and others at Hersey and Heron Lake of this discovery, and they also promised to make a thorough investigation, as I will do here, and the results will be reported forthwith. If the matter is general, deliverance is nigh. * * * I stopped for fifteen minutes one and a half miles west of Wilder, where Section-Foreman Smith took me to that portion of his farm where eggs were deposited. We could find none by general digging; but wherever we found, as we frequently did, the red parasite on the surface, we found the cone beneath, with the parasite at work consuming the eggs. * * * I am aware that two years ago this parasite was found working upon the eggs at Madeira and other places, but here we have the remedy almost as soon as the eggs are laid, while in the former instances the parasite was only discovered in the spring."

It is bright red and oblong oval, as seen in the engraving. The *Tachina* fly (*Tachina anonyma* Riley) attacks the locust, depositing one or more eggs in the back, at the insertion of the wings. The young of the fly is a large white maggot. (See Plate LXIII, Fig. 3*a*, for the maggot of a similar fly.)

Description of the Tachina maggot.—The following description is based on three specimens received from Mr. A. Whitman, of Saint Paul, Minn., and said by him to have been taken from the body of a grasshopper (*C. spretus*). The body is flattened, cylindrical, tapering suddenly toward each end, the head-end being more pointed than the opposite extremity. The segments are quite distinct, with raised ridges. The head is minute, one-third as wide as the segment behind, with two black hooks, *i. e.*, the mandibles. The larvæ of the genus lack the little slender tubercles forming the rudimentary antennæ and mouth parts seen in *Anthomyia* and *Murca*. Length, .35 inch. The egg is said by Riley to be "oval, white, and opaque, and quite tough."

It is this fly probably which attacks the locust in the Western Territories, and I may add to the accounts of its habits given by Professor Riley (Seventh Report, p. 178), the following statement in a letter from Lieutenant Carpenter, dated Camp Robinson, Nebraska, December 27, 1876:

I have often observed a fly, about the size of the blow-fly, of a greenish mottled color with the abdomen tipped with red, annoying *Caloptenus spretus*. It would light on the ground just behind the grasshopper, and the instant it took wing would pounce upon it, and the two roll over and over on the ground struggling for several moments, when the fly would release the grasshopper. I have caught them both in this act, and upon examination of the grasshopper, always found the little red eggs on the body.

This fly is said by Riley to be common and destructive to the grasshoppers. Mr. Whitman writes me regarding its occurrence in Minnesota as follows: "I have opened six hundred and twenty-four grasshoppers (*spretus*); nine of these contained grubs (of the *Tachina* fly probably) and ten had hair-worms."

The locust-egg-eating maggot.—Another fly which is very useful from its habit of devouring the eggs of the locust is the *Anthomyia radicum* var. *calopteni* of Riley. It is quite similar to the onion-maggot and radish-fly, both in its maggot and winged states. I have received several of the maggots from Mr. Whitman said to have been found among the eggs of the locust. I give the following description of them:

Larva of Anthomyia radicum calopteni (Plate LXIII, Fig. 2).—Body long and slender, cylindrical, soft, elongate-conical, tapering gradually toward the minute head; the segments are not very convex; beneath they are thickened to take the place of feet. The antennæ and maxillæ form slender pointed tubercles much as in *Musca domestica*. The prothoracic spiracles are situated on the hinder edge of the segment, and are remarkably long and slender. The end of the body is full and rounded, flattened conical; the end is divided into two portions, of which the upper forms a slope, on the lower edge of which are situated six acute tubercles, of which the three lower are the larger. In the center of the slope are two small, prominent spiracles, or breathing-holes. Below this slope is a transverse ridge, from which arise three sharp tubercles situated above the large anal tubercle or foot. Length about a third (0.30) of an inch.

I adopt Professor Riley's identification of this maggot.

Our figure is not drawn from specimens taken in this country, but copied from Curtis's Farm Insects. It is sufficiently accurate, however, to represent our form.

Professor Riley says that this maggot "is quite common, and has been found in Minnesota, Iowa, Nebraska, various parts of Kansas, Missouri, and even Texas. It has destroyed, in many instances, as many as 10 per cent. of them." These small maggots are found in the locust-egg pods, either singly or in varying numbers, there sometimes being a dozen packed together in the same pod. They exhaust the juices of the eggs and leave nothing but the dry and discolored shells, and when they are not numerous enough to destroy all the eggs in the pod, their work, in breaking open a few, often causes all the others to rot.

"When fed to repletion, this maggot contracts to a little cylindrical yellowish-brown pupa [-case], about half the length of the outstretched and full-grown larva, and rounded at both ends. From this pupa [-case] in the course of a week in warm weather, and longer as the weather is colder, there issues a small grayish, two-winged fly, about one-fifth of an inch long, the wings expanding about one-third of an inch, and in general appearance resembling a diminutive house-fly.

The common flesh-fly (*Sarcophaga carnaria*, Plate LXIV, Figs. 1–3).—The maggot (Plate LXIV, Fig. 1) of this fly also feeds on the eggs, but probably on those which are addled. It is larger than the *Anthomyia* maggot, with no spines around the end of the body; and the pupa-case (Plate LXIV, Fig. 2, enlarged) is much larger, truncate at the end, and tapering toward the head-end. I have received two specimens, half-grown, of the maggots of this species, taken from the abdomen of a locust (*C. spretus*) on the Vermejo River, New Mexico, June 29, by Lieut. W. L. Carpenter, U. S. A.

The two-lined Telephorus grub.—I have also received from Mr. Whitman, of Saint Paul, Minn., a specimen of the larva of *Telephorus bilineatus*, said by him to be destructive to the locust. I add a description copied from my first report as State entomologist of Massachusetts.

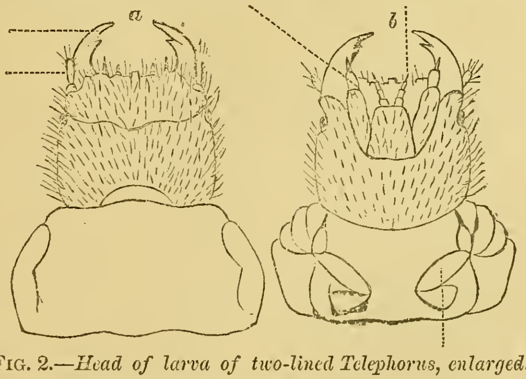

FIG. 2.—*Head of larva of two-lined Telephorus, enlarged.*

a, top view of head and prothoracic segment; *at*, antennæ; *md*, mandibles; *b*, under side showing *mp* the maxillary palpi; *lp*, labial palpi; *f*, first pair of feet.

The beetles of this and other species which belong to the family of fire-flies feed on the leaves of forest deciduous trees, especially the birch.

The larvæ, however, devour snails and insects, and do no injury to vegetation. The larva of this species was identified by Mr. P. S. Sprague, who found it near Boston, under stones in spring, where it changes to a pupa, and early in May becomes a beetle, when it eats the newly-expanded leaves of the birch.

Description.—The body of the larva is rather long and slender, thickest in the middle, where it is about twice as wide as the head, and tapers slightly toward each end of the body, the terminal segment being a little less than half as thick as the middle segment. The segments of the body behind the head are unusually convex, the sutures between them being very deep. The body is covered with fine, dense hairs, giving it a peculiar velvety appearance. Its general color is horn-brown, the head being darker. The head is remarkably flattened and square, being scarcely longer than broad, and densely covered with short hairs above and beneath. The antennæ are inserted on the side of the head, and immediately behind them on the side are the eyes; the occipital suture is situated midway between the base and the front edge of the head, forming a straight line just behind the eyes. The antennæ are two-jointed, and received into a large socket; the first joint is very short; the second joint four times as long as the first, a little slenderer, and increasing slightly in width toward the end, which is abrupt, and contains a minute, rudimentary third joint. The maxillæ are broad, subtriangular, projecting a third of their length beyond the labium, with the ends broad and square. The palpi extend out from the head as far as the antennæ, and are three-jointed, with the basal joint quite thick, rather longer than thick, while the second joint is very short, and one-half as long as thick; the third minute, rudimentary. The anterior edge of the occiput beneath is deeply hollowed out; the chin (mentum) is oblong, with very square edges, and is one-fourth longer than broad. The labial palpi are two-jointed, the basal joint very short, one-half as long as broad; second nearly twice as long as thick, and ending in a stiff hair. The mandibles are large, stout, two-toothed, the inner tooth situated a considerable distance from the tip. The labrum is broad and perfectly square in front, with a median notch dividing the edge into two slight lobes. The clypeus is an ill-defined oval, convex area.

Along the median line of the body is a slightly-marked row of short, paler streaks, more continuous on the thoracic than the abdominal segments, forming on each of the latter segments an elongated spot situated on the anterior edge of each segment except the last. On each thoracic and the last abdominal segment is a pair of lateral oval brown spots, paler in the center. Behind these on each abdominal segment (except the last) is a row of pale short lines, placed in the middle of the segment. Farther down on each side is a similar row of short lines, which are, however, subdivided into two spots, which on the thoracic segments form a row of four or five pale dots. Between these two lines is a row of black dots, one on each segment. The legs are rather short, and quite hairy. The terminal segment of the abdomen is about as long as broad, and well rounded behind. It is three-quarters (.75) of an inch in length. The pupa was not preserved. The beetle itself is soft-bodied, brownish-black and reddish-yellow. Its specific name (*bilineatus*) was given to it from the two short, broad, blackish bands on the prothorax, which is reddish-yellow. The head is reddish-yellow, with a broad black band between the eyes, and the antennæ are black. The body beneath is pale reddish, except the under side of the middle of the thorax (meso and meta thorax). The legs are pale reddish at base, while the end of the femora and the tibiæ and tarsi are entirely black-brown. It is about a third (.30) of an inch long.

Whether this *Telephorus* larva devours the eggs, or young larvæ, or only the sickly and dying locust, is not known.

The ground-beetle grub (Plate LXIII, Fig. 1, enlarged).—Another beetle-grub, which is supposed to devour the eggs, has been received from Mr. Whitman. It is the young of a species of *Harpalus*, and is allied to the larva of the European *H. æneus*, as figured by Schiödte, and may possibly be the young of *H. herbivagus* of Say, a very common beetle found all over the country, having been collected by Lieutenant Carpenter in Southern Colorado and Northern Mexico, according to Le Conte, so that it probably destroys the locust wherever the latter occurs.

The *hair-worm parasite* (*Gordius aquaticus* Linn. and *G. varius* Leidy, Plate LXIII, Fig. 6, see explanation of the plate).—I have received from Mr. Whitman fragments of a hair-worm found by him in the Rocky Mountain locust, but, unfortunately, comprising neither end of the animal, so that it is impossible to tell which species it is. It is probable that it belongs to *Gordius aquaticus*, as I have received one of that species from

Mr. Riley, taken from *C. spretus* in Missouri. Regarding the frequency of its occurrence in *C. spretus*, Mr. Whitman writes, under date of September 19, 1876: "I have opened six hundred and twenty-four hoppers (*spretus*); nine of these contained grubs (of the *Tachina* fly probably) and ten had hair-worms. I do not know that the latter has ever been noticed in hoppers in this State before this year; at any rate, it has been so rarely mentioned that I never heard of it here. I ought to say in regard to the six hundred and twenty-four grasshoppers above mentioned that they were probably some of a band of outsiders that have come into the State within a few weeks. Almost every female had eggs about ready to be laid." The specimen of *Gordius* received from Mr. Whitman was filled with eggs.

I will here give a *résumé* of our entire knowledge of the hair-worm, both because the worm is well known to the public, being sometimes thought by the ignorant to be actually a transformed horse-hair, and because it is prevalent in the bodies of grasshoppers, and has an extremely interesting history.

The first notice of the hair-worm in this country by a naturalist is, so far as I am aware, contained in "The Natural History of Vermont," by Zadock Thompson. The following account is quoted at second-hand from Charles Girard's "Historical Sketch of *Gordiaceæ*:" *

The little animal called the *hair-snake* also belongs to this order (*Annulata*), and to the genus *Gordius*. These are very common in the still waters and mud in all parts of the State. They are usually about the size of a large horse-hair, and are from 1 to 6 or 8 inches in length. In color, they vary from pure white to nearly black, and hence we probably have several species. The vulgar notion that they originate from hairs which fall from horses and cattle and become animated in the water would seem to be too absurd for contradiction, and yet, absurd as it is, people are to be found who believe it.

Mr. Girard adds:

The same popular opinion is prevailing in Europe. *Gordii* have been noticed in the body of insects; also, by an American entomologist, Dr. Th. William Harris, who says, "I have taken three or four of these animals out of the body of a single locust." They have been found by others within the cricket (*Acheta abbreviata*).

We saw a specimen 6 or 7 inches in length caught in the clear waters of the vicinity of Richmond, Va. Several others were detected by Dr. Leidy in the neighborhood of Philadelphia. Finally, we may mention several specimens of *Gordii* from Oregon, brought home by the United States Exploring Expedition. *Gordii*, therefore, are spread all over the Western Hemisphere.

The mode of development of our common *Gordius varius* (Plate LXIII, Fig. 6, *h*), has been studied by Dr. Leidy.† This is quite a different species from *Gordius aquaticus*, the end of the body of the female being trifurcated, while that of *G. aquaticus* is blunt. It is from 4 to 12 inches in length, and appears to be much slenderer than *Gordius aquaticus*. "The *Gordius varius*," says Leidy, "is prolific in a very remarkable degree." A female 9 inches in length placed in a tumbler of water extruded a string of ova 91 inches in length, in which he estimated there were over 6,000,000 eggs. Dr. Leidy saw the eggs undergo the process of segmentation. On the third day, the germ appeared as an "oval, finely-granular body," and by the tenth day the embryo was conical in form, with a cleft or fissure which extends two-thirds the length of the mass. Upon the eleventh day it resembled a cylinder doubled upon itself, and the tail-end was subacute.

From the nineteenth to the twentieth day the embryo alternately retracted and protruded the tentacular or filamentary appendages, and the integument of the anterior

* Proc. of the Academy of Natural Sciences, Philadelphia, v. 1850 and 1851, p. 279.
† Proc. of the Academy of Natural Sciences, Philadelphia, v. 98 and 262, 1850 and 1851.

half of the body appeared to be getting annulated, which was so by the twenty-first day. * * * On the twenty-second day the annulations of the anterior half of the body were very distinct, the posterior half was also becoming annulated, and near its extremity I for the first time observed an anal orifice and one to four small epidermal spines. On the twenty-fourth day, the tubular clavate organ before mentioned, occupying the anterior part of the alimentary canal, was alternately protruded and retracted as a proboscis. The proboscis, when fully protruded, brought into view at its base a second circle of tentacular filaments within the first. On the twenty-sixth day the embryo, when pressed from the egg, progressed forward by moving the posterior half of its body from side to side, and it alternately protruded and retracted the proboscis and the two circles of tentacular filaments. When all the organs were retracted the head presented a truncate or depressed surface, and in their protrusion the extremities of the outer circle of tentaculæ and the end of the proboscis first became visible; as these advanced, the second circle of tentaculæ appeared, and when the proboscis was entirely protruded, the outer tentaculæ were deeply reflected upon the outside of the body, and the inner circle projected obliquely outward and upward. (See also Leidy's figures and description in the American Entomologist, ii, p. 196.)

It is evidently this species whose habits Dr. Leidy further describes in his "Flora and Fauna within Living Animals."* I quote as follows from this work:

The grasshoppers in the meadows below the city of Philadelphia are very much infested with a species of *Gordius* probably the same as the former, but in a different stage of development. More than half the grasshoppers in the locality mentioned contain them; but those in drier places, as in the fields west and north of Philadelphia, are quite rarely infested, for I have frequently opened large numbers without finding one worm.

The number of *Gordii* in each insect varies from one to five, their length from 3 inches to a foot; they occupy a position in the visceral cavity, where they lie coiled among the viscera, and often extend from the end of the abdomen forward through the thorax even into the head. Their bulk and weight are frequently greater than all the soft parts, including the muscles, of their living habitation. Nevertheless, with this relatively immense mass of parasites, the insects jump about almost as freely as those not infested.

The worms are milk-white in color, and undivided at the extremities. The females are distended with ova, but I have never observed them extended.

When the bodies of grasshoppers, containing these entozoa, are broken and laid upon moist earth, the worms gradually creep out and pass below its surface. Some specimens which crawled out of the bodies of grasshoppers and penetrated into earth contained in a bowl, last August, have undergone no change, and are alive at the present time (November, 1852).

In the natural condition, when the grasshoppers die, the worms creep from the body and enter the earth, for, suspecting the fact, I spent an hour looking over a meadow for dead grasshoppers, and, having discovered five, beneath two of them, several inches below the surface, I found the *Gordii* which had escaped from the corpse.

Some of the worms put in water lived for about four weeks, and then died from the growth of *Addya prolifera*. What is their cyclical development?

The history of the *Gordius aquaticus* has been mostly cleared up by A. Villot,† and the following account is condensed from his memoirs:

The eggs (Plate LXIII, Fig. 7, *a*) are laid in long chains; they are white, and excessively numerous. The yolk undergoes total segmentation. (Plate LXIII, Fig. 7, *b*.) At the close of this period, when the yolk is surrounded by a layer of cells, the germ elongates at what is destined to be the head-end, this layer pushes in, forming a cavity, and in this state it is called a "gastrula." (Plate LXIII, Fig. 7, *c*.) By this time the embryo becomes pear-shaped (Fig. 7, *d*); then it elongates. Subsequently the internal organs of digestion are formed, together with three sets of stiff, spine-like appendages to the head, while the body is divided by cross-lines into segments. The head lies retracted within the body. (Fig. 7, *e*.)

In hatching, it pierces the egg membrane by the aid of its cephalic armature, and escapes into the water, where it passes the early part of

*Smithsonian Contributions to Knowledge, v. 1853.

†Monographie des Dragonneaux (Genre *Gordius* Dujardin), par A. Villot. (Archives de Zoologie expérimentale et générale, tome 3, No. 1, 2, 1874, Paris.)

its life. Plate LXIII, Fig. 7, *f*, represents the embryo of *Gordius aquaticus* greatly magnified. It will be seen how greatly it differs from the adult hair-worm, having in this stage some resemblance to the *Acanthocephalus* by its cephalic armature, to the *Nematoidea* or thread-worms by its alimentary canal; and to the larvæ (*cercaria*) of the *Tremotodes* or fluke-worms in the nature of its secretory glands. But the hair-worm differs from all these worms and even *Mermis*, a hair-worm much like and easily confounded with *Gordius*, in having a complete metamorphosis after leaving the egg.*

When in this stage, it incessantly protrudes and retracts its armed head, the spines being directed backward when the head is out.

In the first period of larval life the worm lives encysted in the bodies of aquatic fly-larvæ. The vessel in which M. Villot put his *Gordius* eggs also contained the larvæ of *Tanapus*, *Corethra*, and *Chironomas*, small gnat-like flies. He found that each of these larvæ contained numerous cysts with larvæ of *Gordius*. He then removed the larvæ from the cysts, placed them on the gnat-larva, and saw the larval hair-worm work its way into the head of the gnat-larva through the softer part of the integument; during the process the spines on the head, reversing their usual position, enabled the worm to retain its position and penetrate farther in. Then, finding a suitable place, it came to rest and remained immovable. Then the fluids bathing the parts coagulated and formed a hard, granulated sac. This sac at first closely envelopes the body, then it becomes looser and longer, the worm living in the anterior part, the front end of the sac being probably never closed. In this first larval state the worm is active.

In the second larval period the young hair-worm lives motionless and encysted in the mucous layer of the intestines of small fish, which prey on the gnat-larvæ. A minnow, for example, swallowing one of the aquatic gnat-larvæ, the encysted larva becomes set free by the process of digestion in the stomach of the fish; the cyst dissolving the young hair-worm itself becomes free in the intestine of its new host. Immediately it begins to bore, aided by the spines around the head, into the mucous membrane lining the inner wall of the intestine of the fish, and then become encysted, the worm itself lying motionless in its new home, with its head retracted and the tail rolled in a spiral. The cyst is either spherical or oval. (Plate LXIII, Fig. 6, *g*.)

The return to a free state and an aquatic life occurs in the spring, five or six months after the second encystment. It then bores through its cyst, and passes into the intestinal cavity of the fish, and from thence is carried out with the fæces into the water. On contact with the water great changes take place. The numerous transverse folds in the body disappear, and it becomes twice as long as before, its head-armature disappears, the body becomes swollen, milky, and pulpy. It remains immovable in the water for a variable period, and then increases in size, the integument grows harder, and when about two inches long it turns brown and begins to move. Probably the host differs according to chance. Most of those which have occurred in Europe reside in

* It may here be said that in the *Mermis* hair-worm, which also lives in insects, and is of the same general appearance as *Gordius*, the young when hatched is not annulate, has no cephalic armature, while the body is short and thick, the tail blunt. These remarks are based on some drawings of the eggs and embryos of a *Mermis* made by Mr. James H. Smerton, in Jena (May, 1876), and kindly given me by him. The female genital apperture is situated in the middle of the body, while it is placed at the end of the body in *Gordius*, leading out of a cloacal chamber in which the intestine and two different ducts (male or female, as the case may be) terminate, the common external aperture being ano-genital in its nature.

carnivorous beetles, such as different species of *Carabidæ*. They live in or around the fat body, and sometimes twine around the intestines of their host, and finally pass out of the anus. As the carnivorous insects are liable to devour the larvæ of other insects living in damp places, it is not difficult to see how they should become tenanted by young hair-worms encysted in their victims, but why they should be so common in grasshoppers is not so easy to determine. Grasshoppers probably take the minute larvæ with their food, and fields recently inundated are of course more liable to abound with them. They also live in fish and frogs, and "Diesing speaks, on the authority of Kirkland, of a young girl in Ohio who had expelled *per ano* a *Gordius varius*. It is the popular belief in Europe that they live in man, and that they may be introduced in drinking water from brooks and pools, or in eating fish not properly cooked. In this country they seem to occur not uncommonly in the bodies of grasshoppers, and are useful in keeping them in check.

Description of the species occurring in the United States.—The following descriptions are taken from Villot's Monograph, and embrace all up to this time known to inhabit this country, a few notes of my own being added:

Gordius aquaticus Linn (Plate LXIII, Fig. 7, *a*, *f*, *i*, and *k*).—Anterior end rounded, distinctly swollen. Posterior extremity of the male bilobate, recurved beneath; lobes distinctly hollowed within and abundantly provided with papillæ; a crescent-shaped fold of the epidermis beneath the ano-genital opening. Posterior extremity of the female truncated perpendicularly to the axis; ano-genital opening central, surrounded with a reddish-brown circle. General coloration varying from milk-white to brown; a horny, transparent cap and a deep-brown ring at the anterior extremity; body besprinkled with numerous circular spots of a yellowish-white. Epidermis smooth, divided into lozenges by salient lines crossing obliquely. Dimensions very variable; length, 28–89 centimeters; breadth, ½ to 1 millimeter.

Habitat: Europe and North America (Leidy and Girard). A male of this species from *Gryllus neglectus* June 5, Pittsburgh, Pa. (B. C. Jillson), and a female from Topsfield, Mass., are in the museum of the Peabody Academy of Science at Salem. I have received a female of this species from Prof. C. V. Riley, said to have been a parasite of *Caloptenus spretus* in Missouri. It is probably common all over the country east of the Rocky Mountains.

Gordius lineatus Leidy.—Posterior extremity of the female obtuse; that of the male bilobed and furnished with papillæ. Length, 5 to 7 inches. (Leidy). Essex County, New York. Diesing cites it among the synonymes of *Gordius aquaticus*.

Gordius robustus Leidy.—Posterior extremity a little compressed and obtuse. Body stiff, marked with transverse folds 6 inches long. Pemberton, N. J. From a grasshopper (Leidy). Diesing refers it to *Gordius aquaticus*. A female which agrees with this species, from the body of *Stenopelmata fasciata* Thomas (identified by Mr. Thomas), Wahsatch, Utah (L. E. Ricksecker), is contained in the museum of the Peabody Academy of Science. The posterior extremity is compressed, except at the extreme end, which is cylindrical. The ano-genital orifice is sunken. The body appears as if irregularly segmented, being marked by transverse, impressed lines. Head conical, more acute than in *aquaticus*, and paler. This specimen was 10 inches long, of the same size and proportions as *G. aquaticus*, and would at first be mistaken for it.

Professor Leidy states in the American Entomologist (ii, 194) that a female of this species, about 6 inches long, was found parasitic in a grasshopper, *Orchelimum gracile*, in New Jersey.

Gordius subspiralis Diesing.—Body of the male brown; that of the female attenuated in front, of a clear brown, brilliant, irised. Head surrounded with a ring of an obscure brown. Caudal extremity of the male terminated by two diverging lobes, spiral, recurved beneath, smooth, joined to their base by a membranous fold; that of the female obtuse, a little compressed. Dimensions of the male: Length, 8 inches–2 feet 2 inches; thickness, ¼–⅗ of a line; female, 10 inches–2 feet 6 lines; thickness, ⅓–⅗ of a line.

Habitat: Common in a pond 525 miles west of Fort Riley, Kansas, which would place the *habitat* in Central Colorado, where it lives in company with *Siredon* (Hammon). Diesing, who made the species known in 1860, referred to it a *Gordius*, which Leidy had mentioned without a specific name in 1857.

Gordius fasciatus Baird.*—Body furrowed with cross-lines, attenuated in front and

* Proceedings Zoölogical Society London, 1853, 21, pl. xxx, f. 6.

surrounded with circular wrinkles of a bright brown, besprinkled with broad spots of an obscure brown; extremities of the body blackish. Length of the female, 11½ inches; thickness, about one-half of a line. North America, British Museum.

Gordius reticulatus Villot.—Anterior extremity ending in a sharp point. Diameter of the body increasing from the anterior end to the posterior extremity, which terminates in a truncated point. Ano-genital aperture broad. Maroon-brown. A dorsal and ventral band of a darker brown. Epidermis areolated; areoles forming a net-work, with irregular and unequal meshes, having a mean diameter of 10 millièmes of a millimeter. A simple border of small papillæ around the areoles. Length, about 14 inches; thickness, 1 millimeter. California, Museum of Paris (a single individual).

I have identified a specimen of this species from California, sent by Mr. Henry Edwards to the Museum of the Peabody Academy of Science.

Gordius varius Leidy (Plate LXIII, Fig. 6, *h*).—Body very long, filiform, attenuated at each extremity, especially at the anterior; of a dirty-white yellowish-brown, also very black, shining, areolated, areoles irregularly pentagonal. Head surrounded with an obscure brown or black ring, obliquely truncated and terminated by a transparent cap. Mouth situated at the base of this cap. Posterior extremity of the male reflected, terminated by two conical, recurved, obtuse, and divergent lobes.* Posterior extremity of the female trilobed, lobes almost elliptical, of which one is straighter than the other. Length of male, 4–6½ inches; thickness, $\frac{1}{5}$–$\frac{1}{4}$ of a line; length of a female, 5–12 inches; thickness, $\frac{1}{4}$–$\frac{2}{5}$ of a line.

Habitat: Very common in the rivers of North America (Rancocas, Augusta, Schuylkill, Delaware). Observed, also, in the Niagara by Agassiz; in the Susquehanna and Lake Champlain by Baird.

The American species of Mermis.—Although the genus *Mermis* is very similar in external appearance to *Gordius*, it differs greatly in internal structure, and in the embryo being unarmed and not undergoing a metamorphosis. The species, however, are parasitic in various insects. I quote the following generic characters from Carus's Hand-Book of Zoölogy, giving a free translation for the use of the American student:

Gordius.—Head without papillæ; a short æsophagus opening into the cellular contents of the body; male with forked tail; genital opening between the forks; no spiculum, but with spines; female opening on the end of the tail, entire, two or three pointed; without any lateral expansions (seiten felder).

Mermis.—Head beset with papillæ; a long œsophagal tube sunk in the cellular contents of the body (intestine?); male with an undivided tail-end, with several rows of papillæ and two spiculæ; female genital opening in the middle of the body, with lateral expansions.

In both genera the intestine ends in a blind sac, there being no anus.

Mermis elongata Leidy.†—Yellowish-white, and from 6 to 8 inches in length. New Jersey.

Mermis crassicaudata Leidy.‡—Pure white, with a peculiar tubercular thickening of the integument upon the caudal extremity, 8 inches in length. Philadelphia.

Mermis acuminata Leidy.§—Female. Body filiform, pale fuscous, narrower anteriorly. Head conical, truncate, with the mouth simple and unarmed. Caudal extremity thicker than the head, obtusely rounded, and furnished with a minute spur-like process Length, 5 inches 8 lines; cephalic end at mouth, $\frac{1}{12}$mm; a short distance below, $\frac{1}{5}$mm. middle of body, $\frac{3}{8}$mm; near caudal end, $\frac{1}{4}$mm; mucro, $\frac{1}{12}$mm long, $\frac{1}{80}$mm thick. Parasitic in the larvæ of the coddling moth (*Carpocapsa pomonella*), Philadelphia and Long Island, N. Y. Professor Riley informs me that he had previously to the publication of Professor Leidy's article found a hair-worm in the body of a coddling worm. Professor Leidy has observed a white hair-worm (*Mermis* sp.?) proceeding from the Carolina grasshopper, *Oedipoda carolina* (Linn.), while the latter was struggling in a ditch into which it had jumped from being alarmed. Perhaps in this way we may account for the occasional appearance of a *Gordius* in a drinking-trough or a puddle on the road. (Amer. Ent., ii, 195.)

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* In his article, "The *Gordius* or hair-worm" (American Entomologist, ii, 193, 1870), Professor Leidy describes, under the name of *Gordius longilobatus*, a form which he regards as a distinct species, being slenderer than the true *varius*, with the forks of the tail two or three times the length of the thickness of the body, and the forks do not include at their base a crescentic fold, as in the former. The genital pore is a little in advance of the division of the tail.

† Proceedings Academy of Natural Sciences, Philadelphia, 1852, v, 263.

‡ The same, p. 263.

§ Proceedings Academy Natural Sciences, Philadelphia, 1875, 14.

REMEDIES.

The locust may be most effectually dealt with while in the egg-state. Bounties should be paid by the different States and Territories, as is done by European governments. As the eggs are laid very close together and only an inch beneath the surface, the top soil might be gathered into heaps and heated through by bonfires, or passed through crushing mills, or the egg-sacs picked out by women and children and liberal bounties be paid—so much a bushel—by town or county inspectors, and then burned. Deep plowing and heavy rolling are very advisable, and, on the other hand, harrowing the field in autumn so that the egg-sacs may be turned up and exposed to the frost and birds and hogs and cattle.

When the locust is still wingless it does the most harm, and can then be best kept within due limits. In Colorado and Utah, where irrigation is practiced almost entirely, fields can be flooded, the ditches can be oiled, and myriads be destroyed. Oil or any greasy substance is the best remedy in dealing with any insect, as it should be remembered that insects do not breathe air through the mouth, but inhale it through small openings (spiracles) in the side of the body; if these holes are covered with a thin film of oil or grease of any kind, they die at once. By taking energetic measures; the farmers of Colorado, as will be seen by Mr. Byers's letter on p. ——, in the spring of 1876 effectually destroyed the young brood. Fowls should also be turned among them; the soil should be rolled so as to crush them, and trenches dug and filled with straw and set on fire and the locusts driven into them with switches, or prairie-fires be lighted in a circle around them, and the locusts driven into them.

In Colorado a great deal of ingenuity has been evinced in dealing with the locust, as may be seen in reading the two following extracts from the newspapers, which contain some useful practical remedies:

This is how the embattled farmers of Colorado deal with the grasshoppers: A long sheet-iron box, open at the top, is swung close to the ground, between two wheels, by which it is moved over the field. Rising two or three feet above the top of the box, and bending forward from the rear, is a broad sheet of tin or sheet-iron. When in use a fire is built in the bottom of the furnace, which is then pushed against the wind, the overhanging wing or sail taking the hoppers as they rise, and feeding them in the flames in a hurry. Sometimes a miniature windmill is added to the outfit, and sucks in all the locusts for yards and yards around, destroying them by millions. Millions more have been drowned in irrigating ditches by cunningly-devised traps which prevent their escape from the water. While they were young and green, and before their wings were grown, several tons of them were destroyed by a confidence game which deserves description. Between the young hoppers and the young wheat long rows of dry straw were strewn, which soon became literally black and alive with the wriggling little insects. When no more hoppers could be accommodated, the straw was fired. Another device was to drag over the hopper-infested regions a tarpaulin plentifully coated on the under side with coal-tar, which is instant death to the pests. Still, with all these disadvantages against them, grasshoppers are apparently as numerous as ever.

The farmers of Colorado are busily fighting the grasshoppers, which have appeared in immense swarms. A letter from Denver says they "sluice them down the ditches with water, gather them up in heaps and burn them; for the water will only collect, and not drown, these very vital pests. They set cans of oil, dripping slowly, at the heads of their ditches, and the slightest touch of the oily film, floating down with the running water, destroys the young grasshopper. They drag the ground with huge harrows, covered with blazing brush, and the flame scorches its tiny millions to death. They draw papers or platforms smeared with tar along the fields, and the insects, trying to hop over, fall on the tar and stick there. With all these devices they only thin out the unwelcome visitors.

The following pertinent remarks I find in an editorial in the Rocky Mountain News, November 22, 1876:

The farmers of Colorado have demonstrated the fact that they can successfully combat and conquer the young grasshopper. They undertook the fight with extreme reluctance, but won the victory with less than half the trouble they expected. Only those who feared to plant last spring, or those who planted so late that the flying swarms in August caught their unripened grain, are now mourning the lack of good crops. If they now had information that grasshopper-eggs are deposited plentifully in Laramie Plains, the Sweetwater Country, or Upper Green River Basin, none would plant late next spring. All crops would be put in early and harvested in July, because they would know that if swarms of grasshoppers hatch in any of the regions named, next spring the prevailing winds will be likely to bring their devouring hosts down upon Colorado about the second week of August. But we do not know whether any egg-laying swarms invaded those countries in August, September, or October last or not. So far as that matter is concerned, we are just as ignorant this year as we were in the fall of 1863 prior to the first and most astonishing invasion of August, 1864. Consequently, half the farmers, instead of planting in February and March, will put it off until May, and then trust to luck. If no grasshoppers come, all right; if they do come and eat up the barley and wheat in the milk and the corn when the tassels are shooting, they'll curse the country and their own hard fate—laziness.

Although no one can tell now with present light, or rather darkness, whether or not flying swarms of grasshoppers are *likely* to scourge Colorado next fall, we are all pretty certain that we will have plenty of young ones in the spring, and that some other country will get them "on the wing" in the fall. It will probably be Southern Kansas, Indian Territory, or Texas. They may reach Southwestern Missouri or Arkansas. Consequently, the News advises the people in that direction to plant early and mainly of crops that will be harvested by the 20th of July. The grasshoppers that hatch here will fly two or three weeks earlier than those from higher latitude and altitude.

The farmers of Colorado in 1876 were quite successful in combating the locust. The best account of their mode of fighting them appears in the New York Tribune, from the pen of Mr. J. Max Clark, of Greeley, Colo.

Indeed, notwithstanding those natural barriers to their progress eastward—climate and soil—it is hardly safe to assert that they may not yet reach much farther into the older States than they have heretofore succeeded in penetrating. It is true they thrive best in a dry climate, but they can exist and perpetuate themselves in a wet one; they prefer a dry sandy or gravelly soil in which to deposit their eggs, but the conditions not being so favorable they will lay them in heavy wet soil, with no apparent injury to their vitality. They have been known to hatch in this vicinity on the margin of a lake, in soil almost marshy in its texture. I have myself known them to come forth in an apparently perfectly healthy condition from soil too wet to plow.

While, for the reasons set forth, we can have no great faith in any method of general destruction, there are means of defense which at times are very effective, and which are always worth trying. In this State our main reliance is on water. We surround our fields with ditches, and into the water we drop kerosene oil, which covers the surface and kills the young grasshoppers at the touch. When they deposit eggs in the fields, as they frequently do, we watch for their hatching and scatter straw over them as they come out of the ground, and burn them if possible before they get scattered. When young grasshoppers attack a crop they generally do so in a compact body, much in the form of a line of battle, and for a short time at least after striking the vegetation do not scatter, but eat the border clean as they go. At such times they are easily destroyed, and any farmer who has straw stacks and teams can, if quick and energetic, generally save his crop by spreading straw on the advancing line and burning them. When grasshoppers have invaded a field of young grain, or have hatched in it, and have become scattered through it before they have been discovered, then another line of policy must be pursued, and one not so certain of success. We use a fire-machine, which may be described as being a net-work of heavy wire (telegraph-wire is good) upon runners of iron about 4 inches high, upon which straw, coal, or wood is burned as the machine is drawn by horses attached to long rods, meeting at a point 15 or 20 feet in advance of the machine. The machines vary in width from 8 to 12 feet in their sweep, and are about 3 feet deep from front to rear, with a sheet-iron cover attached to the rear and raised from 1 to 2 feet high in front to throw the flames downward through the net-work of wire as the machine proceeds. This kills the young hoppers without generally seriously injuring the grain.

We also use a platform of zinc or canvas, or even thin boards from 6 to 10 feet long and 3 feet wide, upon which is spread coal-tar with a broom or whitewash-brush, from a pailful of liquid ready for the purpose. This is dragged by hand or with a horse. The runners under the platform are only a couple of inches in length, and the hoppers jump on to the tarred surface and stick fast as the machine is moved along. This is a very simple contrivance, and is generally regarded as about as effectual as the fire-machines, while not costing nearly so much in construction or for running-expenses.

Kerosene oil is a valuable agent whenever it is practicable to use it, both to destroy the grasshoppers and to prevent their depredations. A spoonful of oil, kept well shaken up in a watering-pot filled with water, and sprinkled upon melon-vines, squash-vines, or any other garden vegetables, will effectually prevent their destruction. It is a cheap means of defense and easily applied on a small scale. Various methods are in use for the destruction of the eggs where they are known to be deposited. Deep fall or early spring plowing has a tendency to disturb and destroy them, sometimes wholly and sometimes only in part, but always seriously affecting their vitality. A flock of sheep having the run of a stalk-field of mine last season completely destroyed a large deposit of eggs. The ground was very loose and dry, and the surface becoming completely pulverized and cut up with their feet, not one of them ever hatched. Birds are an important aid in their destruction, and in loose soils they scratch out and eat enormous numbers of them. The much-despised skunk, too, is a most desirable friend to man in this contingency. A single skunk will often clear an acre of ground, even in sod, of all grasshopper-eggs. No farmer in the West who has good sense will kill skunks. They deserve to be propagated, even if it were necessary to nurse them on young chickens.

To defend a field of grain against flying grasshoppers, altogether different tactics must be employed. Clouds of dense smoke made from burning old rags wet with kerosene oil, or by burning coal-tar or sulphur in differint parts of the fields, have proved quite successful when thoroughly tried. Sometimes also they may be driven from a field by dragging ropes through the grain, on which are tied newspapers or rags; when, however, they are tired with a long flight and are hungry from long fasting, this latter method is generally of little avail. In this State the young grasshopper is our worst enemy, our principal crop being wheat. The flying hosts seldom get here in time to injure it. When we came out here the old settlers told us they only had grasshoppers about once in seven years; that season being free from them seemed to lend weight to the statement. The next year bringing a pretty fair crop of them, they said they usually came every other year, but as we have had them every year since, they now say they generally stay about seven years in a place. Perhaps, after all, the "fourteen-year locusts" would be an appropriate designation; at least we look upon them as being a permanent investment, and make our plans to fight them always. We have a fair amount of eggs planted for next year's crop.

In Iowa the farmers spread hay or straw over the surface. "At night the young insects would gather under it, and immense numbers were burned up in this manner. Plowing is resorted to this fall (1876) in some localities for the purpose of covering the eggs deep, by which it is said they will rot. Other methods have been used, such as catching them, and machines have been invented for this purpose. Rolling the ground in the spring had also been suggested as a means for destroying the young insects." (Proc. Conference of Governors.)

Some important suggestions of a practical nature are contained in the following proclamation of the governor of Minnesota, here reprinted from the Grasshopper Conference pamphlet:

STATE OF MINNESOTA, EXECUTIVE DEPARTMENT,
Saint Paul, August 30, 1876.

The continued and increasing ravages of the locusts or grasshoppers in many of the Territories and States of the Union have been deemed sufficiently serious to warrant a meeting of the governors of such States and Territories for consultation, with a view to seek congressional aid, or otherwise secure combined action in resistance of the growing evil. Such conference has been called to meet in October. Meantime the widening area of the visitations of these insects in this State induces me without delay to urge the people whose interests are most directly involved, to assemble in public meetings in their several localities, for the purpose of collecting information, interchanging views, and devising plans of concerted action for the destruction of the insects, and for a common defense against their ravages. Both the correction of exaggerated reports, and the promotion of an intelligent apprehension of the actual evil to be encountered, it is believed, would result from this course, while the hope of thus attaining practical means of mutual protection certainly justifies a united and energetic effort in behalf of an object common to the public welfare.

It is the concurrent belief of all who have given close attention to the subject that it is practicable to destroy the pests in great measure or to insure a vast mitigation of the worst results, by the timely, concerted, and persistent efforts of the several communities directly concerned, and the employment of simple agencies readily available. To this end I have taken pains to collect, from the most reliable sources, information of the several modes which have been successfully employed, which I here detail for the consideration of all concerned, and I earnestly invoke the united and resolute action of the people in a manful defense against a common enemy:

First. The crushing of the insects by rollers and other implements, and the catching of them by bags and traps during the season of copulation or mating, when by reason of their stupid and inactive condition they may be destroyed in vast numbers. This is the first and vital step toward their destruction, and can be resorted to immediately, the insects being in the condition named from about the middle of August variously until the approach of cold weather.

Second. The plowing under deeply of the eggs and the thorough harrowing of the bare, dry knolls and other comparatively small, warm spots where the eggs are deposited, so as to dislodge them from their cells or pods, which destroys their germinating power. New breaking being a favorite resort for such egg deposits, this mode of destruction is readily available in the ordinary course of farm-work, for which purpose these operations should be delayed till as late a period in the fall as practicable.

Third. Co-operative action for the preservation of the prairie-grass until the proper season for its burning in the spring, by means of extended fire-guards along township boundaries or other large areas, to be accomplished by means of plowed strips or by wide parallel furrows and the careful burning of the intervening space. The burning of the grass thus preserved, when filled with the young grasshoppers in the spring, has been found to be a very effectual means for their wholesale destruction.

Fourth. The placing of loose straw on or near the hatching-places, into which the young insects gather for protection from the cold in early spring, where they may be destroyed by firing the straw at a proper time. To this end straw should be carefully saved and not needlessly destroyed at thrashing-time.

Fifth. The construction of deep, narrow ditches, with deeper pits at intervals, as a defense against the approaching insects in their infant condition. Into these the young, when comparatively helpless, accumulate in vast numbers and perish.

Sixth. The sowing of grain in "lands" or strips, fifty to one hundred feet wide, leaving narrow vacant spaces through which to run deep furrows and construct ditches into which the young grasshoppers may be driven and destroyed.

Seventh. The catching of the insects at various stages, and especially when young and comparatively inactive, by means heretofore employed, and by such improved instruments and processes as our experience may suggest.

Eighth. And, finally, the driving of the winged and matured enemy from the ripening grain by passing over it stretched ropes continually to and fro, aided by annoying smoke from burning straw or other smudges, and by loud and discordant noises made by striking tin vessels, and by shrieking and yelling with the voice, which are said to aid in disturbing the pests and inducing their flight.

Let the common enemy be thus fought at every stage of his existence and at every point of his attack. Each one of the modes here prescribed will doubtless aid to reduce the grand total of the annual destruction, while all of them, faithfully pursued in succession, together with other methods to be devised, it is confidently believed, will achieve substantial exemption from loss, or avert its saddest effects. But should all means fail, there will remain the consciousness of having made such helpful and assiduous attempts as deserved success.

The danger of weakening the habit of self-reliance among the people, as well as the difficulty of reaching the most worthy recipients of public aid, renders the distribution of seed-grain and other assistance heretofore extended to the sufferers of very questionable policy; and I feel it my duty to warn all persons against relying upon public aid of this character. Whatever action may be taken by the next legislature or by Congress should wisely contemplate future protection rather than indemnity for past losses, and, if practicable, should discriminate in favor of such as evince a disposition to help themselves. At all events, if aid or succor of any kind or from any quarter may reasonably be expected, it will be both better deserved and better employed after courageous and determined efforts shall have been made for self-protection.

J. S. PILSBURY, *Governor.*

At the grasshopper conference, Prof. C. D. Wilber made the following important suggestions regarding the remedial measures to be taken:

The objects sought to be attained by this meeting are two, viz:

1. The securing of national aid in prosecuting inquiries and research concerning the locusts in the distant or mountain regions, where they are said to originate, with a view of ascertaining such facts as may assist in exterminating them at their source or native haunts.

2. To discuss such plans as may be advisable in defending the localities now threatened by them during the coming year of 1877, or such regions as are now occupied by their eggs.

There is no doubt as regards the assistance sought for from the Government. The emergency is so great and applies to so many millions of inhabitants, and nearly one-half of our commonwealth, that our representatives and governors and others in authority will all unite in obtaining the aid needed to prosecute the scientific research referred to.

The subject which most concerns us is the adoption of any or all the successful means already known, or such as may be provided, for a general and systematic crusade against locusts next year.

It is not certain that we shall have the impending invasion in 1877. They may wholly disappear, as they did from Iowa in the spring of 1867, without doing any damage.

Within the last thirty days I have examined many thousands of the eggs in Southeastern Nebraska, and find a large proportion already destroyed. Those in the hard ground, such as roadsides, are best preserved; while those in soft ground, such as stubble corn-fields, or gardens, are to a very great extent carried away or consumed by some predatory insect. But whatever the results may be in the spring, it is wise meanwhile to disseminate among the people everywhere descriptions of every known device or remedy, whether mechanical or chemical, by which we may secure partial, if not good, average crops. The people are generally uninformed on this subject; they do not know what to do. Arm them with reliable facts, modes of destruction, and we will have a home army of millions of men, who will fight vigorously for their farms and gardens.

Those who understand these matters in Nebraska have succeeded in driving off hordes of these locusts and saving their crops. Governor Furnas, who last year lost heavily by them, has now no fear either as to his farm or nursery. "He has met the enemy and they are his." His modes are exceedingly simple, as he has explained them. Another man in this same county raised one hundred acres of wheat by making a ditch as a barrier against the creeping, unfledged locusts; the ditch sloping to the coming hosts, but steep on the other side.

One man, in Saline County, invented a long box and placed it on wheels, so that it would catch all the locusts as it approached them. By this means he saved his corn-field.

Another man, in York County, burned brimstone in a large pan with a long handle, and drew it through his corn-field after the flying locusts had taken the country, and he was successful in saving his entire crop.

Again, the Mennonites came to Nebraska in 1874, and when they saw the first invasion of locusts in August of that year did not mind them in the least; nor have they manifested any concern or alarm since. The reason is, the Mennonites were familiar with them in Russia, and knew how to fight them successfully.

Some of their modes, in addition to cutting ditches, are as follows: In the spring, as the locusts begin to appear, they are driven, by pushing them with brush or brooms, to the grass or prairie, which is set on fire—that is, just that portion of the prairie which has received the horde from the plowed field. The prairie-fire is then put out; and as they appear day by day, more locusts are driven to the grass, which is also burned, and so on until all have been destroyed.

When the locusts are coming in swarms from abroad, the Mennonites build small smoke-fires, with dry or damp straw or prairie-grass, making fires at intervals of a few rods over a forty or eighty acre field. These fires or smokes are kept until the locusts have passed over, and in this manner the crop is wholly or partly saved.

But it is necessary to familiarize the people with these cheap and simple modes of destruction; and while much can be done through the press, much more can be done by organizing the counties, towns, and districts or precincts into locust clubs, under the authority or direction of the governor of each State or Territory, who may send some competent person or persons over the State to assist in perfecting such organizations and selecting the most available men as local committees, who can receive and distribute such printed matter as the governor may, from time to time, forward for distribution. In this way a whole State may be thoroughly organized for the campaign, and the entire population will become enthusiastic in preparing for and carrying on this warfare.

For other useful hints and suggestions the reader is referred to an article "On the means of destroying the grasshopper," by V. Motschulsky, translated from the Russian by Prof. W. W. Turner, and published in the Smithsonian Report for 1858.

It has also been shown that the most young may be destroyed by good cultivation and a constant stirring of the soil. Swarms of winged locusts may be in part driven off by smudges, or in grain-fields by hitching a long rope to a horse and dragging it over the grain, thus disturbing the locusts and driving them off. But after all they are only driven from one field to another, and it is almost impossible to drive them off on an extensive scale. Among the more general preventive measures to be adopted on the plains and prairies of the West is the planting of forests on as extensive a scale as possible. Farms should be hedged in with growth of coniferous trees, willows, and perhaps the *Eucaliptus* can be planted on the plains of Colorado, Montana, and Dakota, while hard and pine trees can be planted in the State eastward of the plains. Mr. G. M. Dawson has clearly brought out the fact that extensive forests prove an effectual barrier to the flight of locusts, and in the Eastern States as well as California grasshoppers do not swarm as they do in the treeless plains and prairies of the West, the main cause, next to the climate, being undoubtedly the prevalence of extensive forests. As the far West becomes more thickly settled and trees become planted, the ravages of the locust will be checked and their breeding places disturbed and diminished. Meanwhile it may be suggested that the State and General Government should foster the planting of forests along railways and highways, and bounties should be given to aid in this direction. Farmers should co-operate through the medium of their granges and other organizations. Moreover, we believe the time has come in this country for legislation to promote co-operation among agriculturists in dealing with the locust, army and cotton worm, chinch-bug, canker and tent worms, and other injurious insects. The active and forehanded do not need the stimulus of legislation, but there are always enough idle and thriftless members of a farming as well as any other community who ought to be compelled to labor in common with their neighbors in resisting the attacks of injurious insects. When in one season, as in the summer of 1874, the country loses $50,000,000 from the attacks of the locust alone, the matter is sufficiently grave to attract the attention of legislatures. If education is compulsory and vagrancy is a legal offense, surely want of co-operation on the part of the few should be punishable by law. In my first annual report on the injurious and beneficial insects of Massachusetts, for 1871, I made the following suggestion in this direction:

While a few are well informed as to the losses sustained by injurous insects, and use means to ward off their attacks, their efforts are constantly foiled by the negligence of their neighbors. As illustrated so well by the history of the incursions of the army-worm and canker-worm, it is only by a combination between farmers and orchardists that these and other pests can be kept under. The matter can be best reached by legislation. We have fish and game laws; why should we not have an insect-law? Why should we not frame a law providing that farmers, and all owning a garden or orchard, should co-operate in taking preventive measures against injurious insects, such as the early or late planting of cereals to avert the attacks of the wheat-midge or Hessian-fly, the burning of stubble in the autumn and spring to destroy the joint-worm, the combined use of proper remedies against the canker-worm, the various cut-worms, and other noxious caterpillars? A law carried out by a proper State entomological constabulary, if it may be so designated, would compel the idle and shiftless to clear their farms and gardens of noxious animals.

State legislation has also lately been agitated by the Massachusetts Horticultural Society.

A large proportion of the breeding-grounds of the locust are situated on the Indian reservations. Could not the Indians be compelled to search for the eggs and bring them in to the Government posts and be paid in food and clothing? It would not, perhaps, be a difficult matter to compel them to collect both eggs and winged locusts, under the direction of Government officials, and thus habits of industry be fostered, and additional inducements thus be held out to keep them on their reservations.

Locusts may also be eaten as food. Millions of people in the Old World find locusts a nutritious and palatable diet; why should not the

Indians be induced to eat them? In times of famine could not the settlers be brought to store them up and eat them? From the writer's own experience locusts may be roasted and eaten with somewhat of a relish, and Professor Riley in his entomological reports has discussed this subject at length.

It is stated in the Bulletin Mensuel de la Société d'Acclimation, (August, 1875), that Dr. Morran, a physician at Douarnenez, in Finistère, has thought of utilizing the African locust as bait for the sardine-fishery in the maritime districts of the coast of Mancha and the Atlantic Ocean. The doctor hopes to substitute this new bait for that employed until now under the name of roe (rogne), and the price of which, always increasing, is injurious to the interests of French fishermen. The locusts cooked in salt water are dried in the sun and ground. The powder obtained seems to make as good bait as roe. It has a dark color like that of the pickled roe of Norway. It preserves all the nutritive qualities of the locust. It re-absorbs the pickle, and is fatty, unctuous, and soft to the touch. Besides, it falls to the bottom of the water, resembling the flesh of craw-fish, comminuted and dried fish, of which the sardines are very fond. The insect can be put up in different ways, as made into biscuit, pickled, salted, pressed, or dried in the sun. Different methods of preparation have been tried; cooked and salted, the insects can be piled up in cakes, so as to be easily packed and transported. They can also be thrown alive, pell-mell, into brine and pressed. The first of these methods is employed by the Arabs. The Society of Agriculture of Algeria recommends smothering the locusts in soes, then drying in the sun. The bait prepared in these different modes has been tried at Douarnenez with good results. The sardines bit at them eagerly. It appears that in the bodies of a great number of sardines there have been found on examination the remains of locusts which the fish had swallowed. This last fact, stated officially, has well satisfied the maritime population of Douarnenez.

This, possibly, opens up a new industry for the inhabitants of locust-ridden districts in the West, who can put up in locust-years large quantities of bait for the market East.

CONCLUSIONS.

In conclusion, we believe that the locust-years may in the future be predicted by our meteorologists, and Government attention should be directed to this subject, and special consideration on the part of our Weather-Signal Bureau and meteorologists should be given during the future to the study of meteorological cycles. Years of unusual heat and dryness, which are forerunners of locust invasions, may, we believe, in the future be predicted, and farmers warned, while State laws provide that in years of plenty, at least in the frontier States, stores of grain be amassed for a year of famine. Thus, by the predictions of locust-years, by the planting of forests, and the free use of the telegraph in heralding their migrations, and the publication in the newspapers of daily bulletins of their direction and progress, and when they are present the enforcement of territorial and State laws, as well as bounties for the eggs and young, we believe that millions of property will be saved to the country, and the intelligence and wisdom of the American people be evinced in the truly agricultural as it already has in the mechanical arts.

SUMMARY OF OUR PRESENT KNOWLEDGE OF THE LOCUST.

1. The eggs are laid an inch below the surface of the ground in July, August, and September, as the latitude varies; and the young hatch in April and May, becoming fledged in about seven weeks from early in June until the last, swarming from the first of July until last of September. Birds and insects eat the eggs and young, and a mite, Tachina fly, and hair-worms infest the adults.

2. While the Rocky Mountain locust occurs permanently on the eastern slope of the Rocky Mountains, on the high, dry plateaus between 4,000 and 7,000 feet elevation, the district liable to its periodical invasions is between latitudes 30° and 52°, and longitudes 102° and 93°. It occurs, though of smaller size, in California and New England, and probably in British America from the Atlantic to the Pacific.

3. Its migrations take place at irregular intervals during or after hot or dry seasons, when immense swarms are borne from the Rocky Mountain plateau by the prevailing westerly and northwesterly winds, sometimes 500 or 1,000 miles, into British America, Minnesota, Nebraska, Kansas, Missouri, and Texas, where they lay their eggs.

4. The progeny of the emigrant swarms return the following season in a general northwest direction for at least hundreds of miles, to near the original habitat on the plains.

5. The periodical invasions may after a while be predicted with more or less certainty should Government take measures to appoint suitable persons to observe them, or delegate the task to the Weather-Signal Bureau; meanwhile, by the use of the telegraph, the arrival of swarms may be announced several days in advance.

6. In years of plenty in the border States and Territories, grain should be stored up for use in locust-years.

7. Preventive measures, such as planting of forests along lines of railroads, around towns and extensive farms; the use of irrigation, oiling ditches and canals, bonfires and prairie-fires, rolling the soil, and collection of eggs; bounties to be paid by Government in the Territories, or by the local authorities in the States infested, for the egg-sacs.

8. Co-operation among farmers and others in resisting the attacks of insects to be enforced by proper legislation, both in the Territories and border States.

9. We still need more light on the natural history and migrations of the locust, and the United States Government should appoint entomologists, who should study the locust comprehensively for several years in succession. Local entomologists should be appointed for each Territory, and the border State legislatures should appoint salaried entomologists to further study and report on the locust, and serve for a term of years until the entire subject be studied, and the knowledge thus acquired be freely diffused among the agricultural community.

FURTHER INFORMATION NEEDED.

It may be found on subsequent examination that some, if not many, so-called facts and inductions from such facts given in this report are erroneous. Indeed, regarding the laws regulating the migrations of the locust, the greater the number of facts observed, and the greater the area of observation, the less certain seem the opinions already formed by entomologists. Repeated observations by reliable entomologists and the careful sifting of facts recorded by unscientific observers are needed before we can decide what is true and what is erroneous in the published accounts of the western locust.

The following points need to be especially studied and cleared up:

1. How early in the summer are the eggs laid in Minnesota?

2. The direction of flight and history of the newly-fledged swarms in Minnesota particularly, as well as in Texas and Indian Territory.

3. Is the supposed northwesterly return-flight of the locust from Nebraska, Kansas, and Missouri late in June an invariable occurrence, or do the swarms fly in other directions?

4. What is the fate of those early summer swarms; and (*a*) do they lay eggs in the region directly east of the Rocky Mountains, or (*b*) fly north into British America, or are they scattered on the plains midway between the border States and the Rocky Mountain plateau, and lay eggs for swarms which afflict the border States the following year; or (*c*) do they fail to reach favorable breeding-places and lay but few eggs?

5. The exceptions to the northwest direction of the migrations from the border States should be fully stated, and if there be such exceptions, the causes, local or meteorological, carefully inquired into.

6. Ascertain in Minnesota the length of time between the acquisition of wings and oviposition.

7. Make experiments on the vitality of the eggs. The eggs of the Europeo-Asiatic locust survive a temperature of —26° Fahr.

8. Do cold, wet springs and thawing and freezing late in the winter destroy the eggs?

9. Do the locusts always copulate immediately after acquiring wings?

10. Duration of the sexual act—(more than 20 minutes?)

11. How many times does the same female receive the male?

12. How many males will a single female receive?

13. How many females will a single male impregnate?

14. How many times does the same female lay eggs?

15. Does a female lay more than one packet of eggs?

16. Does a female lay more than one packet of eggs after a single impregnation?

17. State the average number of eggs laid in a packet.

18. State the number of days after copulation before the eggs are laid—(more or less than seven days?)

19. Does *Caloptenus spretus* copulate with other, and what, species; does it hybridize with other species, particularly *femur-rubrum*, or var. *atlanis?* Are the hybrids (if any are produced) fertile?

20. State observed (not estimated) rapidity of movement of swarms in the larval state, and whether they migrate in the morning or evening, or both?

21. After which molt do the young locusts begin to assemble in small flocks and mass with larger ones—after the first or second molt?

22. Do the young wingless locusts move and feed by night?

23. Do the swarms of winged locusts descend toward sunset, and at what time? At what time do they take wing in the morning?

24. Make careful observations as to the influence of the wind on their migrations. Are they wholly dependent on favorable winds to bear them on in the course they usually take, and do the locusts wait for favorable winds?

25. Ascertain western limits of *Caleptenus spretus*, and the range of its var. *atlanis*.

APPENDIX A.

Meteorological data afforded for this report by Bvt. Brig. Gen. A. J. Myer, U. S. A., Chief Signal-Officer.

Station and month.	1871.				1872.				1873.				1874.				1875.				1876.			
	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.
BISMARCK, MONT.																								
January																	—8.89	49.11	N	6468	7.92	53.6	NW	5319.3
February																	—5.88	59.25	N	5715	4.85	59.99	NW	5461.1
March																	15.29	59.94	SE	7512	13.06	56.75	N	6247.3
April																	33.95	65.65	NW	8549	40.3	48.63	NW	6571.1
May																	56.13	60.33	S	7480	56.0	51.6	SE	6280.5
June																	60.88	60.87	E	6186	61.4	50.08	NW	6989
July																	69.30	48.90	NE	5973	70.3	53.96	NW	5807.5
August																	66.24	59.57	NW	5727	68.0	59.16	NW	6654
September																	56.10	59.36	NW	5517.7				
October													41.3	51.9	N	6203	42.73	63.06	NW	7593.8				
November													18.1	63.2	N	5742	17.15	61.51	NW	6109.2				
December													15.58	57.59	N	5884	20.08	61.21	NW	5801.5				
BRECKENRIDGE, DAK.																								
January									2.3		NW	11030	2.6	80.1	SE	11285	—9.48	81.85	NW	6437	6.35	53.18	SE	10053
February									8.6		SE	10080	4.2	78.2	SE	8946	—7.94	80.21	NW	6889	4.3	77.5	NW	10574
March									16.4		SE	11770	15.1	80.2	NW	11293	14.69	82.55	SE	11906	10.5	79.0	N	10418
April					41.0		NW		35.0		N	9530	34.0	72.4	SE	9058	36.13	76.38	NW	8669	38.27	71.85	NE	10209
May					53.0		SE	10074	52.0		SE	7676	60.2	60.6	SE	9081	55.97	64.80	SE	8065	56.32	54.46	SE	10318
June					65.0		SE	7530	69.5		SE	7259	65.9	76.7	SE	8061	60.79	77.60	SE	8176	63.12	61.98	NW	10769
July					67.1		SE	5710	67.6	71.0	SE	7146	70.2	71.8	S	6084	67.69	69.53	N		70.92	64.26	SE	9993
August					65.1		SE	5905	67.0	80.0	SE	7504	67.8	77.9	SE	5708	63.76	75.37	SE	6439	67.65	71.21	SE	11323
September					58.3		SE	7435	49.1	75.0	NW	7522	57.7	71.4	S	6499	55.4	78.9	NW					
October					45.0		SE	8810	38.2	66.8	NW	8734	43.8	74.5	NW	7650	42.04	67.9	N	7490				
November					21.0		NW	9390	23.4	78.3	N	8764	21.4	81.7	NW	6923	18.31	74.77	SE	8463				
December					0.4		NW	8620	8.0	83.3	SE	7889	12.8	83.9	NW	7415	18.05	79.14	NW	10914				

Meteorological data afforded for this report by Bvt. Brig. Gen. A. J. Myer, U. S. A., Chief Signal-Officer—Continued.

Station and month.	1871.				1872.				1873.				1874.				1875.				1876.			
	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperatnre.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.
CHEYENNE, WYO.																								
January					26.6		NW	8743	24.6		NW	8905	30.4	46.6	W	9239	12.5	66.3	W	8485	23.8	58.0	W	
February					30.9		W	8659	25.0		W	7420	22.9	52.6	W	6028	25.6	63.2	W	9057	30.7	44.6	W	11531
March					33.0		NW	6935	39.7		W	9313	28.9	55.2	W	6023	24.3	62.6	W	11984	26.8	65.6	NW	10100
April					38.3		W	8639	34.4		NW	8015	39.0	50.3	W	6130	36.9	60.6	NW	11112	42.4	44.8	W	10043
May					52.0		N	7300	49.2		W	6465	56.6	42.4	W	7588	54.7	42.5	W	9780	50.6	55.6	W	9259
June					51.5		W	6660	69.5		W	5266	65.2	39.5	W	6403	63.7	32.7	W	9332	60.8	39.1	W	7878
July					64.5		W	6675	69.7	39.6	W	5584	71.8	43.4	S	6521	64.0	58.4	S	6094	72.3	35.0	S	8483
August					65.1		W	5786	69.2	43.1	W	5548	68.6	39.2	W	6621	63.2	52.0	NW	6382	66.5	38.0	NW	7870
September	59.0		NW	5560	55.6		NW	5975	55.9	38.4		5437	54.2	42.5	W	7374	56.0	57.3	NW	6425				
October	46.0		W	8004	45.2		NW	4973	42.5	47.0	W	6390	46.7	58.2	NW	6704	47.9	40.4	NW	8469				
November	28.9		NW	7940	28.2		W & NW	8276	40.1	39.2	W	7010	35.8	51.8	W	9215	30.3	62.9	W	7539				
December	28.0		W	9830	23.4		W	6306	27.6	54.1	W	5753	29.1	52.9	W	8618	33.4	51.4	NW	4049				
COLORADO SPRINGS.																								
January													30.3	47.0	NW	5306	19.1	63.7	SE	5529	28.22	39.48	N	5133
February													25.5	63.0	N	4402	29.2	73.44	SE	4126	34.97	35.21	N	5271
March													34.5	50.0	SE	5614	30.43	53.45	N	5984	33.5	45.3	N	7522
April													38.5	54.0	N	5012	41.57	53.56	N	6894	46.5	40.2	SE	6553
May													58.6	40.0	N	5933	57.3	45.3	S	5623	54.9	45.1	SE	6938
June													68.9	38.0	S	6097	67.86	42.26	S	6119	64.0	43.4	N	5792
July													73.2	43.0	NW	5464	64.6	68.3	SE	4483	72.0	47.8	N	5479
August													70.3	43.0	NW	4701	65.3	63.4	N	4237				
September													56.7	46.0	SE	5307	57.9	64.4	N	4407				
October													49.9	50.0	SE	5152	51.3	48.0	N	4583				
November									37.4	42.6	N		37.9	45.5	SE	5137	37.1	55.9	SE	4440				
December									42.7	42.7	N	4030	28.1	54.9	N	4428	35.4	44.0	N	5679				

DAVENPORT, IOWA.																								
January					23.0		WSW	8412	17.1		NW	6104	23.7	82.6	W & NW	5806	9.4	83.5	W	5501	29.79	75.52	SW	7917
February					27.8		NE	6884	23.9		NW	6511	25.9	83.0	W	5429	10.9	86.0	W	4805	29.93	70.52	NW	7117
March					33.3		NW	6630	36.7		NW	9541	34.7	74.5	NW	8469	30.4	78.8	W	6706	32.17	73.61	NW	8485
April					50.9		SW	8125	46.9		SW	6645	41.6	64.8	NE	7752	46.3	60.5	W	7385	51.16	59.05	SW	8917
May					61.5		NW	7020	59.6		NE	5922	64.5	58.2	SW	7873	60.9	61.9	E	6536	62.44	63.03	SW	6305
June					73.2		SW		77.9		SW	4386	73.2	68.3	SW	6126	68.6	71.4	NW	5514	69.43	70.91	SW	6320
July					76.3		NW	4680	75.6	63.0	SW	4711	78.0	63.9	SW	5841	74.0	73.3	E	3770	75.89	69.61	SW	4804
August					74.6		SW	4860	78.0	57.0	SW	4426	74.4	67.5	E	5844	69.89	69.01	S	4518	74.94	68.43	SE	4611
September	61.4		SSE	5050	64.6		SW	6690	62.3	62.1	SW	6314	65.5	74.0	SW	5147	61.7	70.47	SW	5917				
October	54.4		SW	6960	52.1		NW	4229	48.3	61.5	NW	5906	52.5	70.8	NW	5654	48.85	62.21	SW	6831				
November	33.6		ENE	6445	32.9		W	6453	34.6	72.6	NW	6332	36.4	73.8	NW	6659	33.51	67.66	NW	6228				
December	20.5		WSW	6159	18.7		NW	6010	29.7	82.0	NW	5719	27.9	81.8	W	5654	34.54	75.62	NW	7172				
DENVER, COLO.																								
January					23.8		S	3696	30.0		NW	4720	31.5	51.5	S	4576	16.79	56.3	N	4131	28.3	40.5	SW	3389
February					33.7		S	4600	30.3		N	3558	24.7	63.9	S	2864	32.27	46.6	NE	4146	37.7	38.77	S	4519
March					36.32		S	5097	44.0		S	5318	36.4	59.6	NE	4238	33.44	48.4	SSW	6150	34.42	52.69	N	5825
April					46.16		N	6276	39.88		N	4761	43.1	54.4	S	4209	44.53	46.8	N	5135	49.34	38.36	S	5071
May					57.7		N	3879	53.31		NE	3744	61.9	41.6	S	6159	60.23	38.42	S	5038	57.06	42.07	N	5193
June					67.28		S	3815	68.93		S	4193	70.0	41.1	S	5022	70.37	28.0	S	4056	65.85	36.63	S	4382
July					69.28		S	3313	71.46	45.0	S	4213	76.1	42.2	S	4932	68.07	55.67	S	4160	76.40	38.63	S	4251
August					69.79		S	3246	70.85	49.0	S	3793	73.0	44.3	S	4349	68.97	46.67	S	3887	70.08	42.30	S	4132
September					60.05		S	3034	59.79	45.0	S	3294	59.0	43.7	S	4144	61.7	51.3	S	3782				
October					50.03		S	2962	45.21	51.0	S	3855	52.9	54.5	NE	3889	54.14	33.45	S	3737				
November					32.51		S	3586	40.6	43.0	S	4331	42.2	42.7	S	5371	37.3	59.8	S	3104				
December	29.12		S.	5193	27.60		S	2693	22.4	59.0	S	3032	29.7	56.5	S	3732	37.8	43.8	S	4283				
DODGE CITY.																								
January																	13.2	63.8	N	5126	35.3	55.7	S	7714
February																	29.8	72.3	NW	4098	41.5	48.1	W	9236
March																	38.1	59.8	N	8212	34.7	73.2	N	11571
April																	47.9	63.9	N	9118	56.6	59.3	N	10923
May																	65.4	62.7	N	8201	64.5	58.9	E	12010
June																	75.4	58.5	S	8269	71.2	51.6	SE	11333
July																	75.5	67.1	NE	6766	79.6	62.1	SE	11311
August																	74.6	66.6	S	6021	77.2	64.1	S	11196
September																	68.7	62.7	S	6462				
October													60.7	55.3	NW	5057	56.6	52.9	SW	6491				
November													38.4	60.4	NE	3110	39.9	53.0	N	8627				
December													34.2	67.4	S	3188	40.7	58.4	W	7565				
FORT GIBSON.																								
January													39.5	71.1	E	7068	27.7	68.7	N	4855	45.4	65.3	SE	6444
February													41.3	69.3	E	5564	38.7	62.2	S	6591	47.6	57.8	SE	7354
March													52.2	65.7	E	7109	47.7	57.3	SE	8902	44.4	62.8	SE	9540
April									56.2		SE	8670	53.0	62.2	N	8361	56.7	56.8	NW	7486	63.4	53.7	SE	7356

Meteorological data afforded for this report by Bvt. Brig. Gen. A. J. Myer, U. S. A., Chief Signal-Officer—Continued.

Station and month.	1871.				1872.				1873.				1874.				1875.				1876.			
	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.	Mean temperature.	Mean relative humidity.	Prevailing wind.	Total movement.
FORT GIBSON–Cont'd.																								
May	......	......	......	......	......	......	......	......	67.6	......	E	6312	70.3	63.8	SE	6718	67.6	68.1	SE	6305	69.6	65.8	SE	6286
June	......	......	......	......	......	......	......	......	70.6	......	SE	4248	78.6	67.9	SE	5471	77.9	68.0	S	6162	73.6	69.9	W	5861
July	......	......	......	......	......	......	......	......	80.7	67.0	SE	5138	83.1	61.2	SE	4557	80.0	75.0	S	4385	81.0	72.0	E	4057
August	......	......	......	......	......	......	......	......	78.8	61.9	E	3358	86.1	48.4	E	5630	74.6	75.7	SE	3763	81.4	67.6	SE	4460
September	......	......	......	......	......	......	......	......	70.2	69.6	SE	5390	71.5	67.9	SE	5265	......	......	......	......	......	......	......	......
October	......	......	......	......	......	......	......	......	56.9	61.9	E	5410	60.9	65.5	SE	4299	57.7	61.5	SE	5258	......	......	......	......
November	......	......	......	......	......	......	......	......	49.8	58.3	NW & E	11335	50.7	68.7	SE	6685	49.4	64.0	N	5948	......	......	......	......
December	......	......	......	......	......	......	......	......	40.6	75.7	E	6139	43.4	73.0	SE	5659	48.4	61.2	S	6325	......	......	......	......
FORT SULLY, DAK.																								
January	......	......	......	......	......	......	......	......	9.6	......	NW	6160	16.1	61.6	NW	6758	0.1	61.9	NW	6948	18.7	64.6	NW	7128
February	......	......	......	......	......	......	......	......	14.7	......	E	6506	20.3	63.9	SE	5032	4.2	65.3	NW	6818	14.4	76.0	NW	7356
March	......	......	......	......	......	......	......	......	32.4	......	NW	9310	27.7	59.1	NW	8603	22.3	73.4	SE	9078	15.9	78.3	N	9365
April	......	......	......	......	......	......	......	......	41.5	......	NW	10500	43.9	41.5	NW	8081	39.2	66.1	N	9265	......	......	......	......
May	......	......	......	......	58.3	......	NW	8110	54.5	......	E	9200	63.2	51.3	SE	9152	60.1	59.7	NW	7638	61.7	53.2	SE	9761
June	......	......	......	......	70.3	......	SE	8250	74.2	......	SE	6900	70.2	63.2	SE	7652	66.0	59.7	SE	9312	68.1	52.0	NW	9332
July	......	......	......	......	73.5	......	SE	7425	74.3	49.0	SE	9010	79.2	40.7	SE	8674	73.9	54.7	SE	6189	75.6	58.6	SE	10173
August	......	......	......	......	72.2	......	SE	8720	75.5	51.6	ESE	9346	76.1	49.1	SE	8830	71.4	51.2	N	7887	73.1	60.7	SE	8476
September	......	......	......	......	62.4	......	NW	8810	57.3	46.8	NW	7896	65.2	39.7	SE	7152	61.3	54.9	N	6753	......	......	......	......
October	......	......	......	......	52.3	......	NW	6990	42.1	53.2	NW	8546	50.9	49.4	SE	7290	48.9	53.2	S	7937	......	......	......	......
November	......	......	......	......	24.5	......	NW	8160	35.1	57.2	NW	6970	26.2	67.6	NW	6438	24.4	63.3	NW	7968	......	......	......	......
December	......	......	......	......	11.5	......	E	6990	14.9	62.9	NW	5197	26.9	62.8	NW	6579	27.0	73.6	NW	6605	......	......	......	......
KEOKUK, IOWA.																								
January	......	......	......	......	25.8	......	W	6593	17.6	......	W	5464	27.8	79.7	NW	6610	16.7	76.3	NW	6337	34.1	73.2	NW	7922
February	......	......	......	......	30.4	......	SE	4827	26.1	......	NW	5018	29.4	79.7	N	5249	18.1	71.6	NW	5955	35.0	67.6	NW	7670
March	......	......	......	......	35.0	......	NW	6230	38.7	......	NW	7676	38.3	70.5	N	7674	34.1	68.9	SE	7452	34.9	72.8	NW	8016

April					53.9		NW	6971	48.5		NW	7181	44.6	63.0	NNE	7681	49.5	60.3	W	7341	53.0	59.4	SE	8827
May					64.5		W	5525	61.5		E	7026	67.2	58.3	S	6608	62.9	62.5	SE	6940	63.9	62.5	S	6852
June					75.2		S	4427	77.9		SE	4338	76.7	69.3	SW	5145	71.4	72.2	SE	5545	70.1	72.4	NW	6204
July					78.6		NW	3716	76.3	68.4	SE	4583	80.5	60.9	SW	4114	76.3	75.8	SW	3546	76.5	74.0	E	5059
August					77.3		S	4117	78.7	59.2	SW	3596	76.8	67.9	E	4979	71.6	70.5	S	4909	76.2	71.5	S	4842
September	63.4		NE	4333	68.2		S	5541	63.9	65.8	NW	5576	67.1	76.0	S	4651	64.3	68.6	S	4819				
October	57.3		S	5477	55.5		SW	5064	49.8	66.9	NW	5424	55.7	68.2	NW	5215	51.1	62.1	SW	5583				
November	30.5		NW	5684	34.6		W	5157	38.9	66.3	NW	6753	40.2	67.7	S	6933	35.3	67.0	N	5694				
December	25.8		NW	6274	20.5		NW	4276	32.0	79.6	W	6424	31.6	77.4	NW	5931	36.5	77.6	NW	6240				
LEAVENWORTH, KANS.																								
January					25.0		NW	5533	19.0		N	5147	28.4	67.0	S	2960	16.7	69.5	NW	4812	35.4	71.0	S	6534
February					30.9		NW	4301	30.0		NW	5614	28.8	72.3	S	4243	22.3	74.5	NW	4626	38.3	60.5	S	7126
March					37.0		NW	6068	42.1		S	8047	40.0	70.4	N	5924	37.6	60.2	NW	5731	35.16	72.6	NW	7862
April					56.2		SW	6595	48.6		N	7804	49.0	62.1	N	6280	49.8	55.2	NW	5640	55.24	60.9	S	7025
May					65.6		SW	5174	63.0		S	5442	67.3	60.0	S	5632	65.8	57.6	S	5644	65.5	64.9	S	6475
June					77.2		SW	5411	75.5		S	4468	77.4	69.5	S	4872	76.7	58.8	S	5778	71.2	66.0	S	
July					78.4		SE	3051	77.5	61.0	S	4902	82.8	59.5	S	4698	77.6	73.7	S	3401	78.9	69.7	S	3440
August					78.4		SE	2839	79.2	54.6	S	3869	81.3	56.0	S	4522	73.1	69.5	S	4223	78.2	69.8	S	3226
September	66.7		E	3662	67.7		SW	4423	65.4	58.0	S	5672	66.8	70.0	S	4286	66.6	66.8	S	4298				
October	56.9		W	4787	56.4		SE	3537	56.9	50.7	S	6040	57.0	67.0	S	4271	53.6	59.8	S	5245				
November	38.0		NW	4896	35.0		NW	6569	41.8	54.3	N	6095	40.0	65.8	S	5758	37.3	62.2	N	5228				
December	24.2		NW	5253	21.0		N	5199	31.9	68.0	N		32.7	70.8	S	4442	39.9	68.0	S	5522				
NORTH PLATTE, NEBR.																								
January																	7.41	70.01	NW	5493	23.6	65.0	SW	4110
February																	21.31	72.68	NE	5000	32.4	54.8	NW	5466
March																	33.19	61.36	NW	8254	27.9	68.2	SE	6607
April																	42.17	66.16	NW	7604	50.3	53.5	SE	7563
May																	61.32		SE	7601	59.6	57.5	SE	7978
June																	69.92	56.69	SE	6954	67.9	42.9	N	7333
July																	72.5	66.4	NE	3518	76.3	53.9	SE	12243
August																	71.7	59.2	SE	4797	72.8	58.9	SE	11239
September																	62.5	60.0	SE	4643				
October													52.4	64.5	NW	5683	53.4	55.4	NW	4991				
November													35.7	58.9	SW	6230	31.5	67.8	SE	4479				
December													28.3	70.1	NW	5044	34.0	64.3	NW	4294				
OMAHA, NEBR.																								
January					19.0		NW	6000	16.9		N	6424	22.3	78.1	S	7447	16.1	75.9	NW	7438	26.8	73.7	S	7317
February					27.5		NW	4045	26.9		NW	5815	23.4	78.7	NNW	4782	13.8	85.5	N	6904	30.1	66.1	NW	8359
March					31.0		NW	5160	38.2		S	8895	33.8	70.7	N	6746	30.5	72.6	NW	9353	29.3	80.0	NW	7683
April					51.0		SE	5820	44.2		NW	8586	45.1	55.5	N	6838	45.4	60.0	N	8290	51.3	62.7	S	7853
May					61.0		SSE	4850	59.0		N	6556	66.6	54.8	S	7201	63.2	58.4	SE	7134	63.6	61.6	S	7935
June					72.7		SSE	4645	74.4		S	5623	73.2	68.8	S	7074	71.1	70.9	S	6229	68.6	63.7	N	7156
July					77.0		SE	3958	75.7	74.2	S	6074	80.0	60.9	SSW	6084	74.4	75.3	SE	4246	75.1	74.1	S	5605
August					75.6		SSE	4521	77.1	72.7	S	4687	77.3	63.8	S	5137	70.2	74.5	S	6350	75.4	73.7	S	5516
September			SE	4250	62.8		SE	5244	60.6	64.2	S	6209	63.0	71.8	S	5696	62.9	74.6	S	5958				
October	52.4		SE	5540	53.0		S	4282	48.5	62.4	NW	7671	54.0	63.8	N	6435	49.6	66.5	S	7611				
November	31.0		NW	6521	30.6		NW	6798	38.5	58.0	NW	8112	36.0	64.8	N	7994	32.6	70.4	N	7313				
December	16.0		NW	5651	19.0		N	5874	25.2	80.8	NW	6199	28.4	74.6	S	6905	33.5	69.8	NW	6737				

Meteorological data afforded for this report by Bvt. Brig. Gen. A. J. Myer, U. S. A., Chief Signal-Officer—Continued.

Station and month.	1871. Mean temperature.	1871. Mean relative humidity.	1871. Prevailing wind.	1871. Total movement.	1872. Mean temperature.	1872. Mean relative humidity.	1872. Prevailing wind.	1872. Total movement.	1873. Mean temperature.	1873. Mean relative humidity.	1873. Prevailing wind.	1873. Total movement.
SAINT PAUL, MINN.												
January	15.9	...	...	...	15.1	...	NW	3650	6.7	...	NW	5917
February	22.3	...	...	...	20.3	...	SE	5250	14.3	...	SW	5438
March	32.0	...	...	...	21.9	...	NW	4930	26.7	...	NW	7100
April	54.4	...	...	...	45.1	...	SE	6920	41.9	...	NNW	5192
May	64.0	...	...	...	55.2	...	W	7120	55.1	...	N	5678
June	67.4	...	...	...	67.9	...	SE	5980	73.0	...	SE	5935
July	71.3	...	...	...	71.2	...	S	4610	71.0	68.7	SE	4944
August	68.5	...	...	...	69.2	...	S	5480	70.7	72.9	SE	5125
September	61.6	...	SE	4575	57.6	...	...	6244	54.1	83.3	NW	6719
October	47.3	...	NW	4845	47.2	...	SE	5984	41.3	69.8	NW	7097
November	27.8	...	N	4450	23.8	...	NW	5729	25.6	76.5	NW	6142
December	9.9	...	SW	4435	...	...	...	...	18.6	78.3	SW	5903
SANTA FÉ, N. MEX.												
January	...	...	...	...	27.0	...	N	4104	29.0	...	N	5181
February	...	...	...	...	34.0	...	N	4664	32.0	...	SW	4773
March	...	...	...	...	38.8	...	N	4640	44.0	...	SW	5335
April	...	...	...	...	45.8	...	SW	6065	44.0	...	N	5816
May	...	...	...	...	58.1	...	N	4730	56.0	...	SW	5449
June	...	...	...	...	66.9	...	SW	3855	65.6	...	N	5050
July	...	...	...	...	67.6	...	NE	3607	71.0	...	SE	5796
August	...	...	...	...	67.0	...	S	3430	66.0	55.0	SW	5013
September	...	...	...	...	60.0	...	SE	3231	61.0	41.0	SW	4562
October	...	...	...	...	49.0	...	SE	3131	51.0	35.1	E	4799
November	...	...	...	...	33.0	...	N	4040	41.1	32.0	N	3594
December	34.3	...	N	2551	32.6	...	N	4116	25.8	54.0	N	5675

Station and month.	1874. Mean temperature.	1874. Mean relative humidity.	1874. Prevailing wind.	1874. Total movement.	1875. Mean temperature.	1875. Mean relative humidity.	1875. Prevailing wind.	1875. Total movement.	1876. Mean temperature.	1876. Mean relative humidity.	1876. Prevailing wind.	1876. Total movement.
SAINT PAUL, MINN.												
January	13.8	74.8	SE	6747	—2.35	75.04	SW	5151	16.59	74.02	NW	5880
February	14.4	73.0	SE	4489	—1.76	70.92	NW	5589	17.3[illegible]	73.35	NW	6258
March	23.7	70.4	NW	7585	22.00	75.93	SE	6968	24.26	72.78	NW	6469
April	37.5	55.6	N	6840	39.73	61.01	NW	6879	43.93	56.58	NW	7286
May	62.2	52.6	N	7899	53.81	53.97	SE	6724	59.16	58.99	SE	6800
June	68.7	71.2	SE	6889	63.59	67.58	SE	6735	66.27	65.09	NW	6604
July	74.7	66.5	SE	6004	73.81	63.93	NW	4534	...	...	SE	5141
August	70.5	73.4	SE	5833	66.6	70.98	SE	5632	69.9	71.8	SE	5992
September	60.9	72.8	SE	6397	57.24	74.59	SE	4864	...	...	...	...
October	49.4	68.9	NW	6551	42.79	67.89	NW	5750	...	...	...	...
November	28.7	75.6	SE	7339	25.19	68.48	SE	6113	...	...	...	...
December	18.8	75.6	NW	6270	25.49	78.09	SE	6178	...	...	...	...
SANTA FÉ, N. MEX.												
January	31.0	60.5	N	5717	28.1	51.1	N	4724	29.0	46.8	NE	4878
February	27.8	62.0	NW	5083	31.4	48.4	N	5796	32.8	38.7	NW	5796.5
March	36.2	48.1	SW	5621	34.4	36.3	SW	7364	36.5	45.1	SW	7464.4
April	42.1	35.8	E	5945	47.4	24.1	SW	6820	50.2	40.9	SW	6122.8
May	59.8	23.1	E	7391	59.2	25.3	SW	7405	55.9	42.1	SW	6818.5
June	69.3	19.5	SW	...	67.9	19.8	SW	6933	66.0	46.7	SW	6569.8
July	71.1	37.9	E	5286	65.2	54.9	SW	5437	69.2	64.6	E	5281
August	69.9	39.7	SW	5731	66.5	46.8	SW	5688	65.2	67.9	SW	4909
September	60.5	38.7	E	5163	58.7	56.1	SW	4879	...	...	...	...
October	52.3	42.3	SW	5187	53.5	23.7	E	5503	...	...	...	...
November	38.7	47.4	N	5525	38.7	54.1	SW	4587	...	...	...	...
December	29.2	44.5	N	4611	32.6	47.7	N	5630	...	...	...	...

YANKTON, DAK.																								
January	......	......	......	......	......	......	......	......	......	......	......	......	15.6	68.0	NW	8679	0.6	68.9	NW	6896	18.87	62.8	NW	6652
February	......	......	......	......	......	......	......	......	......	......	......	......	18.8	69.0	NW	5811	2.5	72.8	NW	6098	20.77	61.48	NW	7601
March	......	......	......	......	......	......	......	......	......	......	......	......	30.6	71.0	NW	8071	23.7	74.5	NW	9366	20.39	75.5	NW	8142
April	......	......	......	......	......	......	......	......	40.09	......	N	12823	44.4	50.0	NE	8143	40.4	66.0	NW	7992	46.71	61.93	NW	8532
May	......	......	......	......	......	......	......	......	54.19	......	NE	11465	62.1	53.0	S	9654	61.2	58.8	NW	7253	61.58	61.71	SE	8653
June	......	......	......	......	......	......	......	......	72.56	......	S	8956	70.7	67.0	SE	5719	66.1	72.2	SE	6059	65.66	61.22	NW	6999
July	......	......	......	......	......	......	......	......	74.68	75.8	S	6706	78.2	59.0	SW	6072	71.8	74.3	SE	3252	73.29	72.47	S	5997
August	......	......	......	......	......	......	......	......	77.08	74.6	E	6212	74.2	69.0	SE	5980	68.3	72.0	SE	5088	72.05	70.87	SE	6254
September	......	......	......	......	......	......	......	......	60.4	72.3	NW	6222	61.7	68.0	NW	5684	60.57	75.58	NW	5490	......	......	......	......
October	......	......	......	......	......	......	......	......	46.1	75.9	NW	......	49.4	63.0	NW	6891	47.18	63.4	NW	6460	......	......	......	......
November	......	......	......	......	......	......	......	......	35.9	59.0	NW	7916	30.4	67.0	NW	6982	25.89	63.8	NW	6715	......	......	......	......
December	......	......	......	......	......	......	......	......	18.1	70.0	NW	6785	23.0	67.8	NW	6382	27.35	63.31	NW	5260	......	......	......	......

THE EASTERN RED-LEGGED LOCUST, *Acrydium femur-rubrum* De Geer; *Caloptenus femur-rubrum* White (Plate LXII, Fig. 5 *b*).—A medium-sized grasshopper, the male differing chiefly from the male *spretus* in the end of the abdomen not being notched, but rounded and much blunter; ranging from Labrador and Canada to the Pacific Coast, including the border States and the Mississippi Valley, not extending south of latitude 35°, occasionally in dry seasons becoming very destructive and gathering in local swarms, but not commonly migrating far from its breeding-place.

All that has been published in regard to the breeding-habits of the eastern red-legged locust is the following passage in Harris's Treatise on the Injurious Insects of Massachusetts: "It comes to maturity with us by the latter part of July; some broods, however, a little earlier, and others later. It is most plentiful and destructive during the months of August and September, and does not disappear till some time in October." Of the larva and its habits we have nothing on record, but it is probable that it hatches late in May and early in June, and as the latitude varies becomes winged in seven or eight weeks or sooner. I have observed the locusts copulating and laying their eggs at Amherst, Mass., during the middle and last of September, after the first frosts, and they continue doing so into October. While they oviposit in the soil of upland meadows and hay-fields, they are more commonly seen in hard gravelly paths in company with *Œdipoda*, *Sordida*, and *Carolina*, and other grasshoppers. Having put a few into a glass jar partly filled with dirt I was able to observe the process.

I placed several *C. femur-rubrum* under glass in a vessel filled with gravelly soil. The insect in boring into the ground brings the end of its abdomen forward so as to be nearly perpendicular to the rest of the body. The end of the abdomen, armed with its stout spines, is then slowly thrust down, not being retracted during the operation unless the insect is disturbed. The hole thus made is not over an inch deep and about one-fifth of an inch in diameter. Plate LXIV, Fig. 4, represents this species after the hole has been made. The size and form of the egg-sac and eggs is shown on the right of the figure. It is 15 millimeters long and 5 millimeters in diameter, the eggs being shown through the thin wall of the sac, which in those I have seen is thinner and lighter than in *C. spretus*, the amount of the spongy substance secreted by the insect being perhaps less. I have ventured to represent a mass of this glutinous matter coming from the body of the female. It is possible that the drawing (made by Mr. Emerton, from a sketch made by myself from life) is incorrect in this particular. The spongy glutinous substance (probably a modified silky secretion) may be deposited in part at first and the eggs arranged in it, passing out of the end of the oviduct singly.* The cockroach ejects her eggs all at once and contained in a sac. In the egg-sacs which I observed the eggs were not arranged so regularly as in those of the Rocky Mountain locust. During the process the abdomen is nearly half longer than usual and greatly distended. The eggs are curved cylindrical, of the same form as in *C. spretus*, but considerably smaller, being 4 millimeters in length. The chorian is pitted in the same manner, and there is a similar constriction at the posterior end.

In *Œdipoda sordida* the egg-mass is 14 millimeters long and 5 millimeters in diameter. The eggs are of the usual size and 5 millimeters in length.

From Mr. S. J. Smith's description (Proceedings of the Portland Society of Natural History) of the mode of oviposition in *Choëaltis con-*

* Mr. W. S. Dallas thinks that the glutinous mass is first produced by the insect, and the eggs afterward laid in it. (Zoölogical Record for 1867.) Further observations are necessary to determine this point; they can (p. 460) easily be made, however.

spersa, it would appear that the eggs are probably laid singly, and that the glutinous substance which afterward becomes spongy and hard is exuded before and during the extension of the eggs, which are each arranged with more or less care so as to pack most closely, forming a cylindrical egg-mass. By means of the anal appendages the female excavates in soft, rotten wood a smooth round hole about an eighth of an inch in diameter. The eggs are placed in two rows, one on each side, and inclined so that, beginning at the end of the hole, each egg overlies the next in the same row by about half its length. The aperture is closed by a little disk of a hard, gummy substance. While boring their holes a frothy fluid is emitted from some part of the abdomen; but whether it serves to soften the wood or to lubricate the appendages and the sides of the hole, I did not determine.

When the hole is made and while the eggs are being deposited, the female sits with her body inclined at a low angle, the ends of the folded wings resting on the ground, and the fore and middle pair of feet in their usual position, the body being mainly supported by the hind legs, which are placed as drawn in the figure, resting firmly on the ground, not elevated as in Riley's figure of *C. spretus*. A female in confinement, September 24, at Amherst, Mass., was observed at 2 p. m. with its abdomen deeply inserted in the soil; at 3.10 p. m. it began to withdraw with much deliberation its abdomen; it stopped during the process of extraction, having withdrawn its abdomen about a quarter of an inch out of the hole; at 3.20 p. m. it entirely withdrew its abdomen. It had laid twenty eggs, naked, in a mass, not having deposited around them any appreciable amount of glutinous matter, though the dirt formed a partial covering for it. This female lived several days after, when I killed it to examine the ovaries, in which were fifteen ovarian eggs from one-third to one-half the size of the ripe eggs.

Another *C. femur-rubrum* was observed in the act of laying for a hour and a half, but the beginning and end of the process was not observed. It seems probable from these observations that the process requires at least more than two hours, and this being the case it is possible that the eggs are laid singly, otherwise the mass might be deposited at once, in a few minutes. During the process the females are not easily disturbed.

Several *Œdipoda sordida* and *carolina* were observed laying in the gravelly walk which I frequented every day for a week or fortnight. An *Œ. sordida* in confinement was observed beginning to bore its hole, pushing the dirt backward and forward with its spines on the abdomen. The duration of the process of copulation not observed.

Dr. Harris has collected, in passages often quoted, the accounts of their ravages in Northern New England during the last century. They appeared most frequently in Maine and were alarmingly abundant in the summers of 1743, 1749, 1754, 1756; in Vermont, in 1797, 1798. They were not afterward noticed by local historians until 1821 or 1822. I condense the following account, the best we can get here, of their migrations, by Dr. N. T. True, communicated to Mr. S. H. Scudder and published in full in the "Final Report of the United States Geological Survey of Nebraska," &c., by F. V. Hayden, 1872. The year 1821 or 1822 was an unusually dry season during the summer months. They devoured the clover and herds-grass, and even nibbled the rake and pitchfork handles made of white ash. "As soon as the hay was cut, and they had eaten every living thing from the ground, they removed to the adjacent crops of grain, completely stripping the leaves; climbing the naked stalks, they would eat off the stems of wheat and rye just below the head, and leave them to drop to the ground. * * * * Their next attack was upon the Indian corn and potatoes. They stripped the leaves and ate out the silk from the corn, so that it was rare to harvest a full ear. Among forty or fifty bushels of corn spread out in the dry-room, not an ear could be found not mottled with detached kernels. While these insects were more than usually abundant in the town generally, it was in the field I have described that they appeared in the greatest intensity. After they had stripped everything from the field they began to emigrate in countless numbers. * * * * They crossed the highway and attacked the vegetable-garden. I remember the curious appearance of a large, flourishing bed of red onions, whose tops they first literally ate up, and, not contented with that, devoured the interior of the bulbs, leaving the dry external covering in place. * * * * The leaves were stripped from the apple-trees. They entered the house in swarms, reminding one of the locusts of Egypt, and as we walked they would rise in countless numbers and fly away in clouds. As the nights grew cooler, they collected on the spruce and hemlock stumps and log fences, completely covering them, eating the moss and decomposed surface of the wood, and leaving the surface clean and new. They would perch on the west side of a stump where they could feel the warmth of the sun, and work around to the east side in the morning as the sun reappeared. The foot-paths in the fields were literally covered with their excrements.

"During the latter part of August and the first of September, when the air was still dry, and for several days in succession, a high wind prevailed from the northwest, the locusts frequently rose in the air to an immense height. By looking up at the sky in the middle of a clear day, as nearly as possible in the direction of the sun, one may descry a locust at a great height. These insects could thus be seen in swarms, appearing like so many thistle-blows as they expanded their wings and were borne along toward the sea before the wind; myriads of them were drowned in Casco Bay; and I remember hearing that they frequently dropped on the decks of coasting-vessels. Cart-loads of dead bodies remained in the fields, forming in spots a tolerable coating of manure.

"It was an object of curiosity to me, then a boy, to catch some of the largest locusts, and turn up their wings to find the little red parasite which covered their bodies. This might have done something toward hastening their destruction, although it did not prevent the ravages on the crops.

"During the years necessary to clear up the forests on the sandy lands in the vicinity, it was no uncommon thing to have the crops seriously injured by these locusts, but never, to my knowledge, to the extent described above.

"In response to my special inquiries concerning the flight of these insects, my correspondent replied as follows: 'I do not remember ever to have witnessed the flight of these grasshoppers to any extent, except during the year mentioned and the preceding one. Nor do I ever recollect a time when the wind blew so steadily for days in succession from the northwest, generally rising soon after midday and going down with the sun. I have no meteorological record, but speak from memory.'

"The town of Pownal was principally settled after the opening of the present century. As the lands were cleared, the Canada thistle and other species sprang up in great quantities; when they ripened, the wind spoken of as occurring at that time carried off immense numbers of the thistle-blows to the ocean. I was wont to spend hours in my boyhood lying on the ground and directing my eyes as near as I could to the sun, to watch the thistle-blows as they passed across or near its disk. I think I could have seen them in this situation several hundred feet high. I injured my eyes permanently by indulging in this amusement. Whether the grasshoppers ever rose to so great a height I do not know, but I think that they generally flew at a lower level. Altogether they would rise in clouds as one approached them; it was only an occasional one that would rise higher, and fly off before the wind, and then only when the wind was blowing freshly. They did not fly with their heads directly before the wind, but seemed to rise in the air, set their wings in motion, and suffer themselves to be borne along by the current. They generally, perhaps always, rose in the afternoon, when the sun was hot and the wind blowing freshly."—(From accounts furnished by Dr. N. T. True, Bethel, Me., February 28 and March 10, 1868.)

In Ohio and Pennsylvania, according to Mr. A. S. Taylor, the grasshoppers made their appearance in vast numbers. In 1859 Mr. Schenck, of Franklin, Warren County, Ohio, wrote to the Ohio Farmer: "Last year we had millions of them; this year we have hundreds of millions." For five years, he says, they have been increasing on his farm, and he fears that unless some means are discovered for their destruction they will totally ruin his own and his neighbors' clover-fields. The speed of the Central Railroad locomotives is considerably decreased by the immense swarms of grasshoppers between Lancaster and Philadelphia. One engineer stated that his train was forty minutes behind owing to the number of grasshoppers on the track, and that he used twenty buckets of sand, which was thrown on the rail in front of the driving-wheels, to enable him to get along at all, Improbable as this story may appear, its truth is vouched for by the engineer above alluded to. (Hayden's Report on Nebraska, 1872.) In 1868, locusts, principally the red-legged species, appeared, according to Riley, in countless myriads in Ohio, invading the vineyards, "destroying entire rows, defoliating the vines, and sucking out the juices of the berries. In the same year I saw them in countless millions in many parts of Illinois and Missouri. They actually stripped many corn-fields in these States, and had not the crops been unusually abundant, would have caused some suffering. They were very destructive to flower and vegetable gardens. In 1869 they were, if anything, worse than in 1868. I remember that in the vicinity of Saint Louis, in addition to their ordinary injuries, they stripped the tops of Norway spruce, balsam-fir, and European larch; took the blossoms off Lima beans, severed grape-stems, and ate numerous holes into apples and peaches, thereby causing them to rot. They were indeed abundant all over Illinois, Missouri, Iowa, and even Kentucky, but attracted no attention east."—(Riley's Seventh Report.)

In the year 1871, the summer of which was dry, while I was in Orono, Me., in July reports came from Aroostook County that the hay-crop was being devoured by the locusts; and in August the evil became still worse, and they attacked the other crops, and became more or less destructive all over the State. They also, as quoted by Riley from the Monthly Report of the Agricultural Department, abounded in Plymouth County, Massachusetts, and in Vermont, as well as in Wayne County, Pennsylvania. In 1872, they were very abundant in New Hampshire, and in 1874 they were destructive in Missouri. In 1875 they were very abundant in the salt-marshes of Essex, Mass., as I was informed by a summer-resident there.

In 1876, in the Monthly Report of the Department of Agriculture for July, it was noted as injurious "in Sullivan, N. H. In Franklin, Va., it was very destructive on tobacco; as also in Person, N. C.; in Cherokee, Ala.; in Robertson and Montgomery, Tenn." In the Report for November and December, it is stated that "Owsley, Ky., reports a great destruction of early-sown wheat by a grasshopper, which is most probably the *Caloptenus femur-rubrum*."

Besides the localities given by Professor Thomas, I have received a male from California, near San Francisco, through Mr. Henry Edwards. The specimen was submitted to Mr. Scudder, who identified it. Mr. Walker* gives the following localities for it: "Arctic America; presented by Sir John Richardson. Arctic America; presented by Dr. Rae. Vancouver's Island-Nova Scotia; from Lieutenant Redman's collection. West coast of America; presented by Captain Kellett and Lieutenant Wood," etc.

On the map showing the distribution of this species, I have represented it as occurring over the whole of Labrador, for if it is found in Arctic America, it must be found there. During a residence of six weeks in the summer of 1860 at the mouth of Esquimaux River, Straits of Belle Isle, I never met with any *Orthoptera*. I heard, however, of grasshoppers about 20 miles in the interior, but they were very few in number. In the summer of 1864, while entomologizing at different points as far north as Hopedale, I never saw any.

We still need information regarding the southern and southeastern limits. I have also indicated on the map the approximative limits of the area where it has been found to be destructive at certain seasons.

Description.—Grizzled with dirty olive and brown; a black spot extending from the eyes along the sides of the thorax; an oblique yellow line on each side of the body beneath the wings; a row of dusky brown spots along the middle of the wing-covers, and the hindmost shanks and feet blood-red, with black spines. The wings are transparent, with a very pale greenish-yellow tint next to the body, and are netted with brown lines. The hindmost thighs have two large spots on the upper side, and the extremity black; but are red below and yellow on the inside. The appendages at the tip of the body in the male are of a long triangular form. Length, from 0.75 to 1 inch; expansion of wings, 1.25 to 1.75 inches.—(Harris.)

As this species, which is so common, varies considerably, I have concluded to give Dr. Harris's description without change, adding the following: Vertex but slightly depressed, with a minute angular expansion in front of the eyes; frontal costa usually but slightly sulcate; sides parallel; eyes large and rather prominent. Elytra and wings generally a little longer than the abdomen. The cerci of the male rather broad and flat; apex of last ventral segment is entire and truncate. The yellow stripes on the side extend from the base of the wing to the insertion of the posterior femora. The ground color varies with localities and age, and most of the specimens from one or two sections appear to have unspotted elytra; sometimes a reddish-brown tint prevails; at others a dark olive; at others a dark purplish-brown; yet the markings generally remain the same.—(Thomas, Acrididæ N. A.)

THE DESTRUCTIVE LOCUST OF CALIFORNIA, *Œdipoda pellucida* Scudder. *Œ. atrox* Scudder. (Plate LXIV, Fig. 5.)

"A third species of grasshopper, unnamed as yet, belonging to the genus *Œdipoda*, appears to be the insect which has ravaged the cultivated districts of California and Oregon, and the neighboring States and Territories. It probably ranges over the whole extent of country west of the Rocky Mountains and included within the limits of the United States. Mr. A. S. Taylor, in one of his articles in the California Farmer, subsequently communicated to the Smithsonian Institution and published in their Report for 1858, describes the grasshopper as found near Monterey, and it is doubtless the migratory species which ravaged the State. It is a species of *Œdipoda*, which, from the devas-

* Catalogue of the Specimens of Dermoptera Saltatoria in the Collection of the British Museum. Part iv. London, 1870.

tating nature of its ravages, may be called *Œdipoda atrox*, or the terrible grasshopper. To the best of my knowledge, it is the only species of the genus which has anywhere proved seriously and persistently injurious to crops. Several species of the closely-allied genus *Pachytylus* have ravaged the fields of Eastern Europe and Asia; and it is interesting, in a zoölogical point of view, to find that California, whose insect fauna bears a much more general resemblance to the peculiar types of the Old World than to those characteristic of the opposite border of the New World, should in this case also harbor a devastating grasshopper so much more nearly allied to the destructive species of the Mediterranean than to those found upon the same continent with itself.

Whether the *Œdipoda pellucida* (*atrox*) or *Caloptenus spretus* is the species which has proved at times so destructive on the Pacific coast has been a matter of some uncertainty. Mr. Scudder (Hayden's Report on the Geology of Nebraska, 1872) believes that it is this species, while Mr. Thomas (Monograph of *Acrididæ*) thinks it must be *C. spretus*. As seen in the previous account of *C. spretus* in California by Mr. Henry Edwards (p.), he regards that locust as the destructive species. Concerning the habits of *Œ. pellucida* in California, he writes me the following explicit account: "*Œdipoda* (*Camnula*) *atrox*. This species is very abundant in the spring and early summer, but at present (1876) appears to be somewhat limited in its range as far as California is concerned. It is found only in our foot-hills, and has not, to my knowledge at least, been regarded as a very destructive insect. I never saw it but once in very large swarms, and it then appeared to attach itself more to the pasture-grasses than to any growing crops, although there were plenty of fields of barley, oats, &c., in the neighborhood. It appears in its larval condition in April, and in the winged state in May, passing entirely out of existence by the middle of June. I have taken it sparingly in Nevada and in Vancouver's Island, and have seen some specimens from Santa Rosa Island, but I am pretty sure that it cannot be called a common insect in those localities." Regarding its habits and distribution in the East I quote as follows from Scudder's Distribution of Insects in New Hampshire (Hitchcock's Geology of New Hampshire, vol. 1): "This insect is silent in flight, and is a northern species, swarming in immense numbers among the White Mountains and on the dry summits of the country south of it. The top of Mount Prospect, near Plymouth, was covered with myriads of them in the autumn of 1873. It is found, however, as far south as Connecticut and Southern Illinois, and west to the latter region and Lake Superior." Thomas states that he has found it in Montana.—(Acrididæ of North America, p. 137.)

Concerning this species, Professor Thomas remarks as follows in Hayden's Annual Report on the Geology of Montana for 1871, p. 458: "Those who live in the East and have not seen a specimen of this species, can see it almost, if not exactly, represented in *Œ. pellucida* of Scudder; in fact, Mr. Scudder's description of this species agrees more exactly, if possible, with specimens from California, submitted to me this season, than his description of *atrox*." In his "Synopsis of the Acrididæ of North America," Hayden's Survey, 1873, he again says: "I give this species as distinct from *Œ. pellucida* on the authority of Dr. Scudder, but I consider the two as identical, the only difference that I can see being that the median carina of *atrox* is severed, while that of *pellucida* is continuous. The coloration shows less difference than is often observed between different specimens of the same species from the same locality. In fact, my specimens of *atrox* agree more exactly with Dr. Scudder's description of *pellucida* than with that of *atrox*, with the exception given."

I am inclined, from the reasons above given, to regard *atrox* as a synonym of *pellucida*, and that its range agrees in the main with that of *Œ. carolina*, which is found on the Pacific coast (Vancouver's Island), according to Walker, and probably Thomas.

Mr. Henry Edwards, of San Francisco, kindly furnishes the following notes:

"This species is very abundant in the spring and early summer, but at present appears to be somewhat limited in its range as far as California is concerned. It is found only in our foothills, and has not, to my knowledge at least, been regarded as a very destructive insect. I never saw it but once in very large swarms, and it then appeared to attach itself more to the pasture grasses than to any growing crops, although there were plenty of fields of barley, oats, &c., in the neighborhood. It appears in its larval condition in April, and in the winged state in May, passing entirely out of existence by the middle of June. I have taken it sparingly in Nevada and in Vancouver Island, and have seen some specimens from Santa Rosa Island, but I am pretty sure that it cannot be called a common insect in those localities."

Description of the adult.—Head uniform, pale brownish-yellow; the raised edge of the vertex dotted with fuscous; a dark fuscous spot behind the eye, broadening posteriorly, but not extending upon the pronotum. Antennæ as long as the head and pronotum together, dull honey-yellow, growing dusky toward the tip. Pronotum dark brownish-yellow, the sides darker anteriorly; median carina extending the whole length of the pronotum, moderately raised, cut once by a transverse line a little in advance of the middle; lateral carinæ prominent, extending across the anterior two-thirds of the pronotum; anterior border of the pronotum smooth, very slightly angulated; posterior border delicately marginate, bent at a very little more than a right angle, the apex rounded; tegmina dull-yellowish on the basal half, with distinct fuscous spots; toward the apex obscurely fuscous, with indistinct fuscous markings; humeral ridge yellowish, and, when the tegmina are in repose, inclosing a brownish fuscous triangular stripe; the spots are scattered mostly in the median field, consisting in the basal two-fifths of the tegmina of small roundish spots, and one larger longitudinal spot in the middle of the basal half; there is a large irregular spot in the middle of the tegmina, and beyond a smaller transverse spot, followed by indistinct markings; wings hyaline, slightly fuliginous at the extreme tip; the veins, especially in the apical half, fuscous; legs uniform brownish fuscous; apical half of spines of hind tibiæ black.

Length of body, 0.9 inch; of tegmina, 0.9 inch; of body and tegmina, 1.125 inches; of pronotum, 0.2 inch; of hind femora, 0.5 inch.

It bears a strong resemblance to *Œdipoda pellucida*, Scudd., common in Northern New England.—(Scudder in Hayden's Geological Report on Nebraska, 1872, p. 250.)

THE AMERICAN LOCUST, *Acrydium americanum* Drury (Plate LXIV, Fig. 6.)

This is one of our largest grasshoppers, being a little over two inches in length. It is occasionally very destructive to vegetation in the Southern States. According to Professor Thomas it occurs in North Carolina, Southern States, Florida, Alabama, Texas (Scudder); Illinois, Tennessee, Mississippi, District of Columbia (Thomas); Virginia, New York (?Drury). I have observed it very abundantly in Virginia, at Danville, in April and early in May. The figure (after Riley) is so good that further description is unnecessary.

In the pupa state this species is occasionally destructive. I have received from Prof. D. S. Jordan specimens which I regard as the pupæ of this species, with the following notes on its habits:

"While seining in Rome, Ga., in the Etowah River, I noticed, about July 25, a fence covered completely with large grasshoppers not fully fledged and extremely brilliant in color. They were very hyaline and of all shades from a clear pea-green to pale clear yellow and a sort of clear reddish amber (scarcely any two the same; all become pale yellow in spirits) color. We found them so thick that we could collect them by the handful, and in consequence of their abundance and brilliancy (else I should not have noticed them) I secured a couple of quarts. All I have at hand I send by American Express to-day, but will send a hundred more if you wish.

"A negro who was mowing near told us that he had never seen that kind of grasshopper before and that they were destroying the cotton. We found no more in the neighborhood of Rome.

"On a visit to Atlanta a week or so later we heard doleful complaints about a new sort of 'hoppergrass' that was destroying everything, particularly the corn and cotton. This kind was said by the Atlanta papers and farmers generally to have been hitherto unknown in Georgia, and we were shown a lot of live specimens on a cotton-plant in a glass globe in the rooms of the State Agricultural Department at Atlanta. The officials asked us if that was not the terrible Kansas hopper. I knew just enough about those fellows to assure them that it was not.

"Later (August 12), near Lookout Mountain on Chattanooga Creek, we saw several splendid fields of corn utterly devastated by these grasshoppers. The silk was gone and *all* the leaves and the husks peeled down as close as if a sheep had been at them, or a rat. I suppose the corn was not worth cutting at all, not even for fodder. As usual, all the fences were covered. We collected here four hundred or five hundred and put them in a large wire cage of lizards and chameleons for the latter to feed on, but the insects tormented the reptiles so much that we had to throw them away."

This species, when winged, sometimes take flight in large swarms. The following account of a flight in Columbia, S. C., has been communicated to me by Professor Baird, assistant secretary of the Smithsonian Institution:

COLUMBIA, S. C., *November* 18, 1876.

Prof. S. F. BAIRD, *Washington, D. C.:*

I inclose you specimens of "locust" which made their appearance on Friday, November 17, at about 9.30 p. m. Quantities could be gathered. I allowed my window to be used to exhibit them, and soon had to stop receiving them. I find they *are* locusts, from Wood's description, but find also that the same insect has been a denizen here for a long time, by reference to a dried specimen which I have had for six months. A week prior to their visit attention was called to the "specks," "meteors," "birds," &c., flying in front of the moon. I have no doubt they were an advance-guard of these locusts, as the under-wing is very brilliant in the light. I find they devour each other, but do not molest linen or cotton or paper in the window. I examined the fæces of the newly-arrived ones with the microscopes to judge of their last food, and found it to be *woody fiber*. The locusts were traveling from northwest to southeast.

Respectfully, &c.,

E. E. JACKSON.

Another swarm is described in the Monthly Report of the Department of Agriculture as "literally covering the streets" of Vevay, Ind., beginning to drop down at half-past 6 in the evening and continuing till 8 p. m. This species has also swarmed in Suffolk County, Virginia, according to Mr. C. R. Dodge.—(Rural Carolinian, quoted by Riley, Seventh Report.)

THE WESTERN CRICKET, *Anabrus simplex* Haldeman and *A. haldemani* Girard.—Very destructive to crops of wheat and other cereals and to grass; a large, stout, dark, cricket-like insect.

The "cricket" is especially injurious to crops in Utah, where it is very annoying and abundant. I have found it (*A. Haldemani* Girard, named by Mr. Scudder) common on the shores of the Great Salt Lake, where the gulls were seen feeding on this insect as well as winged grasshoppers. Mr. Henry Edwards, under date of December 25, 1875, writes me as follows regarding the cricket: "I send you two specimens of the large brown cricket from Idaho. I think it is *Anabrus simplex* of Haldeman. It is extremely destructive to the crops of wheat and other cereals from Oregon to Wyoming Territory, and eastward to Montana, Idaho, and Utah. I do not think it has ever been found in California. When I was in Oregon two years ago, I made some few notes about this pest, and, if I can find them, will willingly place them at your disposal." Maj. J. W. Powell tells me that the cricket is annoying in Arizona.

I extract the following remarks on the geographical range and habits of the species of *Anabrus* from Professor Thomas's report in Hayden's Report on the Geology of Montana for 1871:

Anabrus purpurascens is found, not abundantly, but at certain elevated points from Northern New Mexico to Montana, along the east base of the mountains, but I have met with no specimen west of the range in the middle district, though Mr. Uhler gives Washington Territory as a locality on the authority of Dr. Suckley. It is also found as far south as Texas, and as far north as Red River, in Northern Minnesota. *A. simplex* appears to be confined to the middle district, as I have not met either in the eastern or western districts. Dr. Scudder, who examined the *Orthoptera*, collected by Professor Hayden, in Nebraska, does not mention it in his list; nor did Mr. C. R. Dodge have it among his collections made in Nebraska, Colorado, Kansas, and Indian Territory; nor is it among the collections in the Agricultural Department, made east of the Rocky Mountains. Hence I think we may safely conclude that it is confined to the west side of the range. But what it lacks in range is made up in numbers, for in the northern part of Salt Lake Basin and southern part of Idaho, the only points where I have met with it, it is to be seen in armies of myriads. (p. 431.) Found in great abundance between Brigham City, Utah, and Fort Hall, Idaho; also, occasionally met with farther south, in Utah, and north of Fort Hall, to the boundary-line of Montana, which is here along the range separating the waters of the Atlantic from the Pacific. At some points we found them so abundant as literally to cover the ground. In two or three instances they all appeared to be moving in one direction, as if impelled by some common motive. I recollect one instance, on Port Neuf River, where an army was crossing the road. It was probably as much as 200 yards in width. I could form no idea as to its length. I only know that as far as I could distinguish objects of this size (being horseback) I could see them marching on. I think that in all the cases where I saw them thus moving, it was toward a stream of water. They appear to be very fond of gathering along the banks and in the vicinity of streams. In the north part of Cache Valley I frequently noticed the ditches and little streams covered with these insects, which, having fallen in, were floating down on the surface of the water, and, though watching them for hours, they would flow on in an undiminished stream.

While encamped on a litte creek near Franklin, in this valley, it was with difficulty we could keep them out of our bedding; and when we went to breakfast, we found the under side and legs of the table and stools covered with them, all the vigilance of the cook being required to keep them out of the victuals.

But the strangest part of its history is that it will go in pursuit of and catch and eat the *Cicada*. This latter insect also made its appearance in this valley the past season in immense numbers, covering the grass and sage and other bushes, especially those which formed a fringe along the little streams. Up these the *Anabrus* would cautiously climb, reach out with its fore leg and plant its claw in its victim's wing; once the fatal claw secured a hold, the *Cicada* was doomed, for without ceremony it was at once sacrificed to the voracious appetite of its captor. No uniformity appeared to be preserved in this process; sometimes they would commence with the thorax, at others with the head, not even taking the trouble to remove the legs and wings.

I noticed in the road, where one of the armies was crossing, a number of large hawks feasting themselves upon the helpless victims. As I returned through Malade Valley (August 20, 1871,) the females were depositing their eggs. They press the ovipositor perpendicularly into the ground almost its entire length.

The following notes on *Anabrus simplex* have been obligingly prepared for this report by Mr. Henry Edwards, of San Francisco:

I know little of this species from my own personal observation. It was extremely abundant during a visit to Oregon some four years ago. I extract the following from my note-book: "The large brown cricket (*Anabrus simplex*) is a great trouble to the farmers of this region, (the Dalles,) and this year has been unusually common. It appears that they march to attack the corn fields in columns, and the only way left to the farmers to protect themselves is to dig trenches around their fields into which the crickets fall in enormous crowds and are killed by their own numbers. The upper individuals, however, manage to make a bridge of the bodies of their companions, and sometimes cross the ditches in great quantities. Pigs eat these insects very greedily. They seem to be periodical in their appearance, the great swarms only occurring once in six years. I think their depredations are mostly committed in the night, as I saw none during the heat of the day, but toward twilight they swarmed on the stems of artemisia and other low plants, and were exceedingly active."

Description of Anabrus simplex.—Dark shining brown, posterior femora with an external and internal row of small spines beneath upon the posterior extremity; tibiæ angular, with a row of spines upon each side above, and two approximate rows beneath, with the spines alternating. Length, fifteen lines, pronotum six, ovipositor twelve, posterior femora and tibiæ, each eleven, and tarsi three and a half. This seems to be one of the species which is eaten by the aborigines of the Valley of the Great Salt Lake.—(Haldeman in Stansbury's Report, 1855, p. 372.

Anabrus haldemani Girard.—Antennæ long and filiform, reaching posteriorly the base of the ovipositor; pronotum short, broad; femora smooth, yellowish; feet and ovipositor reddish-purple. Posterior margin of pronotum black, with two parallel black bands on the posterior third of its length.

Description.—The abdomen above exhibits ten segments or articulations, the anterior or basal one being, as stated above, covered by the posterior prolongation of the pronotum. Beneath there are seven subquadrangular plates, situated opposite to the seven middle upper segments. The posterior segments inclose another piece bearing two spine-like abdominal appendages—one on each side. The ovipositor is as long as the abdomen, and entirely smooth. The base of the antennæ is situated above the eyes, and inserted upon an angular movable piece. The joints composing these organs are very short, and provided with minute setæ. The tibiæ are provided with four rows of spines, two anterior and two posterior; the internal posterior row being the stoutest. The posterior rows are more densely set with spines, while the latter are scattered and alternate with each other in the anterior rows. The first and cordate joint of the tarsi is the longest, the second is the shortest, and, from the middle of the third, a fourth slender and long joint arises, slightly convex above, and terminating in two spines or claws curved inward and outward. The ground-color above and below is yellowish; the antennæ, limbs, and ovipositor are of a reddish-purple. The posterior margin of the pronotum is black. Two parallel black vittæ, inclosing a narrow yellow one, are observed on each side of the dorsal line, upon the posterior third of the pronotum. The posterior portion of the upper abdominal segments is occasionally of a deep-brown hue.

This species differs from *Anabrus simplex* Hald., by a proportionally much shorter pronotum.—(Girard in Marcy's Report of Explorations on the Red River of Texas, p. 248.)

So large and conspicuous an insert as the Anabrus is easily kept under by the means already suggested in treating of the locust.

INSECTS SPECIALLY INJURIOUS TO WHEAT, OATS, BARLEY, ETC.

A.—AFFECTING THE ROOT AND STALK.

THE JOINT-WORM, *Isosoma hordei* of Walsh, *Eurytoma hordei* of Harris.

A minute, footless, yellowish-white maggot forming blister-like swellings between the second and third joints of the stalk, immediately above the lower joint in the sheathing-base of the leaf; remaining through the winter in the stubble, straw, or harvested grain, and changing into a small, slender, black, four-winged insect, which deposits its eggs in the stalks of young wheat late in May and in June.

This insect, belonging to a group of chalcid flies which are, as a rule, parasitic on other insects, is a vegetarian, and parasitic on the stalks of wheat and other cereals, living on the sap, and by its presence causing the formation of blister-like galls or tumors on the lower part of the stalk. When the wheat or barley is from 8 to 10 inches high its growth becomes suddenly checked, the lower leaves turn yellow, and the stalks become bent. If the buts of the straw are now examined they will be found to be irregularly swollen and discolored between the second and third joints, and, instead of being hollow, are rendered solid, hard, and brittle, so that the straw above the disease is impoverished, and seldom produces any grain. Suckers, however, shoot out below, and afterward yield a partial crop, seldom exceeding one-half the usual quantity of grain" (Gourgas as quoted by Harris). The worms have been found living in swellings, sometimes from six to ten in a tumor situated between the second and third joints, or immediately above the lower joint in the sheathing-base of the leaf, or in the joint itself. In November, in the New England States, the fully-fed larvæ as a rule (many do not until the spring) change to a chrysalis or pupa within the tumor, and in this state spend the winter in the straw or stubble or even in some cases in the harvested grain. In Virginia, the larva passes into the pupa state in February and March. From early in May until early in July, but mostly in New York in June, the four-winged flies issue from the galls, the males first appearing, and about the 10th of June, in Canada, the females deposit their eggs in the stalks of the young, healthy wheat. The larvæ hatch in a few days, and by the first week of July the young are nearly one-half grown. By the first of September the galls become hard and the worms fully grown.

I have endeavored to represent on the accompanying map the area of distribution of the joint-worm, but the area is probably too restricted. No facts are, however, at hand showing that it has occurred west of longitude 82° or south of latitude 36°, with the exception that a "joint-worm" is reported in the Monthly Reports of the Agricultural Department as having injured wheat in Kansas, but the species referred to has not, so far as I am aware, been referred to a competent botanist. I should be greatly obliged for specimens of this or any "joint-worm" from any part of the country.

The joint-worm of late years has been, so far as reports go, much less abundant than between the years 1825 and 1860, and it is to be hoped that it will not again be so prevalent. In former years the losses in Virginia amounted to over a third of the entire wheat-crop, while some crops in that State were not thought to be worth cutting. It was particularly abundant on rye, barley, and oats in the New England States and Canada, while in New York it was known to destroy one-half the barley-crop. Dr. Fitch has described several so-called species, allied to *Isosoma hordei*, and he supposed that they were restricted to different species of cereals. Mr. Walsh, however, has endeavored to show, with good reason, we think, that they were simply varieties of *I. hordei*, and that this well known species feeds upon all the small grains as well as wheat.

Either two or three specimens of ichneumon or chalcis flies, belonging to the same family (*Chalcididæ*) of hymenopterous insects as the joint-worm itself, prey upon the larva, and probably tend to reduce its numbers. Harris states that the larvæ of a species of *Torymus*, one of these chalcid flies, destroy the joint-worm. A species of *Torymus* (*T. harrisii* Fitch), perhaps the adult of the larval *Torymus* described by Harris, and a species of *Pteromalus*, also prey upon it.

Larva: The joint-worm is described by Harris, from specimens received from Virginia, as a round, cylindrical, footless, maggot-like worm, varying from one-tenth to three-twentieths of an inch in length. It is pale yellowish and without hairs. The head is round and partly retractile, with a distinct pair of jaws, and can be distinguished from the larvæ of the diptenous gall-flies by not having the usual V-shaped organs on the segment succeeding the head.

Adult: The imago or adult fly is a four-winged, hymenopterous insect, a member of the family *Chalcididæ*, most of which are insect-parasites. It is jet black, and the thighs, shanks (tibiæ), and claw-joints of the feet are blackish, while the knees and other joints of the feet (tarsi) are pale yellow; sometimes the legs are entirely yellow. The females are 0.13 inch in length, while the males are smaller, have a club-shaped abdomen, and the joints of the antennæ are surrounded by a verticil of hairs.

Remedies.—While the best way to encounter this insect is to breed and set loose the natural insect-parasites which prey upon it, the most obvious remedy is to burn the stubble in the autumn or early spring for several years in succession. If farmers would co-operate, this means would be sufficient to so reduce the numbers of this species that its attacks would be comparatively harmless. Plowing in the soil is of no use in the case of this insect, as the fly would easily find its way up to the surface of the ground.

THE HESSIAN FLY, *Cecidomyia destructor* of Say. (Plate LXV, Fig. 1.)

Two or three small, reddish-white maggots embedded in the crown of the roots or just above the lower joint, causing the stalks and leaves to wither and die; the maggots harden, turn brown, then resembling a flaxseed, and change into little black midges with smoky wings, which appear in spring and autumn, and lay from twenty to thirty eggs in a crease in the leaf of the young plant.

The Hessian fly was so called because it was first noticed as injurious to wheat during the revolutionary war, and was thought to have been imported from Europe in some straw by the Hessian troops. "It was first observed in the year 1776 in the neighborhood of Sir William Howe's debarkation on Staten Island, and at Flatbush, on the west end of Long Island. Having multiplied in these places, the insects gradually spread over the southern parts of New York and Connecticut, and continued to proceed inland at the rate of 15 or 20 miles a year. They reached Saratoga, 200 miles from their original station, in 1789. Dr. Chapman says that they were found west of the Alleghany Mountains in 1797; from their progress through the country, having apparently advanced about 30 miles every summer. Wheat, rye, barley, and even timothy-grass, were attacked by them; and so great were their ravages in the larva state that the cultivation of wheat was abandoned in many places where they had established themselves."—(Harris.) Dr. Fitch also thinks that this is an European importation, but Curtis in his "Farm Insects" doubts whether the European midge be of the same species. But it is reported by Köllar to have been known in Europe as early as 1833, and by later observers to be commonly diffused in Europe, and Köllar pronounces it as indigenous to Europe. Of late years it has not been reported to be so destructive as formerly, and no mention is made of it by the different State entomologists in their annual reports.

In the accompanying map showing the probable distribution of the Hessian fly and wheat-midge, I have been mainly dependent for my data regarding its distribution south and west of New York upon the Monthly Reports of the Agricultural Department at Washington. But the information there given, I regard as quite unreliable and unsatisfactory. It is quite likely that the Hessian fly may have been in those reports confounded with the wheat-midge and *vice versa*, or that when the "fly" is mentioned as injuring the wheat-crop, some other fly or insect has been the culprit. If, therefore, I have been in error, it will be from causes beyond my control. At the same time it is not unlikely that the area of distribution of both these insects may be found to coincide with that of each of the two, and with that representing the cultivation of wheat.* This latter has been taken from a map compiled

* Specimens of the Hessian fly, wheat-midge, and joint-worm, and notes on their habits and ravages, are earnestly desired by the writer for aid in improving and correcting the maps herewith presented. Specimens of this insect and the wheat-midge from all parts of the country are earnestly desired by the author.

by General Francis A. Walker, from the Statistics of Agriculture, Ninth Census, 1870.

This insect is double-brooded, as the flies appear both in spring and autumn. At each of these periods the fly lays twenty or thirty eggs in a crease in the leaf of the young plant. In about four days, in warm weather, they hatch, and the pale-red larvæ (Fig. 2*a*) "crawl down the leaf, working their way in between it and the main stalk, passing downward till they come to a joint, just above which they remain, a little below the surface of the ground, with the head toward the root of the plant." (Plate IV, Fig. 1*c*.) Here they imbibe the sap by suction alone, and by the simple pressure of their bodies, they become imbedded in the side of the stem. Two or three larvæ thus imbedded serve to weaken the plant and cause it to wither and die. The larvæ become full-grown in five or six weeks, then measuring about three-twentieths of an inch in length. About the 1st of December their skin hardens, becoming brown, and then turns to a bright chestnut color. This is the so-called flaxseed state, or puparium. In two or three weeks the "larva" (or, more truly speaking, the semi-pupa) becomes detached from the old case. In this puparium some of the larva remains through the winter. Toward the end of April or the beginning of May the pupa (Plate LXV, Fig. 1*b*) becomes fully formed, and in the middle of May, in New England, the pupa comes forth from the brown puparium, "wrapped in a thin white skin," according to Herrick, "which it soon breaks and is then at liberty." The flies appear just as the wheat is coming up; they lay their eggs for a period of three weeks, and then entirely disappear. The maggots hatched from these eggs take the flaxseed form in June and July, and are thus found in the harvest time, most of them remaining on the stubble. Most of the flies appear in the autumn, but others remain in the puparium until the following spring. By burning the stubble in the fall their attacks may best be prevented. Among the parasites on this species are the egg-parasites, *Platygaster* and *Semiotellus* (*Ceraphron*) *destructor* Say (Fig. 3), the latter of which pierces the larva through the sheath of the leaf. Two other Ichneumon parasites, according to Herrick, destroy the fly while in the flaxseed or semi-pupa state. The ravages of the Hessian fly have been greatly checked by these minute insects, so that it is in many localities not so destructive as it was formerly. Dr. Fitch has suggested that the European parasites of this insect, and the wheat-midge, could be imported and bred in large quantities, so as to stop their ravages. With proper pecuniary aid from the State this seems feasible, while our native parasites might perhaps also be bred and multiplied so as to effectually exterminate these pests. As regards the increase of parasites, B. Wagner, in his "Researches on the new Corn [wheat] Gall-fly" (Marburg, 1861), finds that the parasites of the Hessian fly increase in a ratio corresponding to that of their hosts. In the same year, he says, in which the hosts are very generally frequent, they are so infested by parasites that the next year only a few of the gall-flies appear. He also found that the parasites only infested the summer brood of Hessian flies, but not the winter brood; seventy per cent. of the former were found to be infested. Thus far the Hessian fly has not occurred west of the Mississippi Valley.

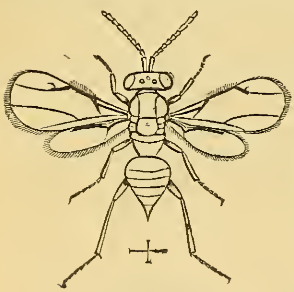


FIG. 3.—Parasite of the Hessian Fly.

Egg and larva: The egg is about one-fiftieth of an inch long and four-thousandths of an inch in diameter, cylindrical, translucent, and of a pale-red color (Herrick).

The larva or maggot when first hatched is pale reddish, afterward becoming white. It is when mature 0.15 inch in length, oval cylindrical, pointed at one end, and is soft, shining white.

Fly: Black with pale-brown legs and black feet and a tawny abdomen; the egg-tube of the female rose-colored, wings blackish, tawny at base; fringed with short hairs and rounded at tip. The body is about a tenth of an inch in length, and the wings expand one-quarter of an inch or more. The antennæ of the male have the joints roundish oval and verticillate.

Remedies.—Besides the parasites of this insect, its natural enemies, large numbers probably fall a prey to roving carnivorous insects and birds, particularly swallows and martins. As, however, the insect remains in the "flaxseed" state in the straw and stubble, the obvious remedy is to burn over wheat-fields for several years in succession. The rotation of crops is also a valuable preventive measure.

THE CHINCH-BUG, *Blissus leucopterus* of Uhler, *Lygæus leucopterus* of Say.

A small bug, while young sucking the roots of wheat and corn, afterward infesting in great numbers the stalk and leaves, puncturing them with their beaks. It appears early in June, and there is a summer and autumn brood, the adults hybernating in the stubble.

This is the most formidable enemy of wheat and corn, much more damage having been done to grain-crops in the Mississippi Valley and the Southern States than from any other cause, as it is more or less abundant each year. It is very abundant in Kansas, Nebraska, and California, according to Uhler. Dr. Shimer states that the female is "occupied about twenty days in laying her eggs, about 500 in number. The larva hatches in fifteen days, and there are two broods in a season, the first brood maturing, in Illinois, from the middle of July to the middle of August, and the second late in autumn." According to Harris, the "eggs of the chinch-bug are laid in the ground, in which the young have been found, in great abundance, at the depth of an inch or more. They make their appearance on wheat about the middle of June, and may be seen in their various stages of growth on all kinds of grain, on corn, and on herds-grass, during the whole summer. Some of them continue alive through the winter in their places of concealment." This species is widely diffused. I have taken it frequently in Maine, and even on the extreme summit of Mount Washington in August, but it is more properly a southern and western insect. It has not attracted notice on the Pacific coast, as M. H. Edwards writes me that it has not yet appeared in California. But as Mr. Uhler records it from California, it probably occurs there only rarely.

Dr. Shimer in his Notes on the Chinch-Bug says that it "attained the maximum of its development in the summer of 1864, in the extensive wheat and corn fields of the valley of the Mississippi, and in that single year three-fourths of the wheat and one-half of the corn crop were destroyed throughout many extensive districts, comprising almost the entire Northwest, with an estimated loss of more than $100,000,000 in the currency that then prevailed," while Mr. Walsh estimates the loss from the ravages of this insect in Illinois alone, in 1850, to have been $4,000,000.

In the summer of 1865, the progeny of the broods of the preceding year were almost entirely swept off by an epidemic disease, so few being left that on the 22d of August Dr. Shimer found it "almost impossible to find even a few cabinet specimens of chinch-bugs alive" where they were so abundant the year before. "During the summer of 1866 the chinch-bugs were very scarce in all the early spring, and up to near the harvest I was not able, with the most diligent search, to find one. At harvest I did succeed in finding a few in some localities." This disease among the chinch-bugs was associated with the long-continued wet, cloudy, cool weather that prevailed during a greater portion of the period of their development, and doubtless was in a measure produced by deficient light, heat, and electricity, combined with an excessive humidity of the atmosphere." In 1868 it again, according to the editors of the American Entomologist, "did considerable damage in certain counties in Southern Illinois, and especially in Southwest Missouri." In 1871 Dr. Le Baron estimates the losses to corn and the small grains in the Northwestern States at $30,000,000, and Riley estimates the loss in 1874 in the same area as double that sum, the loss in Missouri alone being $19,000,000. Apparently no injury was sustained in Colorado in 1875 from this insect.

In the accompanying map showing the distribution of the chinch-bug, I have been mainly dependent on the statements of the State and other entomologists of the West, and the reports of the Agricultural Department. I have found the insect on the summit of Mount Washington, and argue from this fact that it is widely distributed over the colder as well as warmer portions of the New England States. It probably inhabits the entire United States east of longitude 100°, and will probably occur in the Western Territories, wherever wheat is raised, though perhaps the altitude and peculiar climatic features of the Rocky Mountain Plateau may prevent its rapid and undue increase.

Egg, young and adult.—The egg is minute, oval, 0.03 inch long, four times as long as broad, and white. The larva is at first pale yellow, afterward becoming red, changing with age to brown and black, and marked with a white band across the back. The adult is armed with a powerful beak, instead of jaws, with which it punctures the stems of plants and sucks in the sap; it sometimes abounds to such an extent as to travel in armies from field to field; it may be known by its white fore wings, contrasting well with a black spot on the middle of the edge of the wing, and is about three-twentieths of an inch in length. Certain individuals have very short wings.

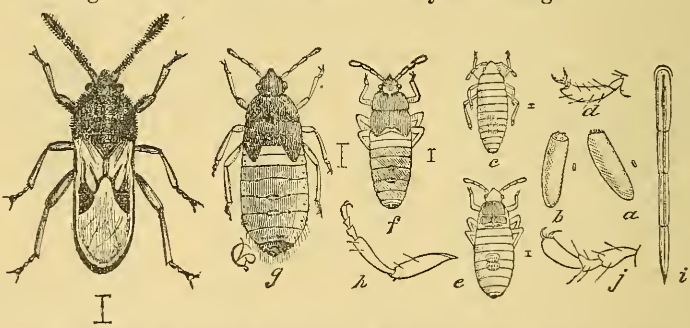


FIG. 4.—Adult and immature stages of Chinch-Bug.—*a*, *b*, eggs; *c*, newly-hatched larva; *d*, its tarsus; *e*, larva after first molt; *f*, same after second molt; *g*, pupa—the natural sizes indicated at sides; *h*, enlarged leg of perfect bug; *j*, tarsus of same still more enlarged; *i*, proboscis or beak, enlarged. (After Riley.)

Remedies.—Burn stubble, old straw, and corn-stalks among weeds in fence-corners in the early spring. Riley advises the early sowing of small grain in the spring, and suggests that the harder the ground is the less chance there is for the chinch-bug to penetrate to the roots of the grain and lay its eggs thereon. "Hence, the importance of fall-plowing, and using the roller upon land that is loose and friable." Heavy rains and cold, damp seasons reduce its numbers materially. Where irrigation is practiced, fields may be flooded for several days in succession, and thus the insects driven off or drowned. The natural enemies of the chinch-bug are larger species of bugs, the lady-bird (*Hippodamia* and *Coccinella*), the larva of the lace-wing fly (*Chrysopa*), and quails, etc.

THE NORTHERN ARMY-WORM, *Heliophila unipuncta* of Grote; *Noctua unipuncta* of Haworth; *Leucania unipuncta* Guenée.

The summer of 1861 will be long remembered by agriculturists on account of the injury their crops received from the sudden and unprecedented appearance of a caterpillar which destroyed the leaves and heads of every sort of grain; and of a species of *Aphis*, or plant-louse, that gathered in immense numbers on the ears of the grain that had been left untouched by the army-worm, sucking out the sap of the ear, and thus lessening very materially its weight; or if in many cases not doing as much damage as this, causing much apprehension and anxiety to farmers generally.

The most injurious of these two insects is the larva of the *Leucania unipuncta*, one of a family of night-flying moths that embraces an immense number of species. The genus *Leucania* has a spindle-shaped body, a robust thorax, with a distinct collar just behind the head, which above is triangular, carrying near the base the thread-like antennæ, or feelers, which are about two-thirds the length of the wings. Two stout palpi, with a slender tip, project from the under side of the head, from each side of the hollow sucking-tube used to suck the sweets of flowers, but which at rest is rolled up between the palpi and rendered almost invisible by the thick-set, long hair-like scales that cover the head. A little behind the front margin of the thorax are placed the wings; the forward pair narrow and oblong, arched slightly at the apex, and just below, the outer oblique edge bulges out slightly. The outer edge or that farthest out from the insertion of the wing is in this genus two or three times as wide as the base. In the middle of the fore wing is a vein that runs out very prominent to just where it divides into three lesser branches; on this point in the species described below is a conspicuous white dot which gives it its name, *unipuncta*.

The hind wings are short, broad, and thin, just reaching out to the outer edge of the fore wing. There is a slight notch near the middle of the outer edge, and the inner edge, or that most parallel to the abdomen, is fringed with quite long hairy scales, that run into the pale fringe of the outer edge, which is always paler and broader than that of the fore wings. Both wings are much paler beneath, and do not show the markings of the upper side. When the moth is at rest, the hind wings are laid upon the abdomen and partially folded, so that the fore wings overlap one another above them like a roof. Thus folded, the ends of the wings are not much wider than the thorax.

The abdomen tapers rather rapidly, ending in a pencil of hairs. The second and third joints of the legs are much thickened, the last joints armed with minute spines, four of which are largest on the third joint.

Characters like these show moths of this genus to be strong and swift on the wing. In meadows and grass-lands, when disturbed they dart suddenly up from under our very feet and plunge into covert very quickly again. In the evening they fly in great numbers into open windows, attracted by the light within.

The eggs are laid near the roots of our wild, especially the perennial, grasses, such as timothy and red-top. Mr. Riley has succeeded in observing the female laying her eggs early in April at Saint Louis, Mo.

"By carefully watching, I have ascertained that the favorite place to which the female consigns her eggs in such grass is along the inner base of the terminal blades where they are yet doubled. The compressed horney ovipositor, which plays with great ease and tentative motion on the two telescopic subjoints of the abdomen, * * * * is thrust in between the folded sides of the blade, and the eggs are glued along the groove in rows of from five to twenty, and covered with a white, glistening, adhesive fluid, which not only fastens them to each other, but draws the two sides of the grass-blade close around them, so that nothing but a narrow, glistening streak is visible. * * * * The female, having once commenced to lay, is extremely active and busy, especially during warm nights, and I should judge that but two or three days are required to empty the ovaries, which have a uniform development. A string of fifteen or twenty eggs is placed in position in two or three minutes, and by the end of ten more I have known the moth to choose another leaf, and supply it with another string. Many must be laid very soon after vegetation starts, as some moths taken in the middle of April had already exhausted their supply; yet the bulk of them are not laid till toward the end of April." The hatching of the larva in a uniform temperature of 75° F. takes place from the 8th to the 10th day after deposition. The larvæ molt five times, and but three days while in confinement intervened on an average between each.—(Riley's Eighth Report.)

In Illinois, the moth lays its eggs in April and May, from four to six weeks earlier than in the Eastern States; so the larva appears earlier.

In Missouri, from the middle of April till the middle of May, and about the middle of June probably in Massachusetts, and a week later in Maine, the eggs placed in local and confined tracts of grass-land hatch their young larvæ, which for four weeks or thereabout feed incessantly till full-fed on the grass around the place of their birth, straying off as their forage is eaten up to fresh pastures.

The caterpillar state lasts for about a month, when it descends into the earth and changes to a chrysalis, remaining in this state two or three weeks. In Southern Missouri the moth appears about the fore part of June.—(Riley.) In New England the moth appears in

It is probable, according to the observations of Mr. Riley and myself, that while the majority of the moths appear in the late summer or early autumn, according to the latitude of the place where they live, a few may hybernate in the pupa state in the Middle States, and still more in the New England States. Mr. Riley thinks that the moths may sometimes lay their eggs upon newly-sown fall-grain.

We first hear of the army-worm when it is about an inch long; but it has eaten up all the grass around its place of birth, and in myriads is pushing out its columns after forage. The mature larva is about an inch and a half long. Its cylindrical body, divided into thirteen rings becomes more contracted and wrinkled at each end, and is sparsely covered with short hairs. The head is covered by a net-work of confluent spots, while along the middle of the face run two lines diverging at each end. A light-colored waved line just above the legs is succeeded by a dark one, then a light one edged with two thread-like lines; while the upper part is dark, with an interrupted white threadru nning exactly through the middle of the back. The prolegs, ten in number, are marked on their outer middle and on their tip with black. Beneath, the caterpillar is of a livid green.

Its name is suggestive of the regular, trained way in which myriads of these caterpillars march together in long, deep columns, side by side, steadily over every obstacle, wherever their instinct leads them. Unlike the cut-worm, which moves by night singly, from field to field, and secrete themselves by day-time amid the roots of the plants they attack, the army-worm feeds in the forenoon and evening generally, scattered over fields of grain or grass, either eating the leaves or cutting off the heads and letting it fall on the ground. They will thus cut across the field, wantonly mowing off the heads of the grain. In this way, in Plymouth County, Massachusetts, they destroyed an acre and a half of wheat in one night, and then attacked a corn-field in the same way.

All young insects, or those in the larval stage, are exceedingly voracious; they eat surprising quantities of food. When these army-worms are shut up together without food, they will quickly devour each other. We give some extracts to illustrate what we have said, from the New England Farmer and Boston Cultivator. A writer in Danvers, Mass., says: "They were seen in great numbers through the entire field of several acres, climbing up the stalks of the barley, eating the blades and cutting off the heads of the grain. The day after these worms were discovered, the barley was mowed in order to preserve it, when they dropped to the ground, throwing themselves into a coil, a habit of the insect when disturbed. Many of them soon commenced a march for the neighboring fields and gardens, while others blindly pushed forward a column across the highways over a stone wall, where they were crushed by travelers on the road. But the main body marched to the adjoining gardens and inclosures, where the proprietors were waiting to receive them in their intrenchments, which had been thrown up a foot wide and two feet deep. The worms, as they fell in their advance into the trenches, were assailed in various ways by eager combatants, some spreading over them lime, tar, or ashes, while others resorted vigorously to pounding them. In this way, countless numbers of them were destroyed. The rear guard, composed principally of those of smaller growth, kept in the field, where they were picked up by a troop of fifty young red-winged blackbirds. I also noticed the robins feeding on these vermin." Again: "In adjoining lots they were commencing their devastation upon the corn, turnips, cabbages, weeds, and grass. They leave the grass-ground completely clean and white, so that it has the appearance of having been scorched in the sun. The cabbage and turnips they destroy by eating the tender parts of the plants, while they attack the corn by descending the spindle and concealing themselves in large numbers among the leaves where the corn is to make its appearance. Corn thus attacked, looks wilted and drooping. In some hills, the stalks were stripped of all their leaves. There were no worms upon the potato-tops, though they have killed all the grass to the borders of the field."

The damage done to crops in Western Massachusetts alone was estimated to amount to half a million dollars. In the Middle and Western States, the army-worm appears in numbers in certain years, and then are rare for some years. In Southern Illinois, in 1818 or 1820, they were more numerous than in 1861. They also appeared in 1825, 1826, 1834, 1841. In 1842 they were about as numerous as in 1861. In 1849 they were numerous in Southern Illinois. In 1856 they occurred in small numbers. In 1855 it appeared in Northern Ohio; in 1854 it abounded in Boone County, Missouri, and in 1865, 1866, and especially in 1869, in portions of the State. In 1871 it occurred in Illinois, and in 1872 in Iowa, Wisconsin, Ohio, and Kentucky, Illinois, Missouri, and Tioga County, New York.—(Riley.) Thus it is well known and established in the South and West, so that when it appeared in New York and New England the past summer there were thought to be two species of army-worms. But the moths from different sections of the East and West have been compared and found to be the same. Dr. Fitch, also, has shown that "worms *in armies*," and "black worms," referred to by writers as occurring in New York and New England in 1743, 1770, 1790, and 1817, with habits like those of the army-worm of 1861, must be the same species. Mr. Sanborn assures me that he took the moth in 1855 near Boston; and has found the larva under stones in grass-plots. On Mr. Clark's farm at Carritunk, near the Forks of the Kennebec, the army-worm did a great deal of damage to the barley, in all destroying forty acres of grain. This was about the middle of August, and soon after the caterpillars entered the ground to transform. Their ravages were especially noticed, according to the Maine Farmer, in North Berwick, Union, Bangor, Ellsworth, and one or two other towns. Mr. Goodale informs us that on Mr. Joseph Clark's farm, in Waldoborough, the worm was found both in wheat and barley fields, though less on the wheat, which was riper. The leaves were consumed, while the heads were not much eaten. Many of the heads were cut off and had fallen upon the ground, while others were cut just enough to hang over. Mr. Goodale collected numbers of the worm on the 14th of August, and fed them till on the 20th all but one had gone into the earth. September 7, these millers appeared, and so several each day until the 16th. I have never taken this species in Maine until I met the worm in Bangor, August 2, in a yard a few rods from the Bangor House, and nearly full-fed; August 13, in a field of barley in Mattamiscontis, on the Penobscot, above Bangor. It was not seen on farms above this point on that river, or on the Allegash or Saint John, so far as I could ascertain, while the wheat *Aphis* was abundant on every farm I visited on those rivers. Whether the army-worm made its appearance for the first time in Maine in 1861 can be only probable. In Massachusetts it was first noticed the first of July; in Maine a month later, where it became generally prevalent.

The year 1875 was another army-worm year, and it abounded all over the country, especially in Missouri, Illinois, Delaware, Ohio, Kentucky, and Iowa, New York, and throughout New England, and in Western New Brunswick.—(Riley.)

While the caterpillar is single-brooded in the Northern States, in Saint Louis, Mo., Mr. Riley finds it to be double-brooded, and he thinks that three broods may sometimes appear in one season.

The following newspaper items will show the time of appearance and degree of damage done by the army-worm in New York, the New England States, and New Brunswick, in 1875:

Another insect-pest has made its appearance in formidable numbers on Long Island. The army-worm has been doing more damage in Suffolk and Queens Counties, especially the former, than even the dreaded potato-beetle. Corn and oats prove more attractive than potatoes to the army-worm, and in some instances the entire crop of oats has been destroyed. It is to be hoped that the recent heavy rains have put a stop to the operations of these caterpillars; at worst, their want of the power of flight will probably confine the damage to the island.—(New York Tribune, August 6, 1875.)

The army-worms have disappeared from Little Compton and Portsmouth as suddenly as they came. They did considerable injury.—(Boston Journal, August 13.)

A special from Rockland says that an immense army of black worms, similiar to caterpillars, were crossing Pleasant street in that city all day Sunday, heading southward. Large crowds gathered to witness their advance.—(Boston Journal, August 2.)

The Times says that the army-worm has appeared in Bath. This worm has appeared in Rockland, and as far east as Machias, and is reported as doing great damage.—(Brunswick Telegraph, August 10.)

SAINT JOHN, N. B., *August* 12.—The army-worms appeared on the marsh-road, a mile from Saint John, yesterday afternoon, in considerable strength. Notwithstanding the efforts to destroy them, they were marching on the city last night with apparently undiminished numbers. To-day they are gone. Considerable damage was done to grass, turnips, and other root-vegetables. The army-worm recently invaded Grassy Island in Saint John River, from which an annual revenue was derived from the sale of grass. This year only one-fifth of the usual amount will be realized. There has been no general invasion of this province, and the alarm has subsided.—(Boston Journal.)

I have represented on the map showing the distribution of the northern army-worm, its probable range. Having received the moth from Texas, I think there is no reasonable doubt but that it also inhabits the other Gulf States as far as and including Northern and Middle Florida.

The army-worm appears in the wheat-fields when the "wheat is in the milk." Previous to this the young larvæ are not noticed. "When less than half an inch long, the worms are scarcely recognizable as army-worms," the general color being green and only feeding by night. Riley states that "in ordinary seasons they are reported along the thirty-third parallel, as in Texas, early in March, and about a week later with each degree of latitude as we advance northward. Then, in Southern Missouri they commence to march about the middle of May; in Central Missouri the first of June, and in the extreme northern part of the State about the middle of the month. In the more northern New England States they seldom do much damage before the middle of July (we should rather say first of August). There may, therefore, be a difference of over two months between the appearance of the worms in Southern Missouri or Kentucky and in Maine."—(Riley's Eighth Report.)

The pupa.—The middle of August, the larva, full-fed, descends into the earth a few inches, and there, by constant wriggling of its body and the excretion of a sticky fluid, constructs a rough earthen cocoon; or often it merely constructs a rude cell of dry grass just below the surface, and there in a day or two, probably, as is the case with most moths, the mahogany-colored pupa, nearly an inch long, with wing-covers reaching to the last third of the body, with two spines slightly curved in, situated on the last segment, emerges from the outer larva-skin or mask, and lying there ten or fifteen days, till the tissues of the future moth shall be formed and hardened, discloses the imago or moth the last of August.

Dr. Fitch shows that the natural habitat of the army-worm is in grass, in low lands. Mr. Riley substantiates Dr. Fitch's opinion, and thus accounts for the occasional undue increase of the caterpillar: "During an excessively dry summer these swampy places dry out, and the insect, having a wider range where the conditions for its successful development are favorable, becomes greatly multiplied. The eggs are consequently deposited over a greater area of territory, and if the succeeding year proves wet and favorable to the growth of the worms, we shall have the abnormal conditions of their appearing on our higher and drier lands, and of their marching from one field to another." * * * "Thus the fact becomes at once significant and explicable, that almost all great army-worm years have been unusually wet, with the preceding year unusually dry, as Dr. Fitch has proved by record."—(Riley's Second Report.)

In this, as probably in all other insects, the unusual prevalence of the individuals is due to unusually favorable conditions for the preservation of the egg and the development of the caterpillar and chrysalis. It should be borne in mind that in ordinary years, of the one hundred eggs laid by each moth (if that be the approximate number), but a small proportion hatch, being eaten by birds and possibly destroyed by egg-parasites and by cold and damp weather. Should fifty or seventy-five worms hatch, probably only three or four perpetuate their kind; and so on throughout the insect-world. The struggle for existence is so great, each species suffering from adverse climatic causes and insect-enemies, that but a small proportion survive the perils of infancy and childhood, so to speak. Were it not so, the world would be overrun with prepotent animals and plants. The increase and great abundance of the few species are an indication of the intense struggle for existence by which the many alone maintain their livelihood.

Remedies.—If lands are burned over in the dead of the year where these eggs or pupæ or moths abound, which is the best remedy we can apply to keep off or kill off this moth, the fire will certainly kill the chrysalids just below the roots of the grass, as it surely will the eggs on the stalks or the moths nestling among them. Tracts of land in Maine thus burned over in the spring of 1861 escaped the army-worm in the summer, while farms near by suffered from the incursions of worms from the unburned grass-lands around.

Ditching, or making a deep trench with steep or undermining sides, especially efficacious in sandy soils, will do much toward keeping them out of fields of grain. People have also laid tar in the bottom of ditches, laid trains of guano, and made bonfires in them. By turning fowl and hogs into fields just as the caterpillar is going into the earth to pupate, great numbers can be destroyed, and the hogs and hens will grow fat on them.

Enemies.—That birds of different kinds feed on these caterpillars has been noticed. There are also night-birds that catch the moths as they fly. Both the larva and moth are exposed on every hand to the attacks of other insects, such as the dragon-flies, which are continually on the wing, especially over low lands. A large purple beetle with rows of golden spots on its wing-covers, the *Calosoma calidum*, which is very common in grass-lands, either running about after their prey, or lying on the watch in their holes among the grass, makes great havoc among the army-worm, and not only the beetle, but its larva, which is more voracious, if possible.

Ants are known to destroy the army-worm. I am indebted to Mr. H. I. Hershs, of Richmond, Ind., for the following instance: "In June, 1875, the army-worms took possession of a grass-plot near my study-window, and for a time threatened to strip it of every vestige of green; but I noticed a few days after they made their appearance that a large number of small black ants were waging a war of extermination against them, which, in conjunction with the unusually wet weather, soon put a stop to their depredations."

But undoubtedly the grand check that nature has imposed upon the too great increase of caterpillars are their parasites, or those ichneumon-flies belonging to the great order *Hymenoptera*, and two species of *Diptera*, or true flies, which lay their eggs on the outside of the caterpillar. The young hatching out feeds on the fatty tissues of the caterpillar, which lives just along time enough for the parasite within to come to maturity. The larger ichneumons only live singly in the body of the caterpillar, while as many as a hundred of the minute species have been seen to emerge from the dead larva-skin, their cocoons placed side by side within.

We first notice a large species which Mr. Shurtleff raised from the army-worm between the first and middle of September.

Ophion purgatus Say. This genus of ichneumons has a slender body, with long filiform antennæ. The thorax above oval, and as wide as the head. The legs are long and slender; but the most apparent character is the long compressed abdomen, which, much arched or sickle-shaped, is attached to the body by a slender peduncle. The end of the abdomen is cut off obliquely inwards below. The ovipositor is scarcely to be seen, which in most ichneumons is very long; and here we see the adaptation of this organ to the habits of the species. Instead of piercing the body of the victim and depositing the egg at the bottom of the wound, the *Ophion* merely lays its egg on the skin of the caterpillar. The egg is bean-shaped and attached by a pedicle to the skin. When the footless grub is hatched it does not entirely leave the egg-case, but the last joints of its body remain attached to the shell, while it reaches out over and with its sharp jaw-pieces gnaws into the side of the caterpillar. Some *Ophions* are parasitic in their ichneumons, just as are the species of *Chalcis* mentioned below.

This species, common in Maine, is of a pale-reddish horn color. The head is yellow, pale testaceous at the base of the antennæ. The large prominent eyes black. Three smaller black simple eyes are arranged in a triangle above, between the compound eyes. The rest of the body, especially the hind part of the thorax, and the joints and under side of the abdomen and legs beneath are covered by a bloom of minute lighter-colored hairs which have their origin in microscopic punctures. On the middle of the thorax above, a little darker; and behind, a yellowish tint. Next the insertion of the abdomen the thorax is thickly and plainly punctate. Same color beneath, except the first three joints of the abdomen, which are touched with yellow, and the lower side is generally darker.

The veins of the wings are dark; the thickened cell on the front margin of the fore wings and the adjacent veins as well as the horny triangular pieces in the cell below, the outer of which is much the smallest, are pale horn color.

Body nearly an inch long. Expanse of wings, 12½ tenths.

Mr. Walsh, of Illinois, has discovered three other ichneumons, descriptions of which we take from his pamphlet:

Mesochorus vitreus Walsh.—Male, general color light rufous. Eyes and ocelli black, antennæ fuscous except toward the base. Upper surface of thorax in the larger specimen fuscous; intermediate and posterior tibiæ with spurs equal to one-fourth their length; posterior knees slightly dusky; tips of posterior tibiæ distinctly dusky. Wings hyaline, nervures and stigma dusky. Abdomen viewed in profile, curves considerably, especially at base, and is quite narrow, except toward the tip, where it expands suddenly. The abdomen of the male is appendiculated. It is of a translucent yellowish-white in its central one-third; the remaining two-thirds piceous black, with a distinct yellowish narrow annulus at the base of the third joint. Appendiculum of abdomen composed of two extremely fine setæ, thickened at their base, whose length slightly exceeds the extreme width of the abdomen.

The female differs in the head, being from the mouth upward piceous. The thorax and pectus are piceous black. Ovipositor, which is dusky, slightly exceeds in length the width of the abdomen. Body, .08–.03 inch long.

Pezomachus minimus Walsh.—This genus is wingless, like the neuters of ants, except that their antennæ are not elbowed like those of ants.

Male, piceous. Eyes black, antennæ black, except toward the base, where they are light rufous. Legs rufous, hinds legs a little dusky. Abdomen narrowed; second and sometimes third joint annulate with rufous at tip. The female differs in the thorax, being almost invariably rufous, and in the first three abdominal joints being generally entirely rufous, with a piceous annulus at the base of the third, though sometimes absent. The abdomen is also fuller and wider. Ovipositor dusky, equal in length to the width of the abdomen. Body .07 to .1 inch long.

The cocoons symmetrically arranged side by side, and enveloped in floss, are found in the dead skins of the army-worm. A minute ichneumon, *Chalcis albifrons* Walsh, was bred from the cocoons of the *Pezomachus*.

Microgaster militaris Walsh, is another army-worm parasite. Head black; palpi whitish; antennæ, fuscous above, light brown beneath toward the base. Thorax black, polished with very minute punctures. Nervures and stigma of the wing fuscous. Legs light rufous, posterior pair with knees and tips of tibiæ fuscous. Abdomen black, glabrous, highly polished. Ovipositor not exserted. Length of body, .07 inch.

Two parasites live in this microgaster, *Hockeria perpulchra* and *Glyphe viridescens*, belonging to the *Chalcid* family of ichneumons. Walsh says:

We now know that of 145 ichneumon-flies, promiscuously taken, that had depredated on the army-worm, 27, or only 18 per cent., perished by *Chalcis* flies.

Ichneumon leucaniæ Fitch.—Dr. Fitch has given an account of another ichneumon.

This parasite resembles a small wasp, nearly half an inch long, of a bright rust-red color, its wings smoky, its breast black, and also the middle of its back, where is a small bright sulphur-yellow spot, which is the scutel. The antennæ have a milk-white band on their middle, below which band they are rush-red, and above it black. There are two narrow bands also on the back of the abdomen, placed on the fourth or fifth joint, and the slender peduncle of the abdomen is also black. Mr. Sanborn has raised this same species, as also another ichneumon, which we describe.

Ichneumon species.—Ichneumons of this genus are rather slender-bodied; the abdomen long oval. Wings not much longer than the slender antennæ, which in turn are a little more than one-half the length of the whole body. The legs and joints of the feet are also slender. The ovipositor of the female is not apparent; her eggs are pedunculated, having a general likeness to those of the genus *Ophion*.

The species before us is black and yellow. Head: face square, yellow; a dark line borders the base of the antennæ, which are rusty, the first joint yellow, and the ends dusky. Head behind the antennæ black. Thorax black; above on its first joint, or prothorax, a yellow transverse elliptical. On the second joint which carries the fore wings are two yellow stripes forking toward the head. Scutellum yellow; another transverse elliptical yellow spot behind. Third joint of thorax yellow above, black beneath. Legs: first and second pairs yellow, reddish above on first joint. Third pair black at base; second joint yellow; third, or femur, black; fourth, or tibia, black at tip. Tarsi, or toes, marked with black.

The elbowed abdomen black at base, the elbow yellow. The next three yellow joints with a narrow black strip on the front edge, the hinder edge of the ring tinged with reddish. Last three rings black.

Our last parasite is a fly, or species of the *Tachina* family, that Mr. Shurtleff and Sanborn have both raised from the army-worm, and I find it to be identical with the species that attacks the worm in the West.

Exorista leucaniæ Kirkpatrick (*Senometopia militaris* Walsh).—This genus resembles in form our common house-fly. The thorax is usually striped longitudinally, and the whole body covered with large hairs. It flies low in sunny spots in woods, with a loud buzzing noise. We copy Mr. Walsh's description, and select some interesting information he gives us about its habits:

Length, .25 to .40 inch; the females not exceeding .30 inch. Face silvery, with lateral black hairs only on the cheeks, at the top of which is a black bristle. Front golden olive, with a black central stripe, and lateral black convergent hairs. Occiput dusky. Labium, brown, with yellowish hair. Maxipalps, rufous. Eyes, cinnamon-brown, covered with very short dense whitish hair. Antennæ, two basal joints, black, with black hairs; third joint flattened, dusky, and from two and a half to three times the length of the second joint; seta, black. The entire hinder part of the head covered with dense whitish hair. Thorax glabrous, bluish-gray and lighter at the sides, with four irregular black vittæ, and black hairs and bristles. Scutel, reddish-brown, whitish behind, glabrous, with black hairs and bristles. Pectus, black, glabrous, with hairs and lateral bristles; legs, black, hairy; thighs, dark cinereous beneath; purvilli, cinereous. Wings, hyaline; nervures, brownish; alulæ, opaque greenish-white. Abdomen, first joint black; second and third, opalescent in the middle, with black and gray, and at the sides with rufous and gray; last joint, rufous, slightly opalescent at base with gray; all with black hairs and lateral bristles.

Beneath, the first joint is black; the others, black marginal with rufous, all with black hairs. In the male, the space between the eyes at the occiput is one-seventh of the transverse diameter of the head; in the female, it is one-fourth.

Some pupa-cases of this fly before me are a little more than a quarter inch long; cylindrical; rounded at each end. The last segment, barely distinguishable, has two little flattened plates that were the breathing-pores in the larva. The two first segments are partially split off, and ruptured across the end, where the fly burst out. The fly appeared the 20th of September.

"The eggs," Mr. Walsh says, "are much the shape and color of those of the flesh-fly. The fly fastens its eggs by an insoluble cement on the upper surface of the two or three first rings of the body. Instinct appears to teach the mother-fly that if she places her eggs further back, the little maggots, as they hatch out and begin to penetrate the flesh, will be felt by the victim and seized by its powerful jaws, as I have seen wood-feeding caterpillars seize and worry like a dog ants that attacked them."

Mr. Walsh had fifty or sixty worms, of which all but two had their eggs, from one to six in number, fastened on their upper side. From these he bred fifty-four *Tachinas* and two moths. "Now these army-worms averaged about three eggs apiece, and consequently two-thirds of the eggs of the *Tachina* must have perished without arriving at maturity."

"My *Tachina* eggs, so far as I noticed, did not hatch till the larva had gone under ground; but from information received from Mr. Emery, I have reason to believe that, under certain circumstances, this, or an allied species, hatches out above ground, adhering externally, and 'growing rapidly, while its victim decreases in size.' They uniformly devoured the larva before it transformed into the pupa state. The time for the entire transformation of such as I experimented upon from egg to fly, was from fifteen to nineteen days." * * * "Jefferson Russell, an intelligent farmer, had repeatedly, on damp, cloudy mornings, watched a large, bluish-green fly, about the size of a blow-fly, attacking the army-worm, and depositing its eggs on the shoulders of the victim, as he ascertained by a double lens. As they were attacked, the army-worms kept dropping to the ground and gathering in clusters, or hiding under clods, until finally the wheat on which they occurred was entirely free from them." Mr. Riley says that in 1875 fully 80 per cent. of the army-worms which he noticed were attacked by the *Tachina* flies. "They never abound or travel from one field to another, but they are accompanied by a number of two-winged flies, which are often so numerous that their buzzing reminds one of a swarm of bees."—(Eighth Report.) This fact supports the opinion of Wagner (see p.) that insect-parasites usually increase in proportion to their hosts.

Egg.—When first laid, spherical, 0.02 inch in diameter, smooth, opaque white; covered with a glistening, adhesive fluid; shell delicate, becoming faintly irridescent and more sordid before hatching.—(Riley.)

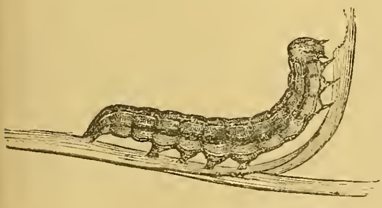


FIG. 5.—Full-grown Northern Army-worm.

Larva.—When first hatched, 1.7 millemeter in length; dull white, and a large dark head.

In the first and second stages, the two front pairs of abdominal legs are atrophied so as to necessitate a looping gait. In the third stage the looping habit is lost, but the front abdominal legs are still somewhat the smallest. In the fourth stage, the color is dull, dark green, and the chameleonitic brown lines appear.—(Riley.)

FIG. 6.—Pupa or Chrysalis.

The mature larva is about an inch and a half long. Its cylindrical body, divided into thirteen rings, becomes more contracted and wrinkled at each end, and is sparsely covered with short hairs. The head is covered by a net-work of confluent spots, while along the middle of the face run two lines diverging at each end. A light-colored waved line, just above the legs, is succeeded by a dark one; then a light one, edged with two thread-like lines; while the upper part is dark, with an interrupted white thread running exactly through the middle of the back. The prolegs, ten in number, are marked on their outer middle and on their tip with black. Beneath, the caterpillar is of a livid green.

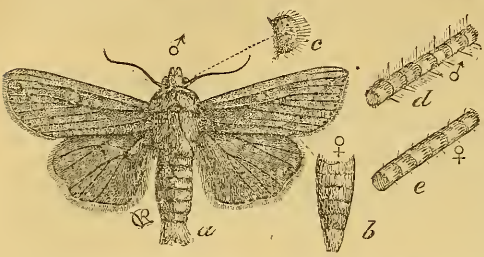


FIG. 7.—*a*, male moth; *b*, abdomen of female—natural size; *c*, eye; *d*, base of male antennæ; *e*, base of female antenna; enlarged.—(After Riley.)

Most of the Maine species of *Leucania* have light-colored wings, with dark streaks and dots, but the *unipuncta* is larger and darker colored. Its prevailing hues are rusty grayish-brown, sprinkled or peppered sparsely with black scales. The upper part of the head, the front part of the thorax or collar, and front margin of the fore wing, are of a lighter shade. Between the front margin of the fore wing and the vein, or raised line reaching out to the white spot in the center, is a rusty patch. Just beyond, about half-way between the white dot and the outer edge, is a row of about ten black dots, situated on the veins, running toward the apex of the wing, but the last three are deflected at a right angle inward and up to the front margin, while a dark line starts from the corner or curve in the line of dots, and proceeds to the upper angle or apex of the wing. The little veins of the outer edge are silvery, and between them, in a row next to the fringe, can just be seen little black dots.

The hind wings are pearly smoke-colored, darker toward the outer edge, with a central spot of the same color, which can be seen on the under side.

Beneath, the moth is a light pearly-gray. The fore wings are clouded in the middle, with a dark spot on the front margin, one-fourth of the way from the tip. The fore wings are rather more pointed in this species than the other. The body measures nearly an inch long, and the wings expand a little over an inch and one-half.

Summary.—The army-worm moth appears late in the summer or early in the autumn, when it hybernates, after laying its eggs near the roots of perennial grasses; or it hybernates in the chrysalis state and oviposits in April and May southward; later, northward. The eggs hatch and the young appear eight or ten days after, and the worms are most destructive in wet summer succeeding a dry one, when the "wheat is in the milk." The caterpillar state took a month; the chrysalis state two weeks. The species is mostly confined to the Middle and Northern States. Besides external enemies it has eight internal parasites. The best way to exterminate the worm is to burn meadows and grass-lands, where the insect lays its eggs, in the autumn.

EUROPEAN WHEAT-FLIES.—Several very destructive flies are known in Europe to injure the stalks and leaves of wheat and other cereals, and as they are liable to be imported into this country, I will refer to them. The *Oscinis granarius* in England lives in the stalks of wheat; *Oscinis vastator* in Europe damages wheat and barley by eating the base of the stalk. The larva becomes fully grown late in June, and a month later the fly appears. It is said to be attacked by numerous *Pteromalus* parasites, and a minute *Prototrupid* ichneumon oviposits in its eggs. Allied species causes the disease called "gout," producing swellings twice the size of the stalks of wheat and barley. *Oscinis frit* affects the ears of barley, in certain years destroying one-tenth of the entire crop. Two species of another genus (*Chlorops*) are especially injurious in Europe. *Chlorops lineata* destroys the central leaves and the plant itself, the female ovipositing on stems when the wheat begins to show the ear. In two weeks the eggs hatch and the fly appears in September. *Chlorops herpinii* attacks the ears of barley, from six to ten larvæ being found in the ears, destroying the flowers and rendering them sterile. In dealing with these insects plowing in has been found to be of no use, and the best preventive measure is the rotation of crops.

THE COMMON WHEAT-FLY, *Chlorips vulgaris* Fitch.—Certain small, slender, pale-green and watery-white shining maggots belonging to the above species with the others mentioned below are said by Dr. Fitch to burrow in different parts of the stalks, dwarfing and often killing them.

It was not until 1855 that it was known that wheat in this country was affected by these maggots, when they were discovered by Dr. Fitch, who thinks that it is from the number of these and other insect depredators that farmers are not now able to raise such large crops as used formerly to be harvested. The *Chlorops vulgaris* is abundant the latter part of June in wheat-fields. It is pale yellow, and 0.15 inch in length. Another fly is the *Meromyga americana* of Fitch. It is yellowish-white and a little larger than the preceding. Another minute fly, found in company with the others, is the *Liphonella obera*. It is less than a line in length and is jet-black. Still another form found in the heads of wheat in New York in June is *Oscinis tibialis*. It is only 0.08 inch in length, and also jet-black, with pale dull-yellow shanks and feet. The last fly mentioned by Fitch is *Hylemyia deceptiva*, which occurs in abundance upon heads of wheat late in June. It is ash-gray, with black legs and feelers, and a quarter of an inch in length.

INJURING THE HEADS.

THE WHEAT-MIDGE, *Diplosis tritici* of recent authors; *Cecidomyia tritici* Kirby.—Several minute orange-red maggots, one-eighth of an inch long, crowding around the kernels of wheat, causing them to shrivel and dry when ripe. The maggots descend into the ground and spin minute cocoons, from which in the following June come bright orange-colored midges.—(Fitch.)

This insect was probably imported into Quebec about the year 1820. It made its way along the Saint Lawrence and Chambly (Sorelle) Rivers into Northwestern Vermont, and soon became so abundant in New England and New York that the cultivation of wheat was mostly abandoned. Its attacks then decreased, and wheat was again raised until in the year 1854, when wheat was largely in cultivation, it again became very destructive, causing a loss in the State of New York alone, according to the estimate of Dr. Fitch, of $15,000,000. In Canada, in 1856, the loss was estimated to exceed $2,500,000. In the same year, in portions of New York, the midge destroyed one-half to two-thirds on the uplands, and nearly all on the lowlands, and the destruction was worse in 1857 and 1858. In 1858 very little white wheat was sown in Western New York, and the midge reduced the value of all the wheat-lands at least 40 per cent. In 1859 the midge unaccountably disappeared, to again become prevalent in 1861.—(Fitch.) Mr. Riley, in the New York Tribune, refers to this insect as infesting wheat in Indiana during the summer of 1876.

As regards the habits of the wheat-midge, I reproduce the following account from my "Guide to the Study of Insects:" "When the wheat is in blossom, the females lay their eggs in the evening by means of the long retractile tube-like extremity of the body within the chaffy scales of the flowers, and in clusters of from two to fifteen or more. In eight or ten days the eggs disclose the transparent maggots, which, with age, become orange-colored, and, when fully grown, are one-eighth of an inch long. They crowd around the germ of the wheat, which, by pressure, becomes shriveled and aborted. At the end of July and in the beginning of August, the maggots become full-fed, and in a few days molt their skins, leaving the old larva-skin entire, except a little rent in one end of it. 'Great numbers of these skins are found in the wheat-ears immediately after the molting process is completed.'

Sometimes the larva descends to the ground and molts there. Harris states that 'it is shorter, somewhat flattened, and more obtuse than before, and is of a deeper yellow color, with an oblong greenish spot in the middle of the body. In this state, which is intermediate between the larva and pupa states, which has, by Dr. Fitch, been termed the "embryo-pupa" and by us "semi-pupa," the insect spins a minute silken cocoon, which, according to Dr. Fitch, is smaller than a mustard seed, and remains in the ground through the winter, situated at the depth of an inch beneath the surface. In the next June they are transformed to pupæ, with the limbs free. When about to assume the adult state, the pupa works its way to the surface in June and July.'"

Description.—The eggs of the wheat-midge are long, oval-cylindrical, and tinged with pale red. When the larva is at rest it is oval, flattened on the under side, deep yellow, and 0.08 inch long. The female fly is nearly one-tenth of an inch long, bright orange or lemon-yellow, and tarnished or slightly smoky on the back forward of the wings, the latter clear, with a small cross-vein near their base; the antennæ are about as long as the body, and composed of twelve oblong joints, which are narrower in their middles and separated by short pedicels. In the males the antennæ are remarkably long, slender, and delicate, and consist of twenty-four globular joints; it is smaller, but in other respects agrees with the female.—(Fitch.)

Parasites.—Dr. Fitch has shown that when the midges increase or diminish in numbers its parasites increase or diminish in the same ratio, "the same as the Hessian fly, once so frightfully destructive to our wheat-crops here in America, has become subdued by its parasites, whereby it is seldom noticed now or known to be present in our country, although it can be found almost every year in our wheat-fields, showing it is still with us, everywhere ready to again increase and become destructive were it not constantly repressed and kept down by its parasitic foes." Mr. Curtis is quoted as saying that in Europe "these parasites so effectually execute their mission, that it has often happened a year or two after the midges were in excess not a specimen could be found." Its destructiveness in this country is due to the fact that we have no native parasites to keep it within proper limits, and Dr. Fitch urges that the parasites be imported from Europe.

GRAIN-APHIS, *Aphis avenæ* Fabricius.—Multitudes of dark plant-lice, clustering on the heads of wheat in August, blackening the fields of grain, and, by sucking the kernels, causing them to shrink in size and diminish in weight.

We will suppose a number of eggs to hatch out their wingless females; with an occasional winged individual there are as yet no males in existence, and yet these virgin aphides, or plant-lice, every few days produce hundreds of young alive; each of which in turn come to maturity and produce their young alive. Hence, by the end of summer we have millions of lice overrunning our wheat-fields, the very youngest as well as the oldest as if for their lives sucking in the sap from the ear of the grain. For by a marvelous adaptation to their mode of life, what in beetles are jaws for biting are here lengthened out and joined together to form a tube, with a sucking-stomach at the base. This tube the louse forces into the root of the ear, and thus anchored by their jaws, whole groups cluster head downward on the heads of grain, and by their numbers color a whole field. But the supply of liquid food is greater than the aphides can manage, hence two tubes open out from the hind part of the abdomen, from which exudes a sweet sticky fluid called "honey-dew." Ants come to eat it as it falls on the leaves, or lap it from the honey-tubes of the aphis, and as the supply lessens, they gently strike the aphis with their antennæ to make them yield more.

At the approach of cold weather, when the whole race of aphides must be cut off, the virgin females produce winged individuals of both sexes, which after pairing die, after depositing their eggs for the spring brood.

Our species is oblong-oval shaped, narrowing toward the head, while the abdomen behind is swelled out and rather blunt at the end, with a rather long ovipositor in the female. Its color is green, covered often with a reddish-brown bloom. The ends of the antennæ, the end of the shanks and thighs and the feet, are black. In the young, these parts are only smoky or dusky. Length of those with wings about one-tenth of an inch.

Dr. Fitch gives in the Boston Courier, interesting observations on this aphis. Of its variation in color he says: "One of the most remarkable circumstances relating to these insects is the change in their color which now began to take place. While they were scattered about upon the leaves and stalks of the grain, they were of a bright grass-green color. Now orange-yellow or deep flesh-red individuals began to appear among them. This color is so wholly different from green, that these orange ones might be suspected to be a different species. But green females placed in vials were found next day to have young with them of both colors; some being green, others orange. And a few days later other green females were found to have orange young only, no green ones being born any longer. It is probably the change in the quality of its food which causes the insect to change thus in its color, the juices which the plant elaborates for the growth of its flowers and seeds being much more highly refined, nutritious, and dainty than those which circulate in the stalks and leaves, where the insect first feeds. And it is truly curious and wonderful that this green-colored insect, on coming to feed on the juices which grow the flowers, begins thereupon to give birth to young having a gray orange color similar to that of the flowers."

Dr. Fitch noticed several years ago in wheat-fields a green plant-louse, though it was not common.

In East Hampden, Mass., "a plant-louse of a pale brick-red color was extremely numerous" in 1860; so, also, a "red insect" on the oats in New York was sent him. We thus know the insect we are to speak of was overrunning the fields in some places last summer.

"Early in May last, when rye and winter-wheat were but a few inches out of the ground, I met with this insect more numerous than any other in every part of every grain-field in my neighborhood. Toward the close of that month specimens having wings began to occur. By inclosing them singly in vials, I found that the winged female usually gave birth to four young lice in twenty-four hours, while those without wings produced eight within the same time."

The grain-aphis became noticed the 18th July in New Jersey, then in the New England States. Probably very few farms in Maine escaped its presence. About the first of August I noticed them on a farm about thirty miles above Mattawamkeag, on the Penobscot River. Also on farms on the lakes that form the headwaters of the Penobscot and Alleguash Rivers, and on the Alleguash and Saint John. I also heard of its occurrence in great numbers on the Saint John in New Brunswick. Like the army-worm, while abundant on some fields, others were entirely free from its attacks.

The injury this aphis does is to lessen the weight of the grain, which of course is a matter of great consequence. The constant draining of the sap that flows into the ear causes it to be very light, if not withered and worthless.

Parasites.—Artificial means of driving off this pest have not yet been contrived. It has been suggested to kindle fires, throw on damp straw, and let the wind carry the smoke over the field.

But the external enemies of this aphis are ready to help us. The lady-bugs, *coccinella*, as larvæ and beetles, the golden-eyed flies, *chrysopa*, as larvæ, have been seen the past season in great numbers in wheat-fields, busily engaged in devouring the plant-lice.

These minute insects have also their internal parasites, little ichneumons of the genus *Aphidius*. We have to go again to Dr. Fitch's article for information respecting their habits:

"On many of the wheat-heads, may at present (August 6) be noticed from one to a half dozen or more of these lice, which are very large, plump, and swollen, of the color of brown paper, standing in a posture so perfectly natural you suppose they are alive. Touch them with the point of a pin, you find they are dead. Pick off a part of their brittle skin; you see there is inside a white maggot doubled together like a ball. Put one or two of these wheat-heads in a vial, closing its mouth with a wad of cotton. In a week's time, or less, you find running lively about in the vial some little black flies, like small ants. These you see have come out from the dead lice, through a circular opening which has been cut in their backs. Drive one or two of these flies into another vial, and introduce to them a wheat-head having some fresh lice. See how the fly runs about them, examining them with its antennæ. Having found one adapted to its wants, watch how dexterously it curves its body forward under its breast, bringing the tip before its face, as if to take accurate aim with its sting. There, the aphis gives a shrug, the fly has pricked it with its sting, an egg has been lodged under its skin, from which will grow a maggot like that first seen inside the dead, swollen aphis. And thus the little fly runs busily around among the lice on the wheat-heads, stinging one after another, till it exhausts its stock of eggs, a hundred probably, or more, thus insuring the death of that number of these lice. And of its progeny, fifty it may be supposed, will be females, by which five thousand more will be destroyed. We thus see what efficient agents these parasites are in subduing the insects on which they prey. I find three different species of them now at work in our fields destroying this grain-aphis."

THE WHEAT-HEAD ARMY-WORM, *Albilinea* Huebner.—Injuring the heads of wheat, rye, and barley, beginning at the base, sometimes the center of the ear, sometimes hollowing out the soft grains, leaving nothing but the shell and the chaff; a caterpillar resembling the northern army-worm, but striped with sulphur-yellow and light and dark brown.

Though this is a common and wide-spread insect, ranging from Maine to Kansas and southward, it was not known to be injurious to crops until 1872, when it was found, according to Riley, seriously injuring oats in Pennsylvania. In 1874 and 1875 it was reported to injure wheat and timothy heads in Maryland and Pennsylvania. It was described as "hollowing out the soft grains and leaving nothing but the shell and the chaff," and "in some rye-fields the heads are almost void of grains and the ground literally covered with chaff, and that late-sowed rye would not be worth the harvesting were it not for the straw." It was more widely destructive in the Eastern States in 1875 than in 1874. June 14, 1876, Mr. J. W. Robson, of Dickinson County, Kansas, wrote Mr. Riley that for ten days past it had been noticed in the wheat. "The caterpillars begin their depredations at the base of the ear, and sometimes near the center of the ear. In one field that I examined to-day the caterpillars were abundant.

They were mostly at rest, reclining at full length on the straw, while only a few were feeding on the ears."

Larva.—The best marked worms are prettily striped with sulphur-yellow and straw-yellow, and with light and dark brown, as follows: A broad, dark-brown line along the back, divided along the middle by a fine white line generally obsolete behind; beneath this broad line on each side a straw-yellow line, half as wide; then a light-brown one of the same width as the last, and becoming yellow on the lower edge; then a narrower dark-brown one, containing the white spiracles; then a sulphur-yellow as wide as the third; then a less distinct light-brown subventral one, the venter being pale yellow. The head is large, straw-colored, and with two attenuating brown marks from the top to the lower face. The chrysalis is of the ordinary mahogany-brown color, and terminates in a stout horny point, with a corrugated base.

Adult.—The moth has the front wings straw-colored, with a pale line running along the middle to the outer third, and shaded with brown as follows: A shade beneath the white line, intensified at each end where it joins the white; another, along the posterior border, narrow at apex and broadening to the middle, where it projects along the middle of the wing above the white line, fading away toward base, and a fainter shade along the front or costal edge, intensifying toward apex. The species is one of the smallest of the genus, having but two-thirds of the size of the army-worm.—(Riley.)

THE WHEAT-THRIPS, *Limothrips tritici* Fitch.—"Upon the heads and stalks in June and July, exhausting the juices of the kernels and rendering them dwarfish and shriveled; exceedingly minute, active, long, and narrow six-legged insects, of a bright-yellow or of a shining-black color."—(Fitch.)

The wheat-thrips in this country also occurs on the onion, and is described more fully under the head of onion-insects. It represents the *Phlœothrips cenalium* of Europe, which does, at times, extensive injury to the wheat, gnawing and puncturing the seed, causing it to shrink and become what the farmers call "pungled." It also gnaws the young stalks just above the knots, causing the ear to become abortive. Another species common on wheat in New York, in June, is the Three-banded Thrips (*Coleothrips trifasciata*) of Fitch. It is nearly double the size of the wheat-thrips, being 0.07 inch in length, and is black; the dark wings having three broad white bands across them, while the antennæ arise close together, "and are composed of only five principal joints, of which the two first are short, and a third thicker than the others, which are long and cylindrical, the last one gradually tapering to a slender point, its apical portion being divided into small indistinct segments."

THE WHEAT-WORM, *Anguilluta tritici* Bauer.—Filling the cavities of a grain of wheat, a white fibrous substance, formed by gluten into balls of a silky nature, which instantly dissolve in water and exhibit hundreds of minute worms, causing the disease called "ear-cockle" or "purples."

Although this worm has not yet been observed in America so far as I am aware, it is not improbable that this disease occurs with us, though not yet detected. I abstract the following account, often word for word, from Curtis's "Farm Insects." Mr. Curtis took his description of the worm and its habits from Bauer's notes contained in Professor Henslow's "Report on the Diseases of Wheat."*

"The eggs are taken up by the sap from the infected grain which may have been planted, and hatch in the stalk as well as in the seed. The largest worms are $\frac{1}{4}$ inch long at least, of a yellowish-white color, and not so transparent as the young worms. Their heads are

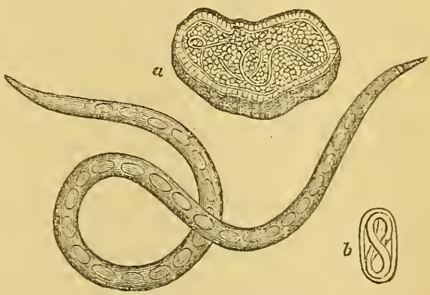


FIG. 8.—*Young Wheat-Worm, greatly magnified.* *a*, section of a grain exhibiting some worms and multitudes of eggs, magnified; *b* an egg containing a worm ready to hatch. (From Curtis, after Bauer.)

* Journal of the Royal Agricultural Society, vol. ii, p. 19.

very distinct; they have a proboscis, which has three or four joints, which they contract or extend like an opera-glass. From the head, which is somewhat roundish, they taper gradually off toward the tail, which is scarcely half the diameter of the middle of their body, and ends in an obtuse, claw-like point. At a short distance from the end of the tail is an orifice surrounded by an elevated fleshy edge; from this orifice the worms discharge their eggs. The back of these old worms is nearly opaque, and appears jointed or annular; the number of joints or rings is from twenty-five to thirty. The belly-side is more transparent, and strings of ova can be distinctly seen through almost the whole length of the worm to the orifice by which the eggs are discharged." Those in the cavities of the mature grain are generally $\frac{1}{33}$ or $\frac{1}{36}$ inch long, milk-white, and semi-transparent. After laying all their eggs the parent worms soon die, and in a few days they decay and fall to pieces; but such is not the case at an earlier period of life, for after being dried, and appearing quite dead, on the application of moisture they become as lively as they were at first, and thus for five years and eight months Mr. Bauer was able to re-animate the worms by immersion, but it required a longer period as the time lengthened, and after that they died; other examples bred by him retained their reviviscent qualities for six years and one month. It seems probable that the glutinous substance in which they are enveloped preserves their vitality. They may be kept alive for three months in water.

"It appears from Mr. Bauer's investigations that the cavities of the grain are at first filled with a white fibrous substance, formed by gluten into balls of a silky nature. In water they instantly dissolve, and exhibit hundreds of minute worms, which become animated in less than a quarter of an hour when moistened, and the grains eventually assumed a dark-brown color, and were as hard as wood."

In some grains approaching maturity only one worm was found with the cluster of eggs, in others there were three (Fig. 8), the section of a grain exhibiting some worms and multitudes of eggs. The eggs come forth in strings of five or six together, and are detached in water; the young worms can then be seen through the transparent skin. (Fig. 8.) In about an hour and a half after the egg is laid in water the young worm begins to extricate itself, which it took one of them an hour and twelve minutes to accomplish.

INJURING STORED GRAIN.

THE ANGOUMOIS GRAIN-MOTH, *Gelechia cerealella* Linn. (Plate LXV, Figs. 7, 8.) Devouring the interior of the stored grains of wheat and corn, and transforming, within the grain, a soft, thick, fleshy caterpillar.

This destructive moth is found in granaries in this country, having been introduced from Europe, where it has been extremely destructive, especially in the French province of Angoumois, from which it has derived its common name. The first account of its occurrence in this country was published in 1768. It was then destructive to stored grain in Virginia, but was said to injure wheat forty years previous in North Carolina. Harris also adds that the French naturalist, Bosc, in 1796, or soon after, found this moth "so abundant in Carolina as to extinguish a candle when he entered his granary in the night." Harris further states that this grain-moth spread from North Carolina and Virginia into Kentucky and Southern Ohio and Indiana, "and probably more or less throughout the wheat region of the adjacent States, between the thirty-sixth and fortieth degrees of north latitude," and it has been found even in New England. "Wheat, barley, oats, and Indian corn suffer alike from it, the last especially when kept unprotected more than six or eight months."—(Harris.)

The moth lays mostly in June and August, but probably at other times during the year, from sixty to ninety eggs in clusters of about twenty in a single grain of wheat or corn. In from four to six days the larvæ disperse, each selecting a single grain, burrowing in at the end whence the plumule grows out. The caterpillar, after eating out the inside of the grain of wheat or corn and exhausting its supply of food, sometimes eats its excrement once or even a second time. It transforms within the grain, spinning a silken web, and before pupating (*i. e.*, transforming to a pupa) gnaws a hole nearly through the shell for the exit of the moth. The larvæ of the first, or summer, brood mature in about three weeks, the moths appearing at harvest time. Those of the second brood hybernate in the grain, changing into moths the following summer.

Description.—The caterpillar (Plate LXV, Fig. 8, much enlarged) is unusually thick and plump, the skin being unusually thin and transparent. The moth (Plate LXV, Fig. 5) is ochreous with a dark-brown streak toward the base, and a few dark dots toward the end of the fore wings, while the hind wings are grayish-ochreous; sometimes the fore wings are unspotted. The wings are long and narrow, beautifully fringed, and expand about half an inch. Several chalcid parasites prey upon it.

Remedies.—Dry the grain in an oven or kiln with a heat of 167° Fahrenheit for twelve hours; fumigate in close vessels with charcoal-gas. Early thrashing and winnowing should be practiced, not later than the end of July. The grain should be stored in tight bins.

THE GRAIN-TINEA, *Tinea granella* Linn. (Plate LXV, Fig. 9.)—Devouring the interior of grains of wheat, tying several grains together, but transforming in cracks, etc., in the floor; a slender caterpillar.

This is also a European importation, and is more or less injurious to stored grain, though less so than the Angoumois moth. It is found flying in granaries in summer. The female lays from thirty to forty eggs, one or two in each grain. The caterpillar hatches in a few days and eats into the grain, closing the entrance with its castings, and after devouring the interior of one grain passes into others, uniting them with silk threads forming a web. When about to transform it deserts the grain, retires to cracks in the floor and constructs a cocoon, often by gnawing the wood and weaving the chips into its web until the cocoon has the form and size of a grain of wheat. In this it hibernates, changing to a pupa in the spring, and in two or three weeks appearing as a moth.

Description.—The larva is cylindrical, with long, fine, scattered hairs, and of a light-buff color, with a reddish head. It is about four or five tenths of an inch in length. The moth differs entirely from the Angoumois moth in form, and is creamy-white, with six brown spots on the costa of the fore wings, and with dark hind wings. The wings expand 0.06 inch.

Remedies.—Besides those suggested for the attacks of the preceding grain-moth, the granary when empty should be thoroughly cleansed and whitewashed, or washed with coal-oil, and when the caterpillars are at work the grain should be often and thoroughly stirred about.

THE GRAIN-WEEVIL, *Sitophilus granarius* (Linn.). (Plate LXV, Fig. 10 *e*.)—A short, maggot-like grub, eating the interior of the grain and transforming into a minute reddish weevil, which also injures stored grain.

While the wheat-fly and several other insects are dubbed "weevils" by the ignorant, the present insect and the rice-weevil are the only ones found injuring wheat, and then only when stored. I copy the following account of this common weevil from Harris, knowing nothing personally of the insect: "This little insect, both in the beetle and grub states, devours stored wheat and other grains, and often commits much havoc in granaries and brew-houses. Its powers of multiplication are very great, for it is stated that a single pair of these destroyers may produce above six thousand descendants in one year. The female deposits her eggs upon the wheat after it is housed, and the young grubs hatched therefrom immediately burrow in the wheat, each individual occupying alone a single grain, the substance of which it devours, so as often to leave nothing but the hull; and this destruction goes on within while no external appearance leads to its discovery, and the loss of weight is the only evidence of the mischief that has been done to the grain. In due time the grubs undergo their transformations, and come out of the hulls, in the beetle state, to lay their eggs for another brood.

Grub and beetle.—The grub is short, thick, fleshy, maggot-like; while the weevil is "a slender beetle of a pitchy-red color, about one-eighth of an inch long, with a slender snout slightly bent downward; a coarsely-punctured and very long thorax, constituting almost one-half the length of the whole body, and wing-covers that are furrowed and do not entirely cover the tip of the abdomen."

Remedies.—These insects are effectually destroyed by kiln-drying the wheat; and grain that is kept cool, well ventilated, and is frequently moved, is said to be exempt from attack.—(Harris.)

The rice-weevil, *Sitophilus oryzæ* Linn. (Plate LXV, Fig. 10 *a*, *b*, *c*), attacks stored rice, and also grain and corn. It differs from the *S. granarius* in having two large red spots on each wing-cover, and in being a little smaller, as it measures only a line in length, exclusive of the snout. It is abundant in the Southern States, where it is called the "black weevil." In the South it is said, according to Harris, to lay its eggs on the rice in the fields; but this statement needs confirmation. "The parent beetle bores a hole into the grain, and drops therein a single egg, going from one grain to another till all her eggs are laid; she then dies, leaving, however, the rice well seeded for a future harvest of weevil-grubs. In due time the eggs are hatched, the grubs live securely and unseen in the center of the rice, devouring a considerable portion of its substance, and when fully grown they gnaw a little hole through the end of the grain, artfully stopping it up again with particles of rice-flour, and then change to pupæ. This usually occurs during the winter; and in the following spring the insects are transformed to beetles, and come out of the grain. By winnowing and sifting the rice the beetles can be separated, and then should be gathered immediately and destroyed." (Harris.) Besides these insects of the granary Dr. Fitch describes the *Agromyza tritici*, which sometimes occurs in great numbers in stored wheat in New York.

THE GRAIN SYLVANUS, *Silvanus surinamansis* (Linn.).—A small brown beetle gnawing the ends of rye, oat, and wheat grains.

This is a very common and annoying little beetle, which in Europe is known to be a great pest in stores and warehouses. In Pennsylvania, it has been found to injure stored rye, wheat, and oats, eating holes in the grain. It is a little flat, brown beetle, not quite a line in length, characterized chiefly by the last three joints of the antennæ being enlarged, and by having three prominent longitudinal ridges on the thorax, which is armed on the sides with six teeth.

Remedies.—"The best way to get rid of it, when the grain cannot be subjected to a killing heat, is to stack the grain a year or two until the insects are starved out of the barns, just as they lay by ships in the grain-trade, or use them for other freight when they once become infested with this insect, or with the true grain-weevil."—(Riley.)

AFFECTING INDIAN CORN.—INJURING THE ROOTS.

CUT-WORMS, *Agrotis suffusa* (Denis and Schiefermüller) and other species. (Plate LXV, Figs. 2, 3, 4, 5.) Eating the roots of corn and other cereals; large, dark, obscurely-colored, smooth-bodied caterpillars, hiding by day and feeding by night.

Not only Indian corn but other cereals and grasses are indiscriminately attacked by different species of caterpillars called cut-worms from their habit of cutting off young, succulent plants as they are coming up out of the ground. They are thick, with a distinct horny prothoracic plate, and are usually marked with shining and warty, or smooth, spots of the same general color as the rest of the body; they are usually striped longitudinally. They are seen early in spring hiding under sticks and stones, having hibernated in this state. They feed by night, hiding in the day-time. The chrysalids are situated under ground. They transform to moths, sometimes call dart-moths, which might be known by their crested trunks and ciliated or pectinated antennæ, while the fore wings are rather narrow, usually with a dark dot near the middle of the wing, and just beyond a reniform marking, while there is usually a basal, median, black streak. The moths appear in midsummer, and lay their eggs near the roots of grasses, which hatch in the autumn, the worms living on roots and sprouts of herbaceous plants. "On the approach of winter they descend deeper into the ground, and, curling themselves up, remain in a torpid state until the following spring, when they ascend toward the surface, and renew their devastations."—(Harris.)

Our largest species, *Agrotis suffusa* (Plate LXV, Fig. 2), was probably imported from Europe. The caterpillar is described as follows by Riley:

Its general color above is dull, dark, leaden-brown, with a faint trace of a dirty yellow-white line along the back. The subdorsal line is more distinct, and between it and the stigmata are two other indistinct pale lines. There are eight black, shiny, piliferous spots on each segment, two near the subdorsal line, the smaller a little above anteriorly; the larger just below it, and a little back of the middle of the segment, with the line appearing especially light above it. The other two are placed each side of the stigmata, the one anteriorly a little above, the other just behind, in the same line with them, and having a white shade above it.

Another cut-worm, which is still more abundant in the Middle and New England States, is the young of the Clandestine moth (*Noctua clandestina* of Harris), and may be called the Corn cut moth. While the fully-grown caterpiller has not been described, the young are said by Harris to be "more or less distinctly marked above with pale and dark stripes, and are uniformly paler below." According to Melsheimer, as quoted by Harris, when first hatched, it feeds on the various grasses, descending, when half-grown, in the ground on the approach of severe frosts, and re-appearing in the spring, and then beginning to grow again, attaining their full size and pupating before the middle of July, often much earlier, as in the New England States the moth is seen from the middle of June to the middle or end of August.

Moth.—It is of a peculiar dull-blackish, with the body very flat when the wings are expanded, and with obscure markings. "The fore wings are generally of a dark ash-color, with only a very faint trace of the double transverse wavy bands that are found in most species of *Agrotis;* the two ordinary spots are small and narrow, the anterior spot being oblong oval, and connected with the oblique kidney-shaped spot by a longitudinal black line." The hind wings are rather dark, and the head and legs darker than usual, almost blackish. It expands an inch and three-quarters.

Remedies.—Among the more general preventive remedies, suggested by Harris, are the soaking of corn, before planting, in copperas-water, and mixing salt with the manure, though these are of less use than plowing deep in the autumn so as to turn up the half-grown worms, so as to expose them to winter colds and insectivorous birds. When the worms have begun their attacks, hand-picking, *i. e.*, digging up the worms which hide by day in the soil around the plant, is, of course, the most efficacious remedy. An excellent plan is to make a deep hole, with a stake, in the hills, down which trap the caterpillar is liable to fall.

WIRE-WORMS.—Eating the roots of corn and wheat, hard cylindrical, round, reddish worms, tapering toward the head and tail, and changing into snapping-beetles.

The roots of corn, wheat, and grasses are often injured to a lamentable extent by wire-worms, the larvæ of various species of snapping-beetles belonging to the family *Elateridæ*.

THE CORN-MAGGOT, *Anthomyia zeæ* Riley.—Gnawing seed-corn after it is planted; a maggot like the onion-worm.

This maggot has been found to injure seed-corn just after being planted, and to abound to such an extent as to nearly ruin whole corn-fields, as it gnaws into the corn, finally causing it to rot. When fully fed they contract, forming a barrel-shaped brown case (Fig. 8, *b*), within which lies the pupa, and in a week after the flies appear. As a remedy, soak the corn before planting in gas-tar or copperas-water.

Fig. 9.—*Corn-Maggot.* *a*, larva, enlarged; *b*, pupa-case; *c*, corn injured by worms, natural size.

Larva.—Closely resembling the maggot of the onion-fly; yellowish-white; blunt at the posterior end and pointed in front. It is about a quarter of an inch in length.

Fly.—Head tawny in front, with a brownish edge; antennæ black; face and orbits brownish-white; thorax and abdomen pale yellow-brownish ash-colored; thorax with an indistinct middle stripe of brown; legs black. Length one-fifth of an inch.—(Riley.)

THE CORN-WEEVIL, *Sphenophorus zeæ*.—Puncturing large holes in young corn near the base of the stalk, before it has spindled, and sometimes destroying whole fields of young corn.

In the Practical Entomologist (vol. ii, p. 117, 1867) the late Mr. Walsh described this weevil, and gave an account of its ravages in the Middle and Western States. Mr. Robert Howell, in Tioga County, New York, was among the first to detect it, and under date of June 14, 1869, he writes me that "this is the fourth year they have infested the newly-planted corn in this vicinity. The inclosed specimens were taken on the 11th instant. I presume they have been in every hill of corn in my field. They pierce the young corn in numerous places, so that each blade has from one to six or eight holes the size of a pin or larger, and I found a number last Friday about an inch under ground, hanging to young stalks with much tenacity. When very numerous, every stalk is killed. Some fields, two or three years ago, were wholly destroyed by this insect." I have detected this insect at Hyannis, Mass., June 25.

It is a rather large black weevil, with a long, narrow, subcylindrical body, and with coarse gray punctures. The head is black, finely punctured, with still more minute punctures on the beak. At the base of the beak just between the eyes is a small oval pit. The beak is nearly one-third as long as the body; it is curved downward, slightly compressed, with the tip seen from above dilated slightly and triangular.

On the prothorax is a long, lozenge-shaped, smooth black median area, with two smooth spots on the side near the front; these, with two longer diverging spots behind, form an inverted Y on each side of the body. Behind are coarse gray punctures. The wing-covers are marked with rows of coarse punctures along the striæ, much larger than those on the thorax. On the smooth spaces between the striæ is a row of more or less crowded minute punctures. On the base of the elytra, near the outer edge, is a low smooth tubercle, and a larger one near the tip. On the extreme tip of the abdomen, near the elytra, are two short diverging rows of fine stiff tawny hairs, which stand out straight from the end. The legs are black, the tarsi reddish, piceous. Beneath, the body is black and widely punctured. It measures 0.40 of an inch in length.

Remedies.—Until we know more of its habits, its mode of life in the larva stage, and its native food-plant, we are at a loss to suggest remedies against the attacks of this insect. When the corn is observed to be suffering from their punctures, they should be picked off with the hand, and the young blades of corn carefully watched. These weevils are so large as to be readily detected after a little practice.

THE SPINDLE-WORM, *Achatodes zeæ* (Harris).—Boring in the stalk before the corn-spindles, causing the leaves to wither, a caterpillar an inch long, smooth and naked, with the head and last segment black.

The ravages of this worm generally begin, says Harris, "while the corn-stalk is young, and before the spindle rises much above the tuft of leaves in which it is embosomed. The mischief is discovered by the withering of the leaves, and, when these are taken hold of, they may often be drawn out with the included spindle. On examining the corn, a small hole may be seen in the side of the leafy stalk, near the ground, penetrating into the soft center of the stalk, which, when cut open, will be found to be perforated, both upward and downward, by a slender worm-like caterpillar, whose excrementitious castings surround the orifice of the hole." It also bores into the stalks of the dahlia and of the elder. The brown chrysalis is rather slender, and is found within the burrow made by the caterpillar.

Larva.—Smooth and apparently naked, yellowish, with the head, the top of the first and of the last wings black, and with a double row, across each of the other rings, of small, smooth, slightly elevated, shining black dots.

Moth.—The fore wings rust-red; they are mottled with gray, almost in bands, uniting with the ordinary spots, which are also gray and indistinct; there is an irregular tawny spot near the tip, and on the veins there are a few black dots. The hind wings are yellowish-gray, with a central dusky spot, behind which are two faint, dusky bands. The head and thorax are rust-red, with an elevated tawny tuft on each. The abdomen is pale brown, with a row of tawny tufts on the back. The wings expand nearly an inch and a half.—(Harris.)

Remedies.—The obvious remedy is, when the leaves are seen to wither, to cut open the stalk, and, on finding the worm, pull all the infested plants.

THE STALK-BORER, *Gortyna nitella* Guenée (Plate LXV, Fig. 6), moth and caterpillar Boring in the stalks of corn, potato, tomato, etc., a caterpillar of a pale, livid hue, with light stripes along the body; also sometimes boring into the cob of growing Indian corn.

This borer not only infests corn and potatoes, but also the tomato and the dahlia, aster, etc., according to Riley. The worm is not found in the Western States earlier than June and July, and the moths appear late in August and early in September. The insect is probably single-brooded. "The young worm hatches about the 1st of July and immediately commences its work of destruction. It works in such a surreptitious manner as to be too often unnoticed till the vine is destroyed. The plant does not generally show any signs of decay until the cocoon is about fully grown, when it wilts and is past recovery. This occurs about a month after the worm is hatched, and it then crawls just under the surface of the ground, fastens a little earth together around itself by a slight net, and changes to a chrysalis of a very light mahogany-brown color, and three-fourths of an inch long. The moth comes forth the fore part of September. The careful culturist need fear nothing from this troublesome insect, as an occasional close inspection of the plants about the 1st of July will reveal the hole where the borer has entered, which is generally quite a distance from the ground, and by splitting downward one side of the stalk with a penknife it may be found and killed. If this inspection be made at the proper time the worm will be found but a short distance from the hole, and the split in the stalk will heal by being kept closed with a piece of thread."—(Riley.)

Description of the larva.—Of a livid hue when young, with light stripes along the body; when full grown, it generally becomes lighter, with the longitudinal lines broader.

Moth.—Of a mouse-gray color, with the fore-wings finely sprinkled with Naples-yellow, and having a very faint lilac-colored hue; but distinguished mainly by an arcuated pale line running across their outer third.—(Riley.)

Besides the chinch-bug, and also other insects already noticed among those preying on wheat, the leaves of corn are infested by the young of the large Io moth and by the *Arctia arge.*

The cotton-boll worm (*Heliothis armigera*) sometimes attacks corn in the ear, eating the silk, and afterward devouring the terminal kernels, hiding within the husk. Whole fields of corn have been thus injured in Kentucky, but it is most destructive in Southern Illinois, where there are two broods of the worm, the early and late corn faring the worst.

INJURING THE ROOTS AND LEAVES OF GRASS.

Besides most of the insects previously mentioned, which injure the roots and stalks of cereals, the grass on lawns is often killed in patches by the white grub or larva of the June beetle (*Lachnosterna fusca*, Fig. 10). So effectually are the roots eaten that the sod can be rolled up like a carpet. The white grub is injurious on lawns in Illinois, as well as in the New England States. Wire-worms, the larva of the various species of *Neonympha*, cut-worms, the larvæ of crane-flies (*Tipula*), and of the salt-marsh caterpillars (*Leucarctia acræa*), and very homopterous insects, such as the spittle insects, especially *Ptyches lineatus*, (Fig. 11), are dependent for their livelihood on grasses. The latter is a very abun-

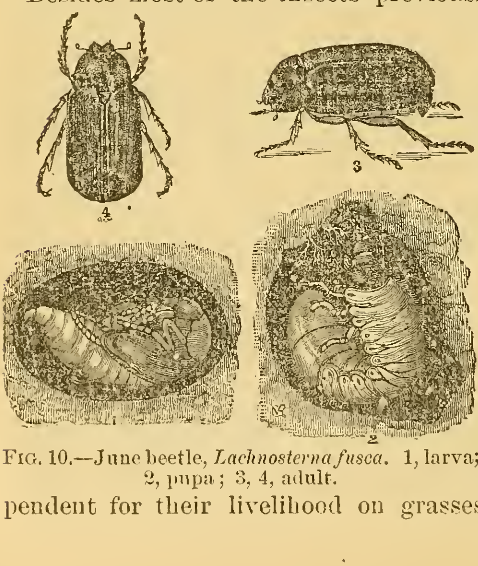


FIG. 10.—June beetle, *Lachnosterna fusca*. 1, larva; 2, pupa; 3, 4, adult.

dant insect in early summer, living in the center of a mass of frost on the leaves of grass. The larva is to be found concealed in a mass of frost late in May and early in June; the adult is exceedingly abundant late in summer.

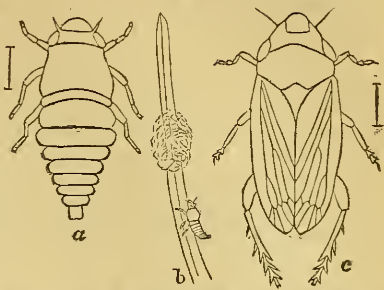


FIG. 11.—Spittle Insect. *a*, larva, enlarged; *b*, natural size of larva; *c*, adult, enlarged.

Clover is attacked by various insects, especially the larva of *Drasteria erechtia*, a moth very abundant in May, and again in August and September, in grass-lands. The seeds are sometimes inhabited by minute weevils, while clover, when stacked or even housed, is sometimes injured by the "clover-worm," the larva of *Asopia costalis*, a dull, whitish worm, changing to a lilac-colored moth ornamented with golden lines and fringes.

THE COLORADO POTATO-BEETLE, *Leptinotarsa decemlineata* of Gemminger and Harold, *Doryphora 10-lineata* Say.—Devouring the leaves, sometimes the tubers, a large, thick-bodied, reddish-orange grub, spotted on the sides with black, changing under ground into a large hemispherical yellow beetle about half an inch long, with ten wide black stripes on the back; three broods of the worm appearing in one season.

Its original habitat.—This beetle was originally described by Mr. Say in 1824, having been found by him the year previous, when he remarked, "This species seems to be not uncommon on the Upper Missouri, where it was obtained by Mr. Nuttall and by myself. The variety (white with two of the lines united, probably the species *juncta*) I found on the Arkansas." (Journal Academy of Natural Sciences Philadelphia, vol. iii, 1824.) This would indicate that its native habitat was the plains of Dakota, Western Nebraska and Kansas, Colorado, and perhaps the western portion of Indian Territory and Texas. Dr. G. H. Horn, the well-known coleopterist, writes me as follows: "West of the Mississippi I have it from Texas. I have never seen it from Mexico nor west of the Rocky Mountains. If it goes west, I believe it will be through New Mexico and Arizona, and not over the Rocky Mountains."

Lieutenant Carpenter, U. S. A., writes me: "I have never seen the Colorado potato-beetle north of the North Platte as far west as Fort Laramie, Fort Fetterman, and Big Horn Mountains." Probably co-extensive with the original distribution of the Colorado potato-beetle, is that of its original food-plant, concerning which Mr. Sereno Watson, the botanist of the United States Geological Survey of the one hundredth parallel, thus writes me: "The *Solanum rostratum* ranges from Texas and New Mexico to the Upper Missouri eastward of the mountains. I have no evidence of its being found at all west of the Rocky Mountains, and, indeed, the order appears to be almost wholly wanting throughout the entire Great Basin."

In Colorado, in 1875, I first met with this beetle at Lawrence, Kans., when Professor Snow told me it was chiefly confined to the *Solanum rostratum*, a road-side weed, which is now very abundant in Kansas and draws off the beetle from the potato, which consequently suffers comparatively little from its attacks in that State.

Professor Snow further writes me that for five or six years past, since taking up his residence in Kansas, "it has never done any damage worth mentioning, always preferring its original food-plant (which abounds here as a roadside weed) to the potato. I did not see it in Manitou, Colo., this summer (1876).

The question arises whether the cultivation of this weed around potato-fields in the East may not be a means of relief from its attacks, though it might breed in larger numbers, if that were possible.

In Colorado I first noticed the beetle in the vicinity of Denver, where it was not then common, but earlier in the season had ravaged potato-fields out of town. At Golden, July 3, it was observed in abundance on *Solanum rostratum*, not only the eggs but the larvæ in all stages as well as the beetles. I was told by one farmer that he had two rows of potatoes devoured by them earlier in the season.

It is evident that in Colorado the injury to the potato will always be limited. Five or six miles up Clear Creek Cañon it has injured the potato-plants for five or six years, but nowhere above an altitude of about 7,000 feet could I learn that it occurred, and it seems indigenous only to the plains, and the cañons among the foot-hills. None were to be seen in Utah.

Mr. T. Martin Trippe writes me that it destroyed potato-plants early in the season in Howardsville, Southern Colorado.

Its journey from the plains east of the Rocky Mountains to the Atlantic.— The history of the successive invasion of the prairies of the Mississippi Valley and of the wooded district of the Middle and Northeastern States, until only the ocean proved a sufficient barrier to their advances, is a subject of a good deal of interest to the naturalist, whatever may be thought of the dismay with which eastern farmers have looked upon its arrival. Some years ago it was confidently announced that the Colorado beetle would not flourish in the damp, cold climate of New England; that the summers were so wet that it would die while lying as a pupa under ground. But at the present time of writing, September 15, 1876, it is doing perhaps as much damage in the Northeastern States as in the Western, and the newspapers report that it has crossed the Atlantic and effected a landing in Bremen, Germany, and there is no reason why it should not overrun Europe after successfully withstanding the great differences in climate between the eastern and western regions of the United States. This insect, so indifferent to ordinary climatic differences, may be compared to a weed which, introduced in a new country, overruns and displaces the native vegetation. Like weeds, the Colorado potato-beetle, with a number of other widely-destructive insects, may be regarded as *prepotent* animals.

Fortunately for the historian of the movements of this insect, the late Mr. B. D. Walsh, at an early date after it began to spread eastward from the plains of Colorado, published in the Practical Entomologist, vol. i, No. 1, October, 1865, an account of its travels. In 1859 it had in its journey eastward reached a point 100 miles west of Omaha, Nebr. It appeared in Kansas and Iowa in 1861. It entered Southwestern Wisconsin in 1862. In 1864 and 1865 it crossed the Mississippi River, entering Illinois from the eastern borders of North Missouri and from Iowa "upon at least five different points on a line of 200 miles." Thence it has traveled eastward at the rate of a little over 70 miles a year. In 1867 it had appeared in Western Indiana and Southwestern Michigan, and in 1868 had generally overspread Indiana and appeared in Ohio. From the statements of Mr. Riley, it appears that this insect entered Canada in July, 1870, and swarmed in 1871 between the Saint Clair and Niagara Rivers. The same year Dr. Trimble reported its presence in Pennsylvania, and in 1871 it also was seen in New York. A southern column advanced eastward into Kentucky, arriving there probably in 1869. In 1872 it had reached Lancaster County, Pennsylvania, and Cattaraugus County, New York; and in 1873, according to Mr. Riley, it had pushed to the "extreme eastern limit" of that State. It was reported in the same year to have been seen in the District of Columbia, according to the Monthly Report of the Department of Agriculture for August and September, 1873.

During the summer of 1876 it was observed by Prof. H. W. Parker in great abundance at Long Branch, being thrown up in windrows on the beach. The two following extracts from the daily papers also show how abundant it has been on Long Island and in Connecticut:

It is said that the potato-bugs on Long Island are very numerous and have already made sad havoc with the early crops. Mr. Jacob Schoemaker, a farmer at Flatbush, has had about $2,000 worth of early sprouts destroyed, and the farmers in that section, in plowing up their grounds, discovered bushels of the bugs.—(Forest and Stream, April 27, 1876.)

Colorado potato-bugs have been washed ashore at Milestone and other places in Connecticut in such numbers of late as to poison the air. The captain of a New London vessel says that they came on board in such swarms while at sea that they had to close the hatches.

In 1874 it became well established in Connecticut, New Jersey, New York,* Pennsylvania, Delaware, Maryland, and Virginia. (Riley's Seventh Report.) In the summer of 1874 it appeared at Williamstown, Mass., in small numbers, as I am told by Mr. J. S. Kingsley. In 1875 they were commonly seen, especially on the railroad-track, before July 9.

Concerning its habits in Connecticut, Mr. J. H. Pillsbury writes me as follows from Middlebury, September 26, 1876:

I took from the sides of a glass jar, in which I had confined a number of beetles of *Doryphora decemlineata*, a few eggs, which had been laid May 30, and placed them in circumstances for hatching them. The eggs hatched June 6, and the larvæ were placed upon fresh leaves of the potato. They immediately commenced eating, and continued almost without ceasing during the day, until June 22, when all but one entered the earth that had been provided for them to pupali in. The remaining larva entered the earth the next day.

Two of the beetles appeared July 1, and more the next day. Upon examining the earth I found one pupa with the wings only slightly developed, and this one did not mature. As soon as the beetles were out they were fed with potato-leaves, and resumed their eating as if determined to make up lost time. The first eggs laid by these beetles were found July 7. The whole time, therefore, from the one brood of eggs to another is only thirty-eight days, twenty-two of which were spent in actively devouring the plant on which it feeds. If we suppose the female to continue to deposit her eggs for forty days, as Professor Packard states, sixty-two days of the seventy-eight which the insect lives are spent in vigorous destruction of its favorite plant, the potato. These observations also indicate the probability of three broods from the earliest of each season before the middle of September, up to which time the insect has been found on the potato in our section.

J. H. PILLSBURY.

MIDDLETOWN, CONN., *September* 26, 1876.

Its first appearance in the center of the State was in Belchertown, where, I am informed by Mr. L. W. Goodell, "a single larva was found July 15, and was apparently the last one of a brood, as several hills of potatoes near were entirely denuded of foliage, and I could find no others nor signs of any in that or other fields of potatoes in the vicinity, although I searched carefully. The one taken was placed in a box of earth and immediately buried itself, and was transformed to a beetle eleven days thereafter. About this time I found and killed some fifty of the beetles on the same potato-patch, which were probably a part of the same brood. No more of the larvæ were seen for about three weeks, when they made their appearance in large numbers in several fields." When I visited these fields during the last of September, thousands of the larvæ, in different stages of growth, were to be seen on the vines.

* At Norwich, N. Y., Mr. J. S. Kingsley first found the larvæ in July, 1874, and they were much more abundant the year following. He found them in abundance in 1875, in Binghamton and Owego.

The next year, 1876, in Essex County, Massachusetts, they attracted the attention of farmers and others about the 1st of June. Specimens brought me from Marblehead and Lawrence laid eggs June 7, which hatched June 12. June 22, I found the beetle and young in all stages, from the egg up to the nearly mature larva, in a garden in Salem, and a few days after heard of its appearance in the towns of Reading, Beverly, Wenham, Hamilton, and Essex. In 1876 it was extremely injurious in Essex County. I am informed by Mr. John H. Sears, of Danvers, that half his crop of late potatoes were devoured by this beetle, and he thinks that there was a proportionate loss throughout the county. Early potatoes mostly escaped their ravages. The potato-fields in the neighborhood of Amherst were overrun with them soon after the plants came up, and in September I saw the beetle everywhere. In 1877 the yield of potatoes will be undoubtedly very light and potatoes high priced. During the autumn of 1876 they were said to be unusually high.

At the same time I learned from Mr. Isaac L. Ham, of Winchendon, Mass., a town about 18 miles west of Boston, that eggs and beetles were found on the vines the 20th of July, 1875. Beetles were seen at Lowell in August, 1875. It appears from these facts that the beetles must have been introduced along lines of railway in different portions of Massachusetts in 1874.

In 1875 it appeared in the western part of Vermont, and during the summer of 1876 has been reported as more or less abundant in various parts of the State. In 1875 it appeared for the first time in New Hampshire, according to C. H. Fernald. In 1866 Mr. Walsh predicted that it would reach Maine "in ten or twelve years." His prediction has proved to be a true one. In Maine, according to Prof. C. H. Fernald, it was first seen in 1875, and occurred not, so far as I can learn, on the southwestern border of the State, but in the central portion, and this leads me to think that its appearance here, as well as in New England generally, has been accelerated by its transportation on freight-cars which have been sent through from different points in the West. It is a well-determined fact that the diffusion of noxious insects over the United States is greatly promoted by railways and "through" freight-cars, as permanent tracks are thus made through forests and across rivers, the natural barriers of insect life.

Regarding its advent in Maine, I will first quote from a letter of Prof. C. H. Fernald, of the Maine State Agricultural College, dated Orono, August 23, 1876:

> The true Colorado potato-beetle is really in this State, but has not yet arrived so far east as this place. It has been reported at Orrington, near Bucksport, but I think it more than likely to have been the three-lined potato-beetle, (*Lema trilineata*). Specimens were sent me from Winterport which proved to be the three-lined. The *true* beetle (imago) was sent to me about three weeks ago from Skowhegan, where it was common enough to attract attention. One of our students found it in Saco in July of this year. A few days ago I had a letter from a friend in Wilton, who says they are common there. Last fall I looked into the matter a little, and could not learn that they had at that time reached the western boundary of Maine, though they were in New Hampshire. Reasoning from their rate of progress across the continent, I concluded they would travel this year as far as the Kennebec River, which they seem to have done. I suppose they have come into the State by their own means of distribution—flying from field to field.

Mr. D. A. Conant, in a communication to the Maine Farmer, dated July 28, states that certain beetles, identified by the editor of that paper (Mr. S. L. Boardman) as *Doryphora 10-lineata*, occurred in Temple, Me., near West Farmington. Mr. R. A. Davis writes to the same paper August 6, from South Norridgewock, as follows:

> We had very dry and hot weather in July; crops suffered very much. Two weeks ago to-day we had a nice rain, with heavy showers, and since that corn and potatoes

look quite well. Grasshoppers have taken all the grain about here, and they are very thick now. The caterpillars took all the leaves from the orchards, consequently there are no apples to speak of; and now the Colorado potato-bug is here, or what we call the same as has been making such havoc in the West for several years past. I send one to you to-day in a box. I hope you will be able to inform us if this is the genuine potato-beetle. [It is the genuine Colorado beetle.—ED.] They first made their appearance in this town on a small piece of potatoes belonging to Herbert E. Hale, near where H. C. Hall & Co. have unloaded considerable corn that came direct from the West, and it is supposed that they might have been brought here in that way. They have also made their appearance on Ed. Farnham's potatoes on the old Whiting farm at Larone. The one I send you I took from the potato-vines in John W. Bates's garden in this town. They have not done much damage here as yet, for they have been pretty thoroughly picked.

Early in October specimens were found on potato-tops in North Dixmont, Me.—(Maine Farmer.)

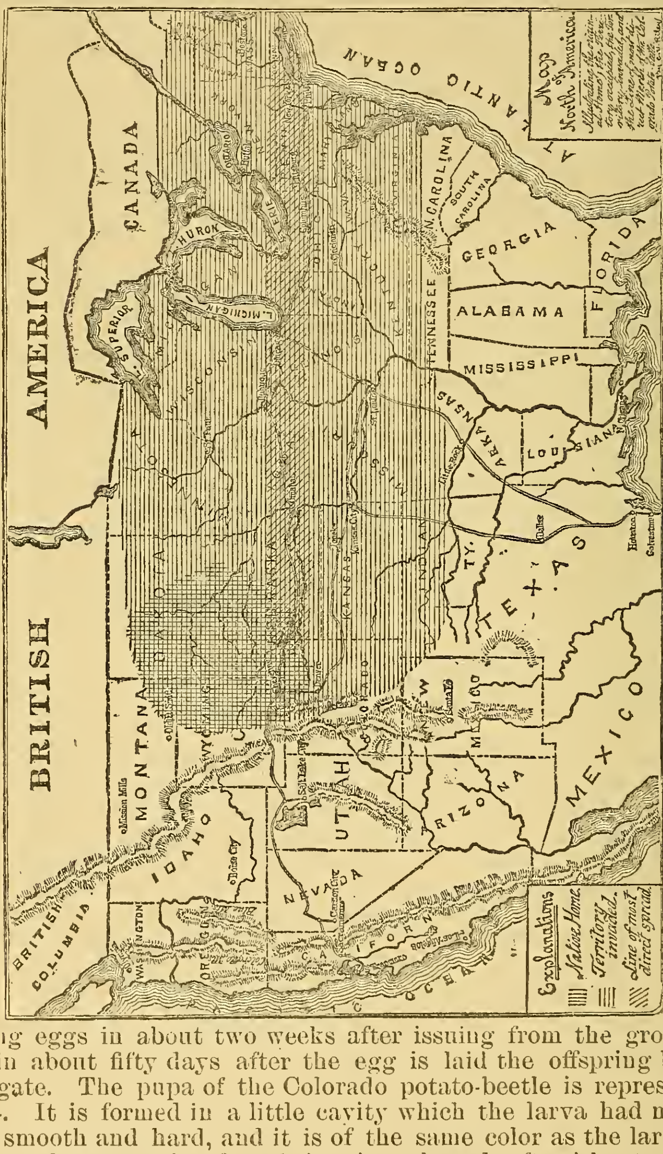
None have yet been reported from New Brunswick or Nova Scotia.

The Colorado beetle has unfortunately got a foot-hold in California. Mr. Henry Edwards, of San Francisco, Cal., writes me under date of September 10, 1876, that the "*Doryphora* 10-*lineata* is extremely rare. It has found its way into the State by way of San Diego and of course will soon spread. I have some specimens from there, but from no other locality."

According to Riley, its eastern progress has averaged 88 miles a year.

The accompanying map is taken from Professor Riley's Ninth Report on the Injurious Insects of Missouri, and explains itself.

Habits.—The habits of the Colorado potato-beetle are apparently the same in New England as in Illinois or Missouri, where it has been watched and studied for more than a dozen years. The following account is based on the observations of Walsh, Shimer, Riley, Le Bauer, and others, and myself. The beetle having wintered a few inches under the surface of the ground, appears above the surface before the potato-plants come up (in New England early in May), and feeds on the young shoots, and by the time the leaves are expanded lays its eggs on the under side of the leaf in clusters of from thirty to forty, side by side, the eggs standing on end. The eggs are oval-cylindrical, and orange-red in color. Regarding the number of eggs laid, Dr. Shimer writes as follows in the Practical Entomologist for 1866: "From an equal number of males and females, well-fed and made as comfortable as possible in confinement, I obtained an average of 719 eggs to each female; but in the fresh pure air, sunlight and freedom of nature, under propitious circumstances, I have no doubt of its exceeding a thousand. They laid some eggs every day for forty days, commencing July 15 and ending on the 1st of September. The smallest average was in the first part of this time, being $7\frac{1}{2}$ eggs per day to each female; the greatest average was about the middle of the time, 75 eggs; the last day they averaged $12\frac{1}{2}$ eggs." The young grub, on hatching out, are deep blood-red, but of nearly the same form as the adult. They usually first appear on the leaves in New England early in June. The following summary of its habits is taken from Riley's first report, and applies to Missouri, Illinois, and neighboring States: "In the latitude of Saint Louis there are three broods during the year, the last brood wintering over in the beetle state underground. They are usually dug up in the spring of the year in land that had been planted to potatoes the year before. The beetles issue of their own accord from the ground about the 1st of May, and the last brood of beetles enters the ground to hibernate during the month of October. Though in general terms this beetle may be said to be three-brooded, yet it may be found at almost any time of the year in all its different stages. This is owing to the fact that the female continues to deposit her eggs in patches from time to time, covering a period of about forty days; and also from the fact that among, those larvæ, which all hatch out in one day, some will develop and become beetles in a week and even ten days earlier than others. Thus it may be that some of the late individuals of the third brood pass the winter in the pupa state, though the normal habit is to transform to beetles. Each female is capable of depositing upward of a thousand eggs before she becomes barren, and in from thirty to forty days from the time they were deposited they will have produced perfect beetles. These beetles are again capable of de-



Map showing spread of Colorado potato-beetle.

positing eggs in about two weeks after issuing from the ground, and thus in about fifty days after the egg is laid the offspring begins to propagate. The pupa of the Colorado potato-beetle is represented at Fig.—. It is formed in a little cavity which the larva had made perfectly smooth and hard, and it is of the same color as the larva. The beetle on first emerging from it is quite pale and soft, without any markings whatever."

Although no species of this family are known to be poisonous, yet it is probably true, from the facts adduced by Riley and others, that the fumes arising from the bodies of a large number of them when killed by hot water produces sickness. This is due, perhaps, to a volatile poison thrown off from their body immediately after death; but since fowl feed upon them to a large extent, and as no one has been known to have been poisoned, at least severely, in handling them, there is no reason why hand-picking should not be resorted to.

Enemies of the Colorado potato-beetle.—Besides a number of bugs and beetles which devour this beetle, a species of *Lydella* (*L. doryphoræ* Riley, Fig. 12) is very destructive to it. Mr. Riley says, "this fly destroyed fully 10 per cent. of the second brood and 50 per cent. of the third brood of potato-beetles that were in my garden. It bears a very close resemblance, both in color and size, to the common house-fly, but is readily distinguished from the latter by its extremely brilliant silver-white face." No ichneumon parasite has yet been found preying upon it. In the Western States turkeys, hens, and chickens, and other birds destroy numbers of the grubs and beetles, and render most efficient aid. J. W. Perry, esq., of Salem, Mass., tells me that he saw a Baltimore oriole and a "small yellow-bird" fly down and eat the grubs.

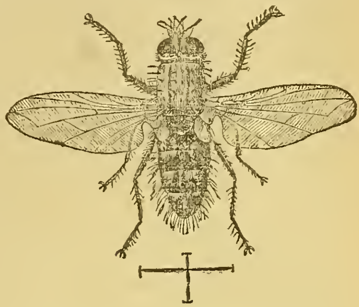


FIG. 12.—Tachina parasite (*Lydella doryphoræ*) of the potato-beetle.

Egg.—The eggs are oval-cylindrical, bright yellow, 0.08 inch long, and laid in clusters side by side, to the number of thirty or forty, on the under side of the leaves.

Larva.—The larva molts three times, four distinct stages occurring with the eggs and beetles in July, either in Colorado or Massachusetts. When first hatched it is deep blood-red, with the head and prothorax dark brown, and with two rows of black spots on the side, the upper row the larger. (In one case the head and prothorax was concolorous with the body, and there was only one row of lateral spots, as in the larva of *L. juncta*). Length, 0.10–0.12. After the first molt it measures 0.17–0.20 inch, and has the same appearance. After the third molt it becomes paler yellowish, and measures 0.25–0.35 inch in length. At this time the body more distinctly than before is seen to be much thicker behind the feet, nearly as thick as broad, while the abdomen is suddenly pointed. The mature larva, when of full size, measures about half an inch (0.40–0.50) in length and is yellow, with the head black, the prothorax yellowish but dark on the hinder edge; two rows of black spots on the side of the abdomen, the two terminal segments of which are dark above, while just behind the head are four small black dots; the legs are black. It matures in about seventeen days after hatching. On comparing about fifty alcoholic specimens in all four stages, from Salem, Mass., taken in July, with the same number collected in Golden, Colo., July 3, I see no difference, unless the latter set are a trifle paler in hue; but some of the Massachusetts examples are as pale as those from Colorado.

Beetle.—Hemispherical, thick-bodied, with prothorax a little narrower than the rest of the body. Yellow; head yellow, sometimes black at the base, with a heart-shaped black spot in the middle; two short diverging black lines in the middle of the prothorax, with smaller lateral dots. Wing-covers with four broad black lines, and the edge of the wing cover lined with black, making ten lines in all. Under side of the abdomen with four rows of black spots. Legs of a reddish tinge, with the ends of the joints dark; tarsal joints dark. Length about half an inch (0.40–0.50).*

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* Though this species was referred to *Doryphora* by Say, and has been retained in this genus by most subsequent authors, it more properly belongs to *Leptinotarsa*. The three species of *Doryphora* in the museum of the Peabody Academy of Science, Salem (*i. e., Doryphora sejcanii* Ger., from Brazil, *D. catenulata* Oliv., from Para, and *D. suturalis* Fabr., from Rio de Janeiro), have a much stouter and thicker body, with a large spine between the anterior pair of legs. In *Leptinotarsa* the spine is entirely absent, and our species (together with *L. craspiena* Kl., from Chiapas, Mexico) are apparently more closely related to the common *Labidomera trimaculata* than to the species of *Doryphora*,

Leptinotarsa juncta (Germar) represents *D.* 10-*lineata* in the Northern and Western States. It may be easily confounded with the latter, but differs from it in the third and fourth lines in each wing-cover (counting from the inner edge of the elytron), being united to form a common band, and the legs are entirely pale yellow, with a dark spot on the thighs (femora). The larva has a lighter-colored head, and but a single row of lateral dark spots. It feeds on the wild potato, not eating the cultivated species. Though first collected in Georgia, it partially inhabits all the Southern States.

Remedies.—The surest and safest remedy is hand-picking. As soon as the eggs are laid they should be looked for on the under side of the leaf and the leaf torn off and burned. Afterward the grubs and beetles should be picked off. The following extract from a correspondent of the New York Tribune shows the efficacy of this remedy:

> From June 7 to August 17 I have caught and killed, by actual counting, over eighteen thousand (18,802) "hard shells," without reckoning the eggs and young ones, on less than a quarter acre of potatoes, so that not a vine has lost its leaves. The bugs have stripped the neighboring patches, and now come swarming on mine. My neighbors Paris-greened, scalded, mashed, and burned bugs till the vines had blossomed, then left them live, grow fat, and migrate. Would it be feasible to fine the negligent bug-catching farmers next year and offer medals to the diligent?

While hand-picking should be practiced and perhaps State bounties paid for the eggs, grubs, and beetles, prizes might be offered by agricultural societies for the largest collections. Co-operation among farmers and others should also be urged, even if legislation should have to be resorted to. President P. A. Chadbourne, of Williams College, advocates higher culture. "Since," he has remarked, "it costs as much to protect an acre of potatoes yielding twenty bushels as one yielding one hundred bushels, less land should be planted and more highly cultivated, as in soil properly tilled it would perhaps not cost more than 5 cents a bushel to protect the potatoes." The aid of fowl should also be invoked, as chickens freely feed on the grubs.

In the Western States the use of Paris green is advocated. This is a preparation of arsenic, and is deadly poison. If used at all in the thickly-settled Eastern States, it should be handled with extreme caution, and only by careful persons, and in gardens and farms where no children are about. One part of Paris green may be mixed with about twenty of cheap flour and dusted over the vines early in the morning while the dew is on the leaves. The simplest way is to sift the flour from a fine muslin bag attached to a pole or from a dredging-box. Although Paris green is freely used in the West, I would not advocate its use in New England on small farms near houses and in the vicinity of large towns. Mr. John H. Sears tells me that several valuable horses and cows have to his knowledge died from this poison. Human life is threatened, as the powder blows about, and the risk of poisoning is too great to be lightly taken.

Various machines have been devised for use on large farms, and liquid preparations and patent sprinklers manufactured for the purpose. Those

Both *L* .10-*lineata* and *juncta*, the latter inhabiting the Southern States and originally representing 10-*lineata* of the eastern slope of the Rocky Mountain Plateau, are represented in Mexico, Costa Rica, Bogota, and Bolivia by *L.* 11-*lineata* Chevr., in which the head is black and the body darker yellow, but the elytra striped in much the same way, while it is a little smaller. Regarding the generic name of the 10-*lineata*, Dr. Horn writes me "there is some difficulty, but I think all will finally settle down to the name *Leptinotarsa decemlineata*." M. A. Preudhomme de Borre, in his writings on this insect, calls it *Leptinotarsa decemlineata*, and says that it has been improperly re erred to *Doryphora*.

who are not inclined to use Paris green may use carbolate of lime, made by mixing in the proportion of half an ounce of crude carbolic acid with a pound of lime, forming a powder, which can be dusted on the leaves. Others have used air-slacked lime with success. Hellebore is ineffectual.

The following suggestions by Prof. H. H. McAfee, of Iowa Agricultural College, are valuable: "We know that the *Doryphora* 10-*lineata* can only remain healthy and increase rapidly when feeding upon solanaceous plants. Cut off his rations for any considerable length of time and he will surely die; hence if we *plant only early potatoes*, whose tops are all dead by August 10, but few potato-bettles will be found alive on your grounds next season. * * * A word as to how this policy has worked in practice. During the seasons past, in which I have grown 2,100 bushels of potatoes on the Iowa Agricultural College farm, the expense of keeping potato-beetles in check by hand-picking, when they became too numerous, has been less than $2, and no poison has been used and no late potatoes have been grown in my department. Of course where potato-patches are contiguous any patch may suffer from the neighbors' bugs, so that this policy of autumn starvation must be general to be most effective."

Also, as a preventive, it would be well to try planting the prickly solanum (*S. rostratum*) around potato-fields, and asertain whether the beetles would not desert the useful plants for the weed; if so, the culture of the weed would be an invaluable adjunct to that of the potato. A correspondent of the New York Tribune states that the Colorado potato-beetle feeds on the common nightshade (*Solanum nigrum*). To quote his words: "The Colorado potato-beetle troubled the potatoes in my garden very little; but at the side of the garden, close at the ends of the rows, were two or three large shrubs or vines commonly called nightshade. Upon these were hundreds of the slugs of the 'pest,' which seemed to thrive splendidly; and so long as the marauders confine their foraging to this noxious plant I shall not molest them."—(G. H. B., Franklin, N. Y.)

It would be also worth while for experiments to be made in planting not only the common nightshade, but the bittersweet (*Solanum dulcamara*), a common vine imported from Europe, growing in our gardens and about our houses. The horse-nettle (*Solanum carolinense*), a common weed flourishing from Connecticut to Illinois and southward, and upon which the *Leptinotarsa juncta* feeds, might also be planted in broad borders around the potato-fields with probably good results. Whether it is a good policy to heed the natural food-plants of insects, and thus perhaps increase the number of the noxious insects preying upon them, has always been a question in my mind. Still it would be an experiment worth trying in the present case, where it seems almost impossible to increase the numbers of this beetle beyond what they have already attained.

THE YELLOW-STRIPED SYSTENA, *Systena mitis* Le C. var. *ligata* Le C. (Plate LXVI, Fig. 3.)—Eating holes in the leaves and making blotches on them; a small beetle nearly two lines in length; black, with two broad yellow stripes along the back.

This beetle I have only noticed in Colorado, where I observed it in a field of potatoes at Idaho Springs, July 5. It was very abundant on the leaves, eating holes in them and making blotches. As they were pairing it is evident that the eggs are laid at this time, and soon after the larvæ should be looked for, either upon the leaves or at the roots or in the stalk.

Description.—Body rather flat, and rather long and narrow; blackish-brown; head with yellow orbits; a broad dark band between the eyes, and a dark patch behind the eyes. Antennæ and head in front yellowish; upper lip (labrum) black; both pairs of palpi reddish-brown. Prothorax yellow, especially on the hinder edge, and tinged with brown on the sides and in the middle. Wing-covers black, each with a broad yellow longitudinal stripe one-half as wide as the wing-covers. Body beneath black. Legs yellowish, tinged with brown on the hind femora, which are much swollen, and become paler toward the tip. Length, 0.18 inch, or nearly two lines. The species has been identified by Dr. Horn.

THE THREE-LINED POTATO-BEETLE, *Lema trilineata*, (Olivier. Plate LXVI, Figs. 4, 5.)—Thick-bodied grubs, much smaller than those of the Colorado beetles, feeding on the leaves and disguising themselves with their own excrement, becoming black beetles striped with yellow, and with a reddish head and prothorax.

This beetle need not be confounded with the Colorado beetle, as it is about half the size of the latter, and is only occasionally destructive in the Eastern States, especially New England. The beetle is black, striped with yellow, with a reddish head and prothorax. The grub or larva is a soft-bodied, thick grub, but slenderer than that of *Doryphora*. It conceals itself by covering its body with accumulations of its own excrement. It matures in two weeks, and transforms in the ground, the beetle appearing about the 1st of August. Hand-picking in the early part of July is a sufficient remedy.

BLISTERING BEETLES, *Epicauta cinerea* Fabricius (Plate LXVI, Fig. 6); *E. macrobasis murina* Le Conte; *atrata* Fabricius (Fig. 7); *E. fabricii* Le Conte (Fig. 8).—Long, slender, gray, striped or spotted, or black beetles, with a prominent head, feeding on the leaves, and sometimes even more destructive than the Colorado beetle.

These beetles are allied to the Spanish fly, and, like that insect, all secrete the blistering substance called "cantharadine."

The gray blistering beetles (Plate LXVI, Fig. 6) in Massachusetts appear, according to Harris, about the 20th of June, and sometimes do a great deal of mischief. In the night-time and in rainy weather they leave the plants and burrow at the roots for shelter, and eat in the morning and evening.

Common as these insects are in the beetle state, the larva of some of our native species have not yet been discovered, and the only information available to me is a brief account of the young of the European Spanish fly *Lytta vesicatoria* in Westwood's Modern Classification of Insects, where it is stated that the larvæ live underground, feeding upon the roots of vegetables. "They have the body soft, and of a yellowish-white, composed of thirteen segments, with two short filiform antennæ, and six short, scaly feet."

While the gray blistering beetle is common northwards, the black species, *E. pensylvanica*, is equally or more so, while *E. cinerea* (Forster) (Plate LXVI, Fig. 8,) is more common southward, and *E. vittata* (Plate LXVI, Fig. 9) is very destructive in potato-fields in the Middle, Western, and Southern States.

Epicauta pennsylvanica is perhaps our commonest species northward, and is totally black, and slightly smaller than *E. cinerea;* it is black, but ash-colored on the head and prothorax and on the under side of the body. It occurs as far west as Kansas. (*E. vittata* is longer and slenderer than the others named, and is clay-yellow, with six black longitudinal stripes.)

Macrobasis muria is found west as far as Northern New Mexico, and is to be looked for in Colorado and Wyoming.

The following is Fay's description: "Lake Superior, two males. Easily distinguished by its more sparse pubescence; the thorax is shorter, more convex, and more narrowed anteriorly, and the upper surface is more distinctly punctured; the antennæ are one-half the length of the body, the first joint reaching the occiput, the second joint equal to the two following. With this species I doubtfully associate a female from Missouri Territory, agreeing in form and punctation, in which the antennæ are a little stouter than in *C. fabricii*, with the second joint about one-third longer than the third."

M. fabricii (*cinerea* of Fabricius) is of a uniform dull-ash color. It is found usually east of the Mississippi, but also occurs in Kansas and New Mexico, according to Dr. Le Conte.

Remedies.—Hand-picking and brushing the insects off the leaves in the morning and evening is the best remedy. Harris says: "I have repeatedly taken these insects in considerable quantities, by brushing or shaking them from the potato-vines into a broad tin pan, from which they were emptied into a covered pail containing a little water, which, by wetting their wings, prevented their flying out when the pail was uncovered. The same method may be employed for taking the other kinds of cantharides when they become troublesome and destructive from their numbers; or they may be caught by gently sweeping the plants they frequent with a deep muslin bag-net. They should be killed by throwing them into scalding-water for one or two minutes, after which they may be spread out on sheets of paper to dry, and may be made profitable by selling them to the apothecaries for medical use."

THE SPOTTED BLISTER-BEETLE, *Epicauta maculata* (Say). (Plate LXVI, Fig. 10.) Feeding on beets and liable to devour potatoes; a light-gray blister-beetle, spotted with black; destructive about Manitou, Colo.

While none of the preceding species have yet been found to be injurious in Colorado or adjacent Territories, there are a number of species of blister-beetles which inhabit the Rocky Mountain Plateau, and two have been found to be injurious to field-crops. While at Manitou during the middle of July I visited a large farm and found this spotted blister-beetle in abundance on the leaves of the beet, and was told that on the 1st of July they swarmed upon the leaves so that "the plants were gray with them." I also found this beetle at Golden, and it is evident that it is destined to be more or less annoying to garden-vegetables and probably potatoes.

Description of the beetle.—Pale yellowish-gray varying to a dark gray, being dark, covered with a gray powder, consisting of minute short hairs when examined under a hand-lens, and finely spotted with black on the wing-covers, the spots being nearly obsolete on the head and prothorax as well as the under side of the body. The legs are of the same color as the rest of the body, but the toe-joints (tarsi) and the tips of the shanks (tibiæ) are blackish, as well as the antennæ and feelers (palpi). It is usually about half an inch long, but varies from a quarter to half an inch. It is rather slenderer in form than any other of the species here named except the striped species (*E. vittata*). It also occurs in Kansas and Eastern New Mexico. This species has been named by Dr. Horn.

THE LEOPARD BLISTER-BEETLE, *Epicauta pardalis* Le Conte. (Plate LXVI, Fig. 11.)—Injuring the potato-leaves in Southern Colorado, and doing more damage locally than the striped Colorado potato-beetle; a beautiful gray-spotted shining-black blister-beetle.

I received from Mr. T. Martin Trippe, a well-known naturalist, numerous specimens of this blister-beetle, with the following account, dated Howardsville, Colo., July 25, 1875:

I send you herewith some specimens of a beetle that has lately destroyed the potato-plant in this vicinity. They are worse than the *Doryphora decemlineata* in the extent and rapidity of their devastations, and seem to have driven the latter out of the country. Before the appearance of this new potato-bug the latter were quite numerous, and had already begun to injure the crops somewhat; but these new-comers stripped the vines in a week, and a few days after they appeared in numbers the *Doryphoras* were nowhere to be seen. No one seems to know of or to have seen them before. Before immersion in alcohol they were spotted with white, the spots being quite small—size of a pin-point; the head unspotted. They feed on wild *Solanaceæ*.

The same remedies may be employed against this and the spotted blister-beetle as suggested for the eastern species.

Description of the Beetle.—It differs from *E. maculata* in being shining black, with pale-gray scalloped lines across the elytra, which unite to form about seven or eight pale-gray irregular ringlets, inclosing black spots, whence the name *pardalis*, or leopard-like. The thorax is black, but gray around the edges, and spotted with gray on the sides and beneath. It is of the usual form, but a little shorter and stouter than *E. maculata*. Length, 0.45 inch. Identified by Dr. G. H. Horn.

THE FLEA-BEETLE, *Haltica* (*Epitrix*) *cucumeris* Harris. (Plate LXVI, Fig. 13.)—Eating holes in the leaves, sometimes riddling them, and causing them to turn rust-color; minute black beetles, which on being disturbed leap off like fleas.

This minute beetle not only infects the potato but also injures beans, beets, tomato-plants, and especially young cucumber-vines. Attacking the leaves when small, and eating round holes in them, by their numbers and the pertinacity of their attacks they each year do much harm, and certain seasons carry off whole beds of young beets and cucumber-vines, as well as seriously injure the potato-plants. The habits of the young of this species are not known, but it is very probable that the eggs are laid on the leaves, and that the larvæ bore into and mine the leaves feeding upon the pulpy substance. The larvæ of other species of the genus known to have such habits are, according to Harris, "little slender grubs, tapering toward each end, and provided with six legs. They arrive at maturity, turn to pupæ, and then to beetles in a few weeks. Hence there is a constant succession of these insects in their various states throughout the summer."

Description.—It is only one-sixteenth of an inch long, of a black color, with clay-yellow antennæ and legs, except the hindmost thighs, which are brown. The upper side of the body is covered with punctures, which are arranged in rows on the wing-cases; and there is a deep transverse furrow across the hinder part of the thorax. (Harris.)

REMEDIES.—Water the leaves with a solution of lime.

THE STRIPED GARDEN BUG, *Lygus lineolaris* (Beauvois) Uhler. (Plate LXVI, Fig. 14.)—Puncturing and poisoning the leaves of the potato and all sorts of garden-vegetables, causing them to wither and turn back; a medium-sized bug.

This bug is very widely disseminated, and is everywhere abundant and annoying in the United States from Maine southward to Alabama, and westward to Colorado and Wyoming. Uhler states that specimens were collected above the timber-line in Colorado by Lieutenant Carpenter; and it occurs on the bald summits of the highest mountains in North Carolina. It hibernates, and in New England appears in April.

Description.—Head yellowish, with three narrow, longitudinal, reddish thorax, bordered with yellow, with five longitudinal yellow lines. The male is much darker-colored; $\frac{1}{5}$ inch in length.

Remedies.—Harris advises sprinkling the leaves with alkaline solutions, such as strong soap-suds, or potash-water, or with decoctions of tobacco and of walnut leaves, or of dusting the plants with air-slaked lime or sulphur.

Besides these insects the sphinx (*Macrosila 5-maculata*) whose horned caterpillar is called the "potato-worm," and the larva of the golden-helmet beetle (*Cassida aurichalcea*) feed on the leaves.

BORING THE ROOTS.

THE POTATO-STALK WEEVIL, *Baridius trinotatus* Say. (Plate LXVI, Fig. 12; *a*, larva; *b*, pupa.)—Boring into the stalks and causing them to wilt and die; a small, white, footless grub.

This is a common insect in the Middle and Western States, where it is at times quite annoying. The female, according to Riley, deposits a single egg in an oblong slit in the stalk about one-eighth of an inch long, which she has previously formed with her beak in the stalk of the potato. The grub afterward hatches and bores into the heart of the stalk, working downward toward the root, causing the stalk to wilt. When observed to suddenly die the stalks should be cut down and burned.

Beetle.—Bluish or ash-gray, with three shining, black, impressed spots at the lower edge of the thorax. The grub (larva) when fully grown is a little over one-fourth of an inch long, and is soft, whitish, footless, with a scaly head.—(Riley.)

Besides these insects the "potato-worm," or caterpillar of the five-spotted hawk-moth, and the caterpillar of the *Gortyna nitela*, which bores in corn, and the helmet-beetle (*Coptocycla aurichalcea*), which usually feeds on the sweet-potato and morning-glory, occasionally prey on the potato-leaves.

The clubbed tortoise-beetle (*Deloyala clarata*) was found in 1871 by Mr. A. G. Smith, of Berlin, Mass., to be feeding on the leaves of the potato, "eating indifferently different varieties."

THE HAIRY POTATO-MAGGOT, *Homalomyia tuberosa* Curtis? (Fig. 13.)—Feeding in decaying (?) potatoes and cabbages; a flat, hairy maggot, which transforms to a fly like the common house-fly, but paler and smaller.

A few years ago specimens of a hairy maggot taken by Mr. C. A. Putnam August 15, 1875, in defective potatoes, were sent to the museum of the Peabody Academy of Science, at Salem, Mass., and shortly after the museum received a number of maggots of the same species found, July 2, 1875, in the Savoy cabbage, by Mr. John H. Sears, of Danvers, Mass. The latter lot consisted of two broods, *i. e.*, of maggots fully grown, and others one-quarter grown. They are very similar, if not identical, with Curtis's *Homalomyia tuberosa*. Our species is probably the one referred by Harris to the *Anthomyia canicularis* of Europe, and is perhaps, as suggested by Baron Osten Sacken, *H. scalaris*.

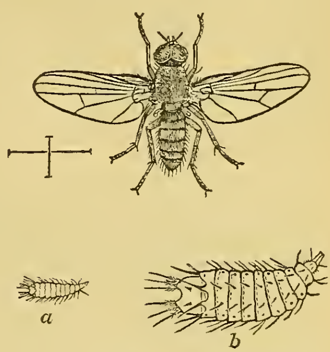

FIG. 13.—Hairy potato-maggot (*Homalomyia tuberosa?*) *a*, larva; *b*, the same enlarged twice. After Curtis.

Description of the larva (Fig. 13: *a*, natural size; *b*, magnified twice).—Head minute, fleshy, not seen in the pupa-case. Body flattened, cylindrical, ovate. Prothoracic segment flat, square, trapezoidal. On the body are two rows of long, slender dorsal spines or hairs, two rows of lateral longer hairs (seen under a high magnifying power to have short spiracles), one subdorsal, the other subventral. The last four dorsal are longer than those in front. The end of the body forms a flat, smooth declivity, on each side of the front edge of which is a thick, stout, short spine (a produced spiracle), much thicker than the others, and ending suddenly in four short, blunt spines. Behind these two spines, on the side of the declivity, are six hairs, with short, slender respiratory hairs on the basal half. Some of the lateral hairs have similar lateral respiratory filaments, but they are less distinct than on the six terminal hairs. The under side of the body is flattened. The spiracles at the base, on each edge of the first segment behind the head, have six long, slender respiratory processes. Length, 0.27 inch. This description will also apply to the pupa-case.

It is easy to see how maggots like these, which bury themselves in cabbages and potatoes, may become swallowed with the food, and if the latter is only partially cooked and hastily swallowed, how the living worms become conveyed into the stomach, and become so annoying that the doctor has to be sent for. The European *Homalomyia scalaris*, or "ladder-maggot," is not unfrequently voided from the bowels of boys and adults in both countries.

I append the following account of several potato-insects of Europe, taken from Curtis's Farm Insects, and which may prove of interest, since the same or closely-allied species are likely to occur in the United States:

"Dead and silent as the earth appears to be, it teems with life; for not only is the soil full of seeds, which merely require light and heat to start them into life, but it must abound with the eggs of insects so minute that even with the assistance of a lens they escape one's notice. To be convinced of the truth of this, if a flower-pot be filled with mold from a field or garden, and then tied over with the finest muslin, the experimentalist will be astonished to find the multitudes of little flies which are constantly making their appearance, bred no doubt from larvæ, nourished on the vegetable matter which such soils contain. Where crops are grown, and any portion of them become decayed, the number of these minute insects is vastly multiplied, and thus where the deceased potatoes have existed additional swarms of various little flies have been the consequence. As a proof of the incredible numbers that must be thus generated, I may mention that from one growing and partially-rotten potato I bred in August, 1845, 128 flies, independent of many more which had died in the pupa state, or been destroyed by damp and mites before I discovered them in the vessel in which the tuber was placed, as well as multitudes of smaller flies, all of which I will now describe.

"The whole belong to the order DIPTERA. The first I shall notice is included in the family TIPULIDÆ and the genus *Psychoda* and has been named—

"*P. nervosa*.—The males are twice as large as the females; they are ashy-white, clothed with longish wool; the little head is buried under the thorax; the black eyes are large and lunatæ; the two horns are as long as the thorax, and composed of eleven (?) small points, black at the base, giving them an annulated appearance; the abdomen is short, and of a dirty color; the two wings when at rest meet over the back slanting; they are iridescent, very large, oval, and lanceolate, with numerous longitudinal, hairy nervures; the entire margin is also hairy; balancers small, clubbed, and white; six legs woolly; the feet fine-pointed, the tips black; length, ⅝ line; expanse, 3 lines.

"In February, 1846, the larvæ and pupæ were abundant in the rotten potatoes, also in decaying leaves and dung-hills, and the flies have been bred by Mr. Haliday from putrescent fungi. These flies sometimes swarm in out-houses and about drains in spring and autumn.

"The larvæ are not ½ line long, yellowish-white, cylindrical, spindle-shaped, with eleven distinct annulations besides the head, which is triangular; the tail is elongated and tubular. The pupa is about ⅜ line long, ocherous, and ferruginous; it is elongate-ovate in repose, but the body can be stretched out and attenuated when disturbed; from the forehead project two slender appendages, like horns; on either side are laid the short, stout antennæ, and the wings meet over the breast, with the legs stretched out between them; the abdominal segments are ciliated and the tail is forked.

"Several species of a little swarthy two-winged fly were bred from the decaying potatoes in multitudes. They are called *Sciara* by Meigen and *Molobrus* by Latreille. The larvæ I received from Mr. Graham; they are slender worms, about ¼ inch long, whitish, and opaque, but when immersed in water they become perfectly transparent, exhibiting the ocherous viscera and the food digesting in the stomach; when in motion they taper toward the head, which is oval, horny, black, and shining; the body is composed of thirteen segments, with seven or eight spiracles on each side; the tail is broad and rounded, but slightly pointed in the center. The pupa is shorter, cylindrical, elliptical, and of a dull-ocherous tint, becoming darker as the period approaches of the birth of the fly; the antennæ, eyes, wings, and legs are visible beneath their horny sheaths. At this period they are deprived of locomotion, but the larvæ, although perfect maggots, and destitute of feet, are able to move along in moisture, at the same time waving about and thrusting out their heads with great energy. There are thirty species of these flies which inhabit England, and three or four of them have been bred from putrid potatoes. One is called—

"*Sciara fucata* Meig.—When alive it is 1 line long. The *male* is of a pale inky black, the head is small and spherical, with two triarticulate feelers bent under, the two horns are not longer than the thorax, tapering, pubescent, inserted in front of the face, and sixteen-jointed; two basal joints the stoutest, the remainder oblong, apex conical; eyes lateral, kidney-shaped, and coarsely granulated; ocelli three, but unequal; trunk gibbose, subquadrate, scooped out at the base, with two indistinct lines of short ochreous hairs down the back; scutel lunate, postscutel oval, of a grayish color; abdomen slender, greenish-black, brownish after death, seven-jointed; the margins of the segments pale, apex obtuse, and furnished with two incurved biarticulate lobes; two wings, incumbent in repose, parallel, longer than the body, iridescent, slightly smoky, but transparent and clear at the base; nervures brown, excepting the central one, which is scarcely visible, but forked and dark at the margin; the costal nervure does not reach the base of the forked cell; balancers pale, dirty yellow or ochreous; six legs, long, slender, and of a dirty-yellow or pale-olive tint. *Female* similar, but larger, being 1½ line long, the wings expanding nearly 3 lines, the thorax is not narrowed behind; the abdomen is spindle-shaped, attenuated, and conical, terminating in two little parallel sheaths; the two balancers are dusky when dry.

"This was bred in the winter of 1845–'46, and again in 1848, in vast quantities; the flies are also found throughout the summer in fields and gardens, on umbellate flowers and on grasses. I have likewise bred them from rotten turnips in March.

"*S. quinque-lineata* of Macquart is 1½ line long. 'It is black, with five lines on the thorax of a deep dull gray; anterior hips testaceous; wings almost hyaline;' balancers brown or dirty white.

"Specimens agreeing with this description were bred from rotten potatoes in March, 1848, and sent to me with the tubers containing the larvæ and pupæ also. The potatoes were like old rotten cheese, and portions of the outside were covered with slimy threads, which Mr. Graham saw the larvæ spin. He thinks they cause the 'scab' in potatoes; but I saw not the least vestige of the insect on one variety of my potatoes, which was very scabby.

"*S. pulicaria?* Meigen, Hoff., is ½ a line long or upward, and is distinguished from the two foregoing species by its longer antennæ, which are equal in length to the rest of the body. It is black, with testaceous legs; the wings almost hyaline; balancers brown.

"My specimens being as big again as Meigen's, with ochreous balancers, I am doubtful if they be the *S. pulcaria* of that author. I bred them in August, 1845, from a rotten potato.

"Another dipterous insect was bred from the potatoes in less quantities. It also belongs to the family TIPULIDÆ, and the genus *Scathopse*. It appears to be Meigen's.

"*S. punctata*.—It is black and shining, the head is small, the eyes are kidney-shaped, with three little ocelli on the crown; the antennæ are short, stout, cylindrical, and composed of eleven cup-shaped joints; thorax elongated and somewhat compressed, with a white dot on each side; scutel small and rough; abdomen broad, oval, and depressed; wings ample, resting horizontally, transparent and iridescent, with a black costal, subcostal, and basal nervure, the first and second united beyond the middle, and divided near the base by an oblique nervure; there are also four other very faint longitudinal nervures, the apical one forked, the anal one waved; balancers yellowish; legs simple, longish, and rusty; extremity of thighs and shanks variegated with fuscous; feet brown, five-jointed, terminated by a pair of minute claws; length, 1¼ line; expanse, 3½ lines.

"The larvæ from which these flies proceed live in various putrid substances, and even in dung; they have also been bred from the cocoons of silk-worms, in all probability containing decomposing caterpillars or rotten pupæ; they are from 2 lines to nearly ¼ inch long, flat and narrowed at both ends, of a dirty grayish-yellow color; the head is brown and oval, with two short feelers; the body is composed of twelve pubescent segments, the first thoracic one with a prominent spiracle on each side as well as the penultinate, which, with the apex, is covered with radiating bristles. The pupa is 1½ line long; it is inclosed in the skin of the larva, and little depressed, and yellowish-brown; from the thorax projects a branched spiracle like a buck's horn, and the tail has a stout spine. It remains from a week to a fortnight in this state, and the flies are often exceedingly abundant in the autumn.

"Two large species of flies belonging to the family MUSCIDÆ I also bred from a single potatoe, as previously stated. There were forty-eight specimens of one which was named by Fallens—

"*Musca stabulans.*—The *male* is 3½ lines long, and the wings expand ½ an inch; it is of an ash-color, and clothed with black bristles; the feelers are ferruginous; the antennæ drooping, five-pointed, and rust-colored, pitchy at the base, third joint elliptical and heavy, except at the base; the seta black and feathery, the basal joint minute; eyes large, approximating, naked, and chestnut color, the margins silvery white as well as the face, with a black stripe tapering from the antennæ to the three ocelli on the crown; thorax hoary, with four black longitudinal stripes before, the two central ones the longest, with a spot on each side beyond the center; scutel hoary, with a dark stripe at the base, ferruginous at the tip; abdomen ashy-ochreous, shining, the back variegated with brown patches; wings with the apical cell not angulated, but suddenly rounded, scales at the base with pale tawny margins, and concealing the ochreous-clubbed balances; legs black, apex of thighs and tibiæ ferruginous; pulvilli at the extremity of the feet elongated. *Female* similar, but the eyes do not approximate, the face has a yellow tinge, and the stripe on the crown is broad and elliptical; the abdomen is broader, with an oviduct at the tail, and the pulvilli are small.

"The maggots had bred and accumulated among the slimy matter of the rotting potato, just as meat-maggots are found, together with the horny pupæ. Indeed, the largest maggots were exceedingly like those of the flesh-flies, being flat and whitish, the ochreous food and white lines of viscera shining through the transparent skin; the head was pointed with a black proboscis formed of two horny claws, and the two spiracles at the blunt tail were like two black horny knobs. The tough and oval pupæ were of a bright chestnut color, the segments slightly marked, the head end rounded and wrinkled to a point; the tail furnished with two black specular tubes.

"Of the other fly I bred fifty-eight specimens from the same potato in the middle of August. The larvæ escaped my notice at first from being so very like the earth in color, and they are still more difficult to detect from their sluggishness. They must be in the greatest force in July, but I have met with them in rotten potatoes in the end of November. The group of flies with these singularly spiny larvæ have been formed by Bouché into a genus called *Homalomia*, being a section of *Anthomyia*. The parent fly of our species is exceedingly like *Musca cunicularis* of Linnæus; still there are differences, and as the larvæ are also dissimilar, I have named this potato-fly—

"*Anthomyia tuberosa.*—The *male* is 2½ lines long, and expands 5½; it is grayish-black and bristly; the eyes are chestnut color, naked, approximating on the crown, the inner margin silvery white; antennæ drooping, five jointed, third joint oblong, fourth a slender elongated basal joint to the longish pubescent seta; thorax with five indistinct broad stripes down the back, second and third abdominal segments with bright ocherous spots on each side, third rarely with two similar minute spots; wings transparent, nervures dark, the two transverse ones not very remote; balancers pale tawny; legs black, base of shanks indistinctly ferruginous. *Female*, ashy slate-color; the eyes smaller than those of the male and remote; the face not silvery; thorax with five distinct broad blackish lines down the back; abdomen ovate-conic, with two indistinct ocherous slightly-diaphanous spots on the second abdominal segment; in other respects this sex is similar to the male.

"The larvæ, although indolent, can crawl well; they are of a dull tawny color, clothed with long bristly spines, somewhat depressed, elliptical, tapering to the head, which is waved about, and when thrust out is whitish and fleshy, armed with two minute hooks like ebony, and there is a little fleshy horn on each side; on the following segment is a spiracle on either side, surrounded by several stout short rays; the two next segments have tubercles on the back; the remainder have a double series down the center, producing bristles, with a double row on each and eight of the segments have a pair of short spines each beneath, which enable it to walk; the apex is armed with six long bristles a little spiny at the base, but most of the others are naked, or with the slightest appearance of pubescence or little spines at the base; on the apical segment are two spiracular tubes. The pupa being formed within the indurated skin of the larvæ, it varies from it only in being more convex above, and the fly escapes by a lateral opening in the thorax.

"These larvæ and purpæ I find occasionally in my garden where cabbages have long occupied the ground, and Dr. Harris remarks that the hairy maggots of *Anthomyia cunicularis*, or an allied species, live in rotten turnips; they also abound in privies, and the purpæ-cases are found in multitudes under boards.

"From the large quantities of these maggots which have been ejected from the human stomach and intestines, accompanied by the most distressing symptoms, I am led to conclude from their economy that the eggs or larvæ are conveyed into the stomach in badly or half cooked vegetables, for it is evident they subsist upon decomposing vegetables and excrementitious substances, and I have found similar but very small larvæ on cabbage-leaves in October. It is, therefore, very probable that, under certain morbid conditions of the constitution, they are able to live in the human body until they have arrived at their full growth, when they are necessarily ejected to become pupæ, and after a short time to be transformed into flies. It is not a little remarkable that the maggots of *Musca stabulans* should have been also voided from the intestines, and that fact tends to substantiate the view I have taken of the subject and the cause of their presence in the human system, for that is the other species of large fly which I bred from maggots generated in the same potato.

"I also detected the larvæ and pupæ of a smaller species of fly called *Drosophila*, which hatched in the middle of August with the foregoing insects. They are also inhabitants of cellars, as their specific name implies, where the larvæ are usually very abundant all the year round. They will breed in stale beer, and probably are generated where there is any leakage from the tap and oozing about the bung, as well as from the fungi which spring up round rotten wood, etc., in cellars. I have also known them to be bred from vinegar, and it will be remembered that one species, *D. flava*, lives on the pulpy substance of the turnip-leaves, and another, *D. graminum*, I have bred from cabbage-leaves. In spring and autumn the flies abound, and are not unfrequently on the inside of our windows. They belong to the family MUSCIDÆ and the genus *Drosophila*. That bred from the potatoes appears to be the Linnean species named

"*Drosophila cellaris*.—It is 1½ line long, and expands 4 lines; the general color is ochreous; the head is broad as well as the face, in the center of which are inserted the two little drooping pubescent horns, the third joint is oval, and from the back arises a feathery bristle jointed at the base; the orifice forming the mouth is very large; eyes large, hemispherical; ocelli three on the crown; thorax globose-quadrate; scutal semi-ovate; abdomen small, depressed, oval, blackish, and six-jointed, with four or five ochreous bands; the apex pointed in the female; wings incumbent in repose, very long, and ample, yellowish and iridescent, with a very short marginal cell, and four longitudinal nervures, the second and third united toward the base, the third and fourth toward the margin; balancers small, clavate; six legs, tapering; feet long, slender, and five-jointed, terminated by minute claws.

"The larvæ are 2½ lines long, of a whitish color, tapering toward the head, composed of twelve joints; on each side of the thoracic segment is a short branching spiracle, and the tail is furnished with four divaricating blunt spines, the edges of the segments being serrated with hooked ones. When full grown this skin becomes horny, changing to a rust color, the maggot is transformed to a pupa within an internal horny shell of a chestnut color, and of course the pupa greatly resembles the larva.

"There is also an extensive group of flies called *Borborus*, the larvæ of which live upon decomposing vegetables, and probably animal substances also; at all events they are generated in fungi. A portion of these flies is now distinguished by Macquart, under the generic name of *Limosina;* one of them I have bred from rotting potatoes, and it seems to be identical with that author's—

"*L. geniculata.*—It is only 1 line long, and expands a little more than 2 lines. It is black; the head is moderately large, with an ample cavity beneath to receive the mouth; the eyes are hemispheric and rust-colored, and there are three minute ocelli on the crown; the face is concave, with two little horns in the center, the third joint orbicular, with a tomentose seta; thorax broader, very convex; scutel semi-orbicular and flat; abdomen very short, the segments equal in length; wings rather small, smoky, nervures pitchy; costal the strongest; submarginal cell not extending to the apex, second and third longitudinal nervures united at the middle, third and fourth forming a loop with two minute branches at the extremity; balancers small and ochreous; legs pitchy; hips ochreous, as well as the tips of the anterior thighs and the base of the shanks; hinder with a few spines outside; feet long, five-jointed, especially the hinder, which are slender and longer than the shanks; dull ochreous, basal-joint very long and pitchy, terminal one very short, and furnished with short claws.

"M. Rayer also observed a species in the infected potatoes which has been named by Guérin *Limosina payenii*, and it is not improbable that it may be the male of Macquart's species, for it agrees very well with our female, except in the color of the wings and the structure of the hinder feet.

"With the foregoing *Diptera* I often bred a parasitic insect in considerable numbers, but to which it is attached, or whether to any of them, I am unable to ascertain. It belongs to the order HYMENOPTERA, the family PROCTOTRUPIDÆ, and the genus *Cerapsilon*, which has been divided by Mr. Westwood into three genera, one of which is called *Paramesius*, and to that section our insect belongs. It is included by Nees ab Esenbeck in the genus *Diapria*, and has been named by him—

"*P. brachialis.*—The *male* is scarcely 1 line long and expands 1⅔; it is very glossy black; the head is globose, the face short, ovate, and at the bottom are attached the antennæ, which are nearly as long as the body, ferruginous and fourteen-jointed, basal joint long, second short, obovate, third notched or comma-shaped, remainder short and obovate, apical joint conical; eyes small, lateral, with three ocelli on the crown in a triangle; thorax very globose, scarcely larger than the head; scutel small, semi-oval, deeply hollowed at the base; metathorax ferruginous and uneven; petiole forming a ferruginous knob, woolly behind; abdomen small, ovate-conic, pitchy, base ferruginous, with four longitudinal channels on a very large segment, apical segment very short; fore wings dusky and pubescent, with a few nervures at the base of the superior, forming an elongated cell; six legs short, slender, and ochreous, pitchy at the base; thighs thickened, as well as the anterior shanks, and pitchy at the middle; feet slender, five-jointed, tips dusky. *Female*: Above 1 line long, and expanding 1¾; this sex is not only distinguished by its larger size, but the horns are shorter, with only twelve joints, the third being simple like the second; and the extremity of the abdomen is acuminated, and very acute.

"This insect belongs to a family which is very serviceable in keeping down wire-worms and other subterranean larvæ, as will be seen by a reference to a former chapter and the Gardener's Chronicle. Nees also says that the *Diapriæ* breed in the subterranean larvæ of *Tipulæ*, or gnats.

"I must not omit to record another fly, called *Dilophus febrilis*, which is exceedingly abundant every year, the larvæ causing much mischief in gardens; and at the close of the year 1845, many of them were sent to me as abounding on decayed portions of planted potatoes, and I have met with them likewise about the tubers and in flower-pots, where they burrow in all directions. Some I received in July were about ¼ of an inch long, of an ochreous-brown or snuff color, and shagreened; the back is slightly convex, with twelve well-defined wrinkled segments, and a horny, shining head, much narrower than the body, intensely black or inclining to chestnut color, and slighty hairy; there are eight distinct spiracles on each side, the penultimate segment is rounded, with four teeth on the margin, and the anal one has four smaller teeth, with two large spiracles near the base; it has no feet.

"They were transformed to pupæ in the earth in the beginning of August, and were then yellowish-white; the thoracic portion was very thick, with two horns in front; the body slender and subcylindric, the segments very distinct, with spiracles down the sides, and the tail spiny.

"The flies hatched on the 21st of August, but they abound in fields, hedges, especially under trees, and even in the highways around London, the whole of that month; and there must be two broods of them, as they are found likewise in May. They belong to the family TIPULIDÆ, and to the genus *Dilophus*. The species was named *febrilis* by Linnæus, from the generally-received opinions in Sweden of these flies resorting to houses where intermittent fevers existed.

"*D. febrilis* is intensely black, shining, and hairy. The head of the *male* is hemispheric, and covered with large densely pubescent eyes of a reddish-brown color. There are three minute ocelli forming an elevated triangle near the base; the tip is broad, and the feelers incurved; the trunk is oval and gibbose, with two transverse rows of minute teeth before; the scutel is short and broad; abdomen sublinear, eight-jointed, the apex clubbed; the two wings are incumbent in repose, perfectly transparent and white but iridescent, the pinion only is slightly tinged with brown, the costal nervures pitchy, the others very faintly marked; a radial nervure uniting with the costa at the middle forms a brown spot at the extremity; two balancers, with a large compressed brown club; it has six long legs; anterior thighs the thickest, the shanks very short, the apex surrounded by a coronet of teeth. There are also several short spines outside; feet slender, five-jointed, terminated by claws and suckers; length, 2½ lines; expanse, 5 lines. The *female* is larger and very different, the head being much less, with small oval eyes not meeting on the crown; the abdomen is brownish and elongated, ovate at the extremity but narrowed at the base, and the tip is furnished with two minute tubercles; the wings are much longer and very ample, entirely brown, the pinion being the darkest, with a brown stigmatic spot; all the nervures are pitchy; the anterior thighs are incrassated.

"These insects fly heavily, their hinder legs hanging down, and in the evening they become sluggish, resting on herbage and bushes. The larvæ also inhabit cow-dung and horse-muck; it is therefore very possible they may be introduced into potato-grounds with the manure, or the flies may be attracted to highly-manured ground to deposit their eggs; for so little is known of the economy of many insects, that it is impossible to determine their exact habits; indeed, no description or figures were to be found of the larvæ and pupæ of this fly until I sent them to the Gardener's Chronicle."

INJURING THE SWEET-POTATO.

THE HELMET-BEETLE, *Coptocycla aurichalcea* (Fabricius).—Feeding on the leaves; broad, flattened, spiny grubs, holding their cast-off skins over their backs.

This beetle, which usually feeds on the leaves of the morning-glory, will sometimes destroy whole fields of sweet-potatoes, and is specially injurious to plants transferred from hot-houses.

The larva is broad and flat, with a row of large, long, barbed, spines along the edge of the body, sixteen on each side, the two posterior of which serve as a fork to hold the cast skin, covered with excrement, over its body, probably as a protection from its enemies, the birds. The eggs are irregular, flattened, with three spines behind, sometimes, however, wanting, and they are laid on the leaves. The larva matures in three weeks after hatching, molting three times. The larva, when about to change to a pupa, adheres by a mass of silk to the surface of a leaf, with its cast-skin about it. The pupa is smooth, its tail movable, and the limbs, according to Riley, are soldered to the body, as in the chrysalids of moths and butterflies. The pupa state lasts a week. In Massachusetts, during the last week in July, I have found the larvæ in all stages of growth very abundant on the morning-glory (*Convolvulus*), eating holes in the leaves. They pupated late in July and early in August; the beetles appear from the 7th to the 12th. Hand-picking is obviously amply sufficient to destroy them if too numerous.

Description of the beetle.—Of a rich amber-yellow, with a reddish tinge over the body. Two black spots on the back and two on each side, disappearing a few days after casting off the pupa-skin. The wing-covers are ornamented with finely-impressed punctured lines. Body beneath shining black; antennæ pale on the basal half, dark beyond. Legs pale amber. Length a little less than a quarter (0.22) of an inch.

THE TWO-STRIPED SWEET-POTATO BEETLE, *Cassida bivittata* Say.—In the Western States the most common helmet-beetle found on the sweet-potato, and, according to Mr. Riley, feeding exclusively upon it, is the above-named beetle. The grub or larva is dirty-white or yellowish-white, with a more or less intense neutral-colored longitudinal line along the back, usually relieved by an extra light band on each side. It differs from the larvæ of all other known species in not using its fork for merdigerous purposes. Indeed, this fork is rendered useless as a shield to the body, by being ever enveloped, after the first month, in the cast-off prickly skins, which are kept free from excrement. The beetle is of a pale yellow, striped with black. (Riley.) Besides these two helmet-beetles, two other species (*Cassida nigripes* and *Coptocycla guttata*) prey to a certain extent upon the sweet-potato. The cucumber flea-beetle, *Epitrix cucumeris* (Harris), and a few caterpillars are said by Riley to feed on this plant. Besides these, Harris states that plant-lice sometimes infest the leaves, and to drive them off he recommends dusting the leaves with lime.

INJURING THE ONION.

THE ONION-FLY, *Anthomyia ceparum* Meigen. (Plate LXVII, Fig. 1.)—Killing the tops, causing them to turn yellow and wilt; a smooth, conical, white maggot, attacking the bulb soon after the leaves appear early in June, and afterward through the summer, and changing to an ash-gray fly, a little smaller than the house-fly, and with a row of black spots along the middle of the hind body, which lays its eggs on the leaves, close to the earth.

The onion-fly has been an inhabitant of this country for about forty years, having been imported from Europe. Fitch remarks that "in many parts of New England and New York it was extremely numerous and destructive about the year 1854, and again in 1863." In Essex County, Massachusetts, it has been for a number of years, and still is, very annoying and destructive. Having had little opportunity of observing the habits of this fly, I avail myself of the quite full account given by Dr. Fitch in his Eleventh Report on the Noxious Insects of New York, often using his own words: "In June, as soon as the young seedling-onions are only an inch or two in height, these insects commence their depredations and continue them through the whole season, getting their growth and coming out in their perfect state one after another, whereby some of the flies are liable to be always present in the garden, in readiness to deposit their eggs; and maggots of widely-different sizes are commonly met with in the same onion.

"The eggs or 'fly-blows' are loosely placed upon the onion slightly above the surface of the ground (Fig. —), some of them being dropped along the thin edge of the sheath or white membranous collar, which is formed by the base of the lower leaf clasping around the stalk, and others are crowded into the crevices between the bases of the leaves, slightly above where they issue from this sheath. From two to six or more eggs are usually placed on particular plants here and there through the bed. They are perceptible to the eye, being white and smooth, four-hundredths of an inch (0.04) long, and a fourth as thick, and of an oval form." When the minute maggot hatches from the egg, it works its way downward inside of the sheath, its track being marked by a slender, discolored streak, till it reaches the root, on which it feeds till it is wholly consumed, only the thin outer skin remaining. After eating the bulb of one plant they attack the next, until sometimes a third or a half of the bed is destroyed.

The first indication that the plant has been attacked is afforded by the leaves turning yellow and wilting. "On carefully digging up and examining the affected plant, if it is young and the root small and cylindrical, we commonly find it completely cut asunder as represented in Fig. —, only the thin outer skin remaining, whereby the slightest pulling upon the top draws it up out of the ground. Later in the season, when the round bulb is beginning to be formed, as in Fig. —, we find a hole perforated in its side, opening into a cavity in the interior, and the earth around this perforation is wet and slimy, forming a mass of filthy mud in which those worms are lying which are not engaged in feeding. And by this interior cavity the central leaves of the plant are severed from their connection with the fibrous rootlets, as shown in the figure, whereby it is now these central and not the outer leaves which first turn yellow and die, and all the upper portion of the root soon becomes soft and putrid, while the bottom part, continuing to be nourished by the fibrous rootlets, remains sound, and the worms now crowd into this part to feed, whereby it sometimes presents a wonderful appearance, being thronged with worms wedged together side by side in a compact mass, all with their heads downward, eagerly consuming the last remains of food there is there, and only the rounded hind ends of their bodies exposed to view, these forming an even surface similar to the cobble-stones of a street-pavement, as represented in Fig.—."

The maggot attains its growth, in summer, in about a fortnight, and changes to a pupa either in the cavity in the onion or in "the wet, slimy earth which is in contact with the onion. It here ceases to move, it becomes contracted and shorter in length, its skin hardens and changes to a tarnished yellow and finally to a chestnut color with a stain of black at each end." This is the pupa-case, and the true pupa is inside. In this condition it lies about two weeks before the fly escapes.

In Essex County, Massachusetts, this fly is very destructive. The maggots appear about the middle and last of May, and by the third week in August the larvæ are not found, only the pupa-cases.

Description.—The larva or maggot is shining, dull white, cylindrical, tapering to a point in front, and when crawling and elongated, nearly the whole length of the body becomes tapering. At the forward end the jaws appear under the skin as a short black stripe. The hind end is cut off abruptly in an oblique direction, forming a flattened surface, on which, slightly above the center, are two elevated dots of a cinnamon-brown color, and appearing somewhat like a pair of eyes; and around the margin are eight small projecting teeth, of which the two lowest ones are largest; and a little forward of these, on the under side of the body, are two additional teeth, like minute feet, by the aid of which the maggot shoves itself forward when crawling. (Fitch.) Specimens from Essex County, Massachusetts, are long, conical, the end of the body squarely docked, with barrel-shaped spiracles projecting from the end of the body. On the under side of the segments are raised folds, one to each segment, and of service in locomotion. The spiracles and termination of the tracheæ or air-tubes are very distinct on the prothorax, while there are no traces of antennæ. The fly is like the common house-fly, but smaller and slenderer. The two sexes are readily distinguished from each other by the eyes, which in the males are close together and so large as to occupy almost the whole surface of the head, while in the female they are widely separated from each other. These flies are of an ash-gray color, with the head silvery, and a rusty-black stripe between the eyes, forked at its hind end. The species is particularly distinguished by having a row of black spots along the middle of the abdomen or hind body, which sometimes run into each other, then forming a continuous black stripe. This row of spots is quite distinct in the male, but in the female it is very faint or is often wholly imperceptible. This fly measures 0.22 to 0.25 inch in length, the females being usually rather larger than the males. (Fitch.)

Remedies.—As a preventive measure worth trial the seed should be sown two inches deeper than usual, so that the fly cannot so readily get to it to lay its eggs. Sow also on ground on which straw has been previously burned. Rotation of crops is also a most important preventive measure. When the roots are infested pour boiling water along the drills near the roots, or even on the plants, going over the bed four times during one season. The diseased onions should be pulled up and burned. Fitch recommends cultivating the onions in hills, scattered among the other vegetables in the garden. "With only three or four seedlings in a hill it is evident that the young worms could nowhere find a sufficient amount of food to nourish them to maturity. Having consumed all the young plants in one hill, they will be unable to work their way through the ground to come at another hill except it be by the merest chance, and will thus perish."

THE BLACK ONION-FLY, *Ortalis flexa* Wiedermann. (Plate LXVII, Fig. 2.)—Infesting the bulb in the Western States; a more slender, less conical maggot than the European onion-maggot, with the head blunter; killing the tops and causing the onions to decay; changing to a black fly, with three oblique white stripes on each wing.

This native onion-fly was first found to be destructive to onions in Illinois by Dr. Henry Shimer, who writes in the Practical Entomologist (i, 4) as follows regarding it: "In the latter part of June I first observed the larva or maggot among the onions here; the top dead, tuber rotten, and the maggots in the decayed substance. From them I bred the fly. They passed about two weeks in the pupa state. At that time I first observed the flies in the garden, and now few are to be found. Their favorite roosting-place is a row of asparagus running along the onion-ground, where they are easily captured and destroyed, from daylight to sunrise, while it is cool and wet. During the day they are scattered over the ground and on the leaves and stalks of the onions, and not easily captured. Their wings point obliquely backward, outward, and upward, with an irregular jerking, fan-like movement; flight not very rapid or prolonged. They are not very numerous, probably not over 200 or 300. All that I observed originated in one part of the bed, where they were doubtless deposited by one parent fly. Two broods appear in a season."

THE ONION-THRIPS, *Limothrips tritici* Fitch. (Plate LXVII, Figs. 3–5.)—Attacking the leaves, causing them to turn yellow and wilt and die; minute, yellow, slender insects, living on the leaves in all stages of growth.

The following account is taken from my Second Annual Report on the Injurious and Beneficial Insects of Massachusetts:

"About the middle of August my attention was called by Mr. B. P.

Ware, of Swampscott, to his serious loss of onions from the attacks of a minute insect. The leaves were observed to suddenly turn yellow and wilt, and the plant died. In this way large patches became infested and turned yellow, until in two or three days these prolific insects spread over the whole field. They seemed to increase most rapidly during the unusual dry, hot weather that we experienced about the middle of last August. On the 11th of August a whole acre was thus cut off. Mr. Ware informed me that the onion-plants have been more or less infested in this way for some fifteen years, but the damage done this year was greater than ever before. This evil seems wide-spread in Essex County, as not in Swampscott alone, but in Lynn, Salem, and parts of Danvers, the onion-crop has been similarly infested. About $100,000 worth of onions are raised in Essex County alone, and Mr. Ware judged that at least a tenth part was destroyed by this new pest; so that in one county alone and by one kind of injurious insect we have in one season lost $10,000. The onion-crop is next to the hay-crop in value, as it is sold for cash.

"On examining the specimens brought into the Museum of the Peabody Academy of Science the leaves were found to be covered with hundreds of a minute thrips, which, by gnawing the surface of the leaves, had caused them to turn white in spots, and subsequently yellow; where they were most numerous the outer skin of the fleshy leaves was entirely eaten off, and though it was difficult to imagine that so minute insects could have caused the death of so stout and thick-leaved a plant, yet here were hundreds of the culprits in all stages of growth plying their jaws before our eyes in proof.

"This insect, which occurred in both sexes and in all stages of growth from larvæ of minute size, proved to be the wheat-thrips of Fitch (*Limothrips tritici*), who gives an account of its appearance and habits in his 'Second Report on the Noxious, etc., Insects of New York,' p. 304. His attention was first called to this insect by a correspondent in Wisconsin, who found them in great numbers in blossoms of various plants. He wrote Dr. Fitch that they first 'made their appearance about the middle of June, or at least they were then first noticed, so far as I have heard. For about two weeks they were found in the blossoms of wheat and of clover, causing numbers of the blossoms to wither, and in some cases the kernel was also attacked.' Dr. Fitch himself never seems to have noticed this insect in New York, nor that it has ever been found in the onion, but thinks it is the species to which Dr. Harris refers in his treatise. In that work the author speaks of a 'pernicious insect in the ears of growing wheat,' which 'seems to agree with the accounts of the *Thrips cerealium* which sometimes infests wheat in Europe to a great extent.' From his brief description it is probably the insect now under consideration to which Dr. Harris refers.

"The various kinds of thrips are minute, narrow-bodied insects seldom exceeding a line in length, and remotely allied to the bed-bug and squash-bug in structure, but differing from them in having free jaws adapted to biting, while those of the bed or squash bug form with the other mouth-organs a sharp, hard beak, with which they puncture leaves, or the flesh of their victims, when carnivorous in their tastes. These thrips are further distinguished by their wings being very long and narrow, and beautifully fringed; and when folded over their back they do not conceal the body beneath, as is usually the case. Moreover, they are exceedingly active in their habits, running or leaping like fleas.

"*Description.*—The females alone are winged, the males being wingless and closely resembling the larvæ. The body of the female is smooth and shining, uniformly greenish-yellow, with no other markings; the legs are a little paler toward the articulations. The antennæ are eight-jointed, slightly longer than the head; the two basal joints are the largest; the three succeeding joints equal, regularly ovate, the sixth a little longer than the fifth; seventh and eighth minute, seventh a little shorter than eighth, each joint bearing four large bristles. This species differs from the European *L. cerealium* in having but eight joints, the seventh and eighth being minute, and with no intermediate short one, as described in the European insect.

"The prothorax is square, the scutellum short, crescent-shaped, and the abdomen is long and narrow, smooth and shining, ten-jointed. Length, four one-hundredths of an inch, or less than half a line.

"The larva (Plate LXVII, Fig. 4 *b*) is entirely greenish-yellow, the head and prothorax of the same color as the rest of the body; the eyes are reddish; the feet and antennæ are whitish, not annulated, as in *L. cerealium;* the feet (tarsi) consist of but a single joint ending in a point.

"The male (Plate LXVII, Fig. 4 *a*) differs from the larva in having two-jointed feet (tarsi) and seven-jointed antennæ, those of the larva being four-jointed. The second joint is exactly barrel-shaped, with two ridges or lines surrounding it, third and fourth joints long, ovate, the third being a little larger than the fourth, and with about twelve transverse lines, there being about eight on the fourth joint, from the end of which projects a remarkable tubercle, as seen in the figure. The fifth joint is square at the end, with about eleven transverse lines, and three or four stout hairs externally; sixth joint minute and spherical, while the seventh is three times as long as the sixth, and is finely striated, and with four unequal stout hairs. It is just twice the length of the female, measuring 0.08 inch.

"*Remedies.*—The best remedy of a preventive nature against further ravages, after this insect has made its appearance, is to build a bonfire upon the diseased patch, pull up the onions about, and throw them into it. By thus sacrificing a few onions at the outset, the evil may be nipped in the bud. As remedies less effective we would recommend showering the plants with strong soap-suds, or sprinkling them with sulphur, or the use of a solution of copperas, such as is used in killing the currant saw-fly, *i. e.*, a solution of a pound of copperas to ten gallons of water. The use of a carbolate of lime or air-slaked lime may also be recommended.

"A heavy shower of rain will cause them to disappear for a while, and they probably only appear in such overwhelming numbers as this past year in consequence of the summer being an unusually dry and warm one."

INSECTS INJURING THE TURNIP.

THE TURNIP FLEA-BEETLE, *Haltica* (*Orchestris*) *striolata* Illiger.—Feeding on the seed-leaves in the spring and later; small, yellow-striped, flea-beetles. In June, the plants die from the attacks of the grubs which live in the roots.

This is a very annoying little beetle, universally abundant in gardens, and especially injurious to the seed-leaves of the turnips, cabbage, and other garden-vegetables. The fullest account which we have of its habits is that given by Dr. Shimer in the American Naturalist, vol. 2, p. 514, which I copy:

"This beautiful little beetle, also called striped turnip-fly (*Haltica striolata* Fabricius) at the West, is well known and abundant. Every gardener is conversant with the fact that, like fleas, grasshoppers, etc., it springs away to a great distance when he attempts to put his finger upon it. It appears in early spring, and is a constant annoyance to the gardener during the whole summer.

"From my notes I see that on June 14, 1865, I put a number of the larvæ into a breeding-box, with a supply of their natural food. June 17 some of the larvæ had disappeared beneath the ground. July 4, I found in the box the beetle. This gives us seventeen days from the time the larva entered the ground, having ceased eating, until I obtained the perfect insect. I did not open the breeding-box every day, but as the insect was yet quite pale and soft, conclude that it was not more than a day or so out of the ground. The actual time, however, in the pupa state, was less than seventeen days, for, like the larva of the cucumber-beetle and other beetles, these worms pass a kind of intermediate state, in a quiet, motionless condition, in their little dirt-tombs beneath the ground. During this time they decrease in length very much, becoming a shorter, thicker 'grub.' This period is a peculiar part of the larval state, and may be called the quiescent, or 'shortening period,' in contrast with the feeding period. At the end of this preparatory shortening period, the little larva casts its skin and becomes a pupa.

"During the past summer I bred a good number of these beetles from the larva and pupa, taken from their breeding-places beneath the ground; but as I took no precise notes of the date, I can say no more regarding the time of the pupa state, except that it is short, only a few days.

"Every gardener knows that these insects are very injurious to young cabbages and turnips as soon as they appear above the ground, by eating off the seed-leaves; he also almost universally imagines that when the second or true plant-leaves appear, then the young plant is safe from their depredations, then the stem is so hard that the insect will not bite it, and the leaves grow out so rapidly as not usually to be injured by them; but if we would gain much true knowledge of what is going on around us, even among these most simple and common things, we must learn to observe more closely than most men do.

"The gardener sees his young cabbage-plants growing well for a time, but at length they become pale or sickly, wither and die in some dry period that usually occurs about that time, and attributes their death to the dry weather; but if he will take the pains to examine the roots of the plants, he will find them eaten away by some insect, and by searching closely about the roots will find the larva, grub, worm, or whatever else he may choose to call it; from this he can breed the striped turnip-beetle, as I have often done.

"I have observed the depredations of these larvæ for ten years, and most of that time had a convincing knowledge of their origin, but only proved it in 1865; since that time I have made yearly verifications of this fact.

"Every year the young cabbage-plants and turnips in this region receive great damage from these larvæ, and often when we have dry weather, in the latter part of May and early in June, the cabbage-plants are ruined. A large proportion of the plants are killed outright in June, and the balance rendered scarcely fit for planting; but when the ground is wet to the *surface* all the time by frequent rains, the young plant is able to defend itself much more effectually, by throwing out roots at the surface of the ground, when the main or center root is devoured by the larva; but in the dry weather these surface roots find no nourishment and the plants must perish.

"This year I saw these beetles most numerous in early spring, but have often seen them in August and September so abundant on cabbages that the leaves were eaten full of holes and all speckled from their presence, hundreds often being on a leaf, and at this time the entire turnip-crop is sometimes destroyed by them, and seldom a year passes without their doing great injury."

These observation are not entirely in accordance with the teachings of the masters in entomology. From Westwood's Introduction we learn that the *Chrysomelians* feed on the leaves of plants; that some of them attach themselves to the leaves to transform, and that others descend into the ground for this purpose; but he has no notes of species feeding beneath the ground. Harris was of the opinion that the striped cucumbre-beetles, in the larval state, fed on the roots of plants, but was never able to find them. I have demonstrated many years ago that they feed on the roots of melon, cucumber, squash, and pumpkin vines, and ever since I attempted to raise any kind of vine my greatest trouble has been *not to find them*.

"The *Chrysomelians*, probably, as a rule, feed on the leaves of plants in the larval state, but in my limited researches I have found the majority of them beneath the ground. According to undisputed authority, they often congregate together in great numbers and do great injury to the leaves of plants, even so as to compare with the ravages of caterpillars. I, myself, have observed some of this work.

"As the cucumber-beetle exclusively raises its young on the roots of the *Cucurbitaceous* (gourd) family, so from these observations I am led to believe from analogy that the striped turnip beetle raises its young always on the roots of the *Cruciferous* (mustard) family.

"The striped turnip-beetle (Fig. 14) is less than one-tenth of an inch in length. Its general appearance is black, with a broad, wavy-yellowish or buff colored stripe on each wing-cover. The larva (Fig. 14) is white with a faint darkened or dusky median line on the anterior half of the body, being probably the contents of the alimentary canal seen through the semi-translucent skin. The head is horny and light brown. On the posterior extremity is a brown spot equal to the head in size; and there are six true legs and one proleg. In its form and general appearance it somewat resembles the larva of the cucumber-beetle, but it is much smaller. Its motion is slow, arching up the abdomen slightly, on paper or any smooth surface, in such a position that its motions are necessarily awkward and unnatural, because in a state of nature it never crawls over the surface, but digs and burrows among the roots in the ground. Its length is 0.35 of an inch, and breadth 0.06 of an inch. It feeds upon roots beneath the ground.

FIG. 14.—Turnip Flea-beetle, larva and pupa.

"The pupa is naked, white, and transforms in a little earthern cocoon, pressed and prepared by the larva, in the ground near its feeding-place. This period is short."

THE TURNIP-BUTTERFLY, *Pieris oleracea* (Harris).—Devouring the leaves of the turnip; a velvety dark-green caterpillar, changing to an unspotted white butterfly.

Though this butterfly is spread all over the northern portion of our continent from Maine to Utah, and is more abundant in Colorado and Utah (having probably recently been introduced there) than in the Eastern States, so far as my observations have extended, it is nowhere particularly distinctive. As I am somewhat dependent on my own observations regarding the transformations of this delicate-tinted butterfly, I extract the following notice of it from my Guide to the Study of Insects: "We have found the larvæ of this species on turnip-leaves in the middle of August at Chamberlain Farm, in northern Maine. They are of a dull green, and covered with dense hairs.

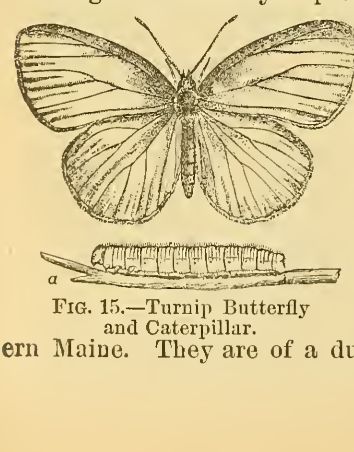

FIG. 15.—Turnip Butterfly and Caterpillar.

They suspend themselves by the tail and a transverse loop, and their chrysalids are angular at the sides and pointed at both ends (Harris). *Pieris oleracea* is white, with the wings dusky next the body. The tips of the fore wings are yellowish beneath and the hind wings are straw-colored beneath. The yellowish, pear-shaped, longitudinally-ribbed eggs are laid three or four on a single leaf. In a week or ten days this larvæ are hatched. They live three weeks before becoming full-fed. The chrysalis state lasts from ten to twelve days. There is an early (May) and a late summer (July) brood."

Remedies.—It should be borne in mind that the caterpillar feeds on the under side of the leaves, so that if they are turned over in June and again in August and carefully examined, the dark-green caterpillar, whose color blends with that of the turnip-leaf, can be picked off and trod under foot.

INSECTS INJURING THE CABBAGE.

THE EUROPEAN CABBAGE-BUTTERFLY, *Pieris rapæ* Schrank.—Feeding not only on the outer leaves, but boring into the heads in all directions; a green, velvety caterpillar with a yellowish stripe along the back and side, and turning into a white butterfly with four (male) or six (female) conspicuous black spots.

While the caterpillar of our native cabbage (and turnip) butterfly (*P. oleracea*) feeds on the outer leaves, the present species is much more destructive and difficult to destroy, from its habit of boring into the interior of the cabbage-head. It also devours the cauliflower and feeds on the mignonette.

It was introduced from Europe to Quebec about the year 1857, having been captured in 1859 by Mr. Bowles, of that city. It rapidly spread into New England along the different railroads leading in from Canada, and is now common about Boston and New York and southward to Philadelphia and Washington. During the year 1870 it did much damage in gardens in Monmouth County, New Jersey, as I am informed by Dr. S. Lockwood. About Quebec it annually destroys $250,000 worth of cabbages, according to the Abbé Provancher.

A correspondent of the American Agriculturist for November, 1870, states that "it is estimated that the loss from this insect will, in the vicinity of New York [city] alone, exceed half a million of dollars, and already the price of cabbages has advanced." He says that Mr. Quinn, the owner of a large plantation, "has found carbolic powder, superphosphate, and lime together to destroy them. The carbolic powder appears to be sawdust impregnated with carbolic acid. Salt has been recommended, but Mr. Quinn did not find dry salt efficacious, though lime has been reported by others as useful."

It is evident that in this newly-arrived insect we have another formidable pest added to our list of imported insects.

It is to the parasites of this butterfly that we are to look for the natural means of keeping this insect pest within bounds.

Mr. Curtis has described and figured several parasites of the three species of cabbage-butterflies found in England, and he shows how thoroughly they keep in check these troublesome worms. Certain minute ichneumon-flies (*Chalcids*) lay their eggs in those of the butterflies. Another chalcid fly (*Pteromalus brassicæ*) lays its eggs on the outside of the chrysalis of the white cabbage butterfly (*Pieris brassicæ*), and sometimes 200 or 300 of the little chalcid maggots have been found living riotously within a single chrysalis. They turn into minute brilliant flies, which multiply in excessive quantities. Mr. Curtis remarks that "some species of this extensive genus (*Pteromalus*), probably comprising nearly 1,000 species (!), swarm even in our houses, especially in the country, where in October and November I have seen immense numbers inside of the windows, and I believe that they hibernate behind the shutters, in the curtains," etc.

Were it not for the native ichneumon parasite, (Fig. 16, *a*, male; *b*, female,) which has been found to prey upon it very extensively, the cultivation of the cabbage would have to be given up in some districts. This invaluable ichneumon is one of the chalcid family, and is the *Pteromalus puparum* of Linnæus. It is well known that the cabbage-caterpillar (*Pieris rapæ*) was introduced into this country about the year 1857. I had supposed that the parasite had perhaps been imported with its host, but now find that it is undoubtedly a native of this country as well as Europe. Having been favored by Mr. Francis Walker with specimens of both sexes from England, labeled by him *Pt. puparum*, I found that our specimens did not differ specificially. Further, Mr. Walker wrote me that there were specimens of the same species in the British Museum, taken in Hudson's Bay territory in 1844. During the past summer Mr. P. S. Sprague, sent me specimens which had been raised from the rape caterpillar in Vermont. Mr. J. A. Lintner has also published a note in the American Naturalist stating that he had reared this parasite from the same kind of caterpillar, and previously to this Mr. S. H. Scudder had received numerous specimens from Mr. A. G. T. Ritchie, of Montreal, Canada, who, if I understand his letter aright, first observed these chalcids upon the cabbage-leaves in July, 1870, when the caterpillars were abundant. On the 23d of August of the same year he had some of the parasites hatch out. To Mr. Ritchie, then, is due the credit of being the first to make known the history of this invaluable insect.

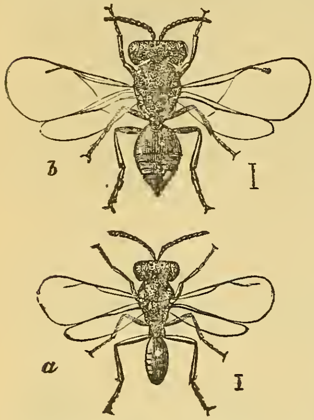

FIG. 16.—Parasite of the imported Cabbage Butterfly.

It seems that the parasite covers even a wider field than its host, and probably preys on our native cabbage-butterfly, the *Pieris oleracea*, as in Europe it preys on *Pieris brassicæ*, the caterpillar so destructive to the cabbage there.

Description.—The male of this *Pteromalus* is a beautiful pale-green fly, with the body finely punctured and emitting metallic tints; the abdomen, or hind body, is flat, in dried specimens with a deep crease along the middle of the upper side, and it is much lighter in color and with more decided metallic reflections than in the rest of the body. The antennæ are honey-yellow, with narrow black wings. The legs are pale honey-yellow. It is .08 inch to a tenth in length.

The body of the female, which would be thought at first to be an entirely different kind of insect, is much stouter, broader, with a broader oval abdomen, ending in a very short ovipositor, while the under side of the body near the base has a large conical projection. It is much duller green than the male, and the body is more coarsely punctured. The scutellum of the metathorax is regularly convex, not keeled, in both sexes. The antennæ are brown, and the legs brown, becoming pale toward the ends, the ends of the femora being pale; the tibiæ pale brown in the middle, much paler at each end, while the tarsi are whitish, though the tip of the last joint is dark. It is from a line to a line and a third in length. It differs from Harris's *Pteromalus vanessæ* in the little piece known as the scutellum of the metathorax being smooth, not keeled, and by its darker legs.

The larva is a little white maggot about a sixth (.17) of an inch in length. The body consists of thirteen segments, exclusive of the head, and is cylindrical, tapering rapidly toward the head, while the end of the body is acutely pointed. The chrysalis is whitish, the limbs being folded along the under side of the body, the antennæ reaching to the end of the wings; the second pair of legs reaching half-way between the end of the wings and end of abdomen; while the tips of the third pair of feet reach half-way between the second pair of feet and the end of the abdomen. It is from a line to a line and a third in length.

In the middle of September Mr. F. W. Putnam handed me one hundred and ten chrysalids, all but two of which were infested by these parasites in both the larval and pupal states; while from other chrysalids the adult chalcid flies were emerging. They continued to emerge until late in the autumn. The infested chrysalids of the butterfly could be easily distinguished by the livid and otherwise discolored and diseased appearance of the body, while those unattacked had preserved the fresh color, and the tail moved about readily; the diseased ones becoming stiff and more or less dried. Mr. Putnam thinks that at least two-thirds of the chrysalids of this butterfly, hundreds of which had in the early autumn suspended themselves about his house and fences, had been attacked by these useful allies.

On opening the body of the infested chrysalids I found about thirty parasites in different stages of growth, in one case thirty two, in another only twelve. We can readily see how efficient these minute insects become in reducing the numbers of their hosts. A large proportion of the *Pteromalus* undoubtedly winter over in the body of the chrysalis, the adult insects appearing in the spring. In England Mr. Curtis found the fly in June, so that evidently there is an autumn and spring brood of flies.

Another parasite is the larva of a parasitic fly, *Tachina* (Fig. 17, enlarged three times), the adult form of which closely resembles the common house fly. It is a flattened, cylindrical maggot, both ends of the body rounded much alike. The mouth parts are partly aborted, there being only two retractile horny mandibles by which the fatty portions of its host is eaten.

FIG. 17.—Larva of Tachina.

Besides this large *Tachina* I found a minute fly in the same bottle with a number of the chrysalids of the butterfly, and am inclined to think that it may have lived parasitically in them, but would not be confident that it is so. It is a small black fly, about a line in length, and with dark wings.

The male butterfly (Fig. 18) is white, with the tips of the fore wings

FIG. 18.—European Cabbage Butterfly, male.

black, dusted with white, while on the fore wings is a single, and in the female there are two large black spots, situated two-thirds of the distance from the base to the outer edge of the wing. It expands about two inches. The female lays her eggs singly on the under side of the leaves. The caterpillar (Fig. 20, *a*) is green, and so densely clothed with minute hairs as to be velvety; it has a yellowish stripe down the back and another along each side, the belly being of a paler, brighter green; it is often more than an inch long, and about as thick as a large crow-quill. It changes in September, under some board or stone, to a chrysalis, suspended by a thread spun over the back as shown at Fig. 20, *b*. It is of a pale flesh-brown color, freckled with black. It winters in this state, the butterfly appearing in Massachusetts early in May.

FIG. 20.—European Cabbage Butterfly. *a*, caterpillar, *b*, chrysalis.

The native cabbage-butterfly (*Pieris protodice*, Figs. 21–23) is but slightly injurious to the cabbage in the Southern and Western States.

Remedies.—It does not appear to have been very destructive in Europe, but, like other introduced species, it suddenly becomes a fearful scourge in a new country. The best remedies are evidently hand-picking, when the caterpillars can be seen, and the capture of the butterflies by means of a light gauze-net mounted on a wire ring a foot in diameter, and attached to a short pole. Affected cabbage-heads should be carefully examined, and if much infested by worms, be burned; for, if they are suffered to lie about the garden after being pulled up, the caterpillars will attack the other plants.

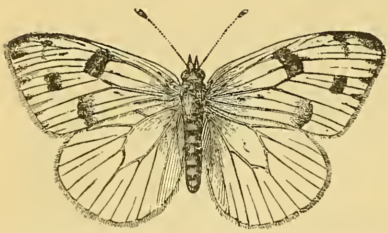

FIG. 21.—Native Cabbage Butterfly, male.

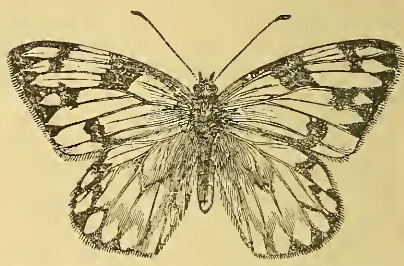

FIG. 22.—Native Cabbage Butterfly, female.

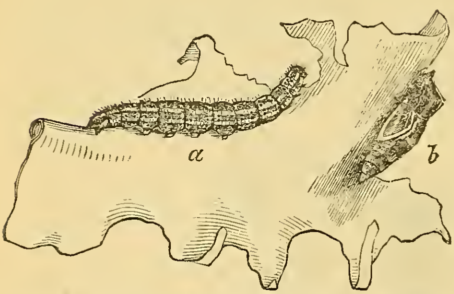

FIG. 23.—Native Cabbage Butterfly. *a*, caterpillar, *b*, chrysalis.

Mr. C. S. Minot, in an article entitled "Cabbage-butterflies," in the American Entomologist, vol. ii, strongly recommends destroying the chrysalis, which may be found under chips, boards, stones, etc., and advises that boards, raised two inches above the surface of the ground, be placed among the plants to attract the caterpillars when about to change to a chrysalis.

Riley recommends drenching the plants with a wash of cresylic soap, for this and other noxious cabbage-insects. As those chrysalids which are infested by the chalcid flies are readily distinguished from the healthy ones by their livid and diseased appearance, they can be selected and preserved or left alone, and thus the parasites can be bred.

The Toronto Globe recommends hot water to be applied to cabbages that are infested with the *Pieris rapæ*, sprinkled on from a fine rose watering-can. The water may be boiling-hot when put into the can, but it will not be too hot when it reaches the leaves. The thick fleshy nature of the leaves enables them to withstand considerable heat with very little injury. The sacrifice of a few heads of cabbage will soon teach an experimenter how far he can go with the hot water. A Rural Home correspondent speaks also from his own experience and says: "I heat water to nearly a boiling-heat, and put it on with a common watering-pot, with the sprinkler removed. If it is very hot it will color some of the leaves, but it does not seem to hurt the cabbage in the least. This will kill the young worms and nearly all the old ones. There will sometimes be a few that do not get touched with the water. These can be picked off with a small pair of pincers. If there are not a great many the last remedy will do."

THE EUROPEAN CABBAGE WEB-MOTH, *Plutella xylostella* (Linnæus).—Small green caterpillars, feeding on the under side of the outer leaves, and spinning web-like cocoons in folds in the leaves; changing to a small moth somewhat like a clothes-moth.

My attention was first called to this moth, now almost cosmopolitan in its distribution, in September and October, 1870, at the Agricultural College at Amherst, Mass. The little green caterpillars were quite abundant on the under side of the outer leaves of the cabbages on the college-farm, and their web-like, delicate cocoons were found attached to the leaf in depressions or folds. Afterward a correspondent in Michigan sent me specimens of the worm, the cocoon, and moth, stating that it was doing great damage to the cabbages there. The season at Amherst, as all over New England in 1870, was very warm and unusually dry, which accounts for the unusual increase in this insect.

This insect, well known in Europe, whence it has been carried all over the civilized world, was first noticed in this country by Dr. Fitch in 1855, who gives an account of it in his "First and Second Reports," etc., having observed it in Illinois, but not in New York. He called it *Cerostoma brassicella*, but it is undoubtedly the well-known European *Plutella xyllostella* Linn. Though the insect has been observed in this country only late in the autumn when the cabbages have headed, yet these worms, as Dr. Fitch suggests, probably belong to a second brood. Stainton, in his "Manual of British Butterflies and Moths," states that the moths fly in May and August, while the caterpillars appear in June, July, and a second brood again in September. Dr. Fitch suspects that the first brood of caterpillars may feed on the young cabbage-plants in early summer, and thus do more mischief than in the autumn when the heads are fully formed.

Mr. C. A. Putnam, of Salem, brought me specimens found on the cauliflower. On November 15 it pupated in a thin cocoon consisting of a single layer of silk forming a very open web.

Description.—The *caterpillar* is a little pale-green worm, with small, stiff, dark hairs scattered over the body; it is a quarter of an inch long. When about to transform it spins a beautiful open net-work of silk as a cocoon, open at one end, of white silken threads; it is a third of an inch long.

Pupa with a long, broad, white dorsal band, and a broad, lateral band, widening before and inclosing three oblique dark stripes, the lower of which is formed by the antennæ. In a more mature chrysalis the white bands become narrower, and the dark portions darker.

The moth is pale gray, with the head, palpi, and antennæ white, but the latter are ringed alternately with white and gray on the outer half. The rest of the body is gray, except on the under side, and on the middle of the thorax, where there is a broad, white, longitudinal band, which, when the wings are folded, is continuous with the white band along the inner side of the wings. The two front pair of legs are gray, with the tarsal joints ringed narrowly with white; the hind legs are whitish and hairy. The fore wings are gray, with a conspicuous broad, longitudinal, white band along the inner edge, and extending to the outer third of the wing; this band sends out three teeth toward the middle of the wing, the third tooth being at the end of the band. There is a row of dark dots along the outer edge of the stripe; a row of blackish dots along a pale shade just outside of the front edge of the wing, and two diverging rows of blackish dots diverging upon the tip or apex of the wing. The fringe is marked with a few dark spots. The middle of the wing next the white band is darker than the front edge, while a faint yellowish shade runs along the middle of the outer half of the wing toward the tip, inclosing a few black dots. It expands a little over half an inch.

Remedies.—Should young plants be attacked by the worms, the best remedy would be to shower them with soap-suds. For the autumnal brood of worms the plants should be plentifully showered; and if this is not efficacious, the worms, and the cocoons especially, should be picked off by hand.

THE CABBAGE PLUSIA, *Plusia brassicæ* Riley. (Fig. 25.)—In August and September, gnawing large, irregular holes in the leaves; a rather large, pale-green caterpillar, marked with still paler, more opaque lines, and with three pairs of abdominal feet, being a semilooper, and changing to a grayish-brown moth, whose wings are marked with a distinct silver interrogation mark.

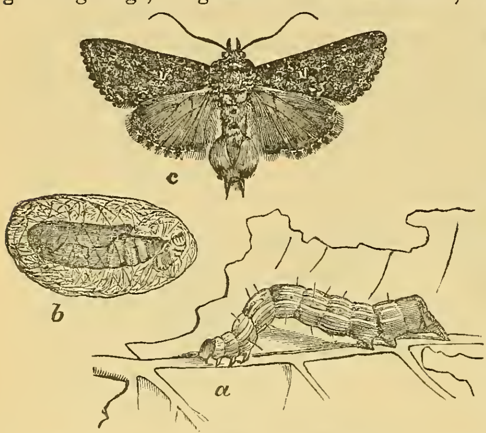

FIG. 25.—Cabbage Plusia. *a*, caterpillar, *b*, pupa in its cocoon, *c*, moth. After Riley.

This caterpillar has been found by Mr. Riley to do considerable mischief in Missouri. I quote his account of its appearance and habits:

"In the month of August and September, the larvæ may be found quite abundant on this plant, gnawing large, irregular holes in the leaves. It is a pale-green translucent worm, marked longitudinally with still paler, more opaque lines, and, like all the known larvæ of the family to which it belongs, it has but two pair of abdominal prolegs, the two anterior segments, which are usually furnished with such legs in ordinary caterpillars, not having the slightest trace of any. Consequently, they have to loop the body in marching, as represented in the figure, and are true 'span-worms.' Their bodies are very soft and tender, and as they live exposed on the outside of the plants, and often rest motionless, with the body arched, for hours at a time, they are espied and devoured by many of their enemies, such as birds, toads, &c. They are also subject to the attacks of at least two parasites, and die very often from disease, especially in wet weather; so that they are never likely to increase quite as badly as the butterflies just now described.

"When full-grown, this worm weaves a very thin, loose, white cocoon, sometimes between the leaves of the plant on which it fed, but more often in some more sheltered situation, and changes to a chrysalis, which varies from a pale yellowish-green to brown, and has a considerable protuberance at the end of the wing and leg cases, caused by the long proboscis of the inclosed moth being bent back at that point. This chrysalis is soft, the skin being very thin, and it is furnished at the extremity with an obtuse roughened projection which emits two converging points, and several short, curled bristles, by the aid of which it is enabled to cling to its cocoon.

"The moth is of a dark smoky-gray, inclining to brown, variegated with light grayish-brown, and marked in the middle of each front wing with a small oval spot and a somewhat U-shaped silvery-white mark, as in the figure. The male is easily distinguished from the female by a large tuft of golden hairs, covering a few black ones, which springs from each side of his abdomen toward the tip.

"The suggestions given for destroying the larvæ of the cabbage-butterflies apply equally well to those of this cabbage plusia, and drenchings with a cresylic wash will be found even more effectual, as the worms drop to the ground with the slightest jar."

THE ZEBRA CATERPILLAR, *Mamestra picta* Harris.—Feeding on the leaves of turnips and cabbages, and other garden vegetables; a long, cylindrical caterpillar with a red head, with a broad band along the side, composed of numerous transverse, short, black lines, like Runic characters upon a white ground, changing to a reddish-brown dark moth.

While this pretty caterpillar, than which none are more curiously and gaily decked, is ordinarily harmless, feeding indiscriminately on different vegetables, it has been twice found in Massachusetts, within my own knowledge, to be extremely destructive to the ruta-baga turnip, nearly destroying entire beds. In the summer of 1876, up to the middle of September, it was very abundant and eat off the tops of a good many ruta-bagas on the farm of the Massachusetts Agricultural College, at Amherst, Mass. I am also told that it sometimes attacks the roots. Harris says that it "is often found to be injurious to cabbages, cauliflowers, spinach, beets, and other garden vegetables with succulent leaves." In the New England States the caterpillars are usually seen in August and September. Harris remarks that early in October it leaves off eating, goes into the ground, changes to a shining-brown chrysalis, and is transformed to a moth about the first of June. It is probable that there are two broods of this kind of caterpillar every summer in some, if not all, parts of this country; for Dr. Melsheimer informs me that it appears in Pennsylvania in June, goes into the ground, and is changed to a chrysalis toward the end of June or the beginning of July, and comes forth in the moth state near the end of August." In Missouri, according to Riley, early in June the young worms, which are first almost black, though they soon become pale and green, may be found in dense clusters on these plants, for they are at that time gregarious. As they grow older they disperse and are not so easily found, and in about four weeks from the time of hatching they come to their full growth. * * * * It changes to chrysalis within a rude cocoon, formed just under the surface of the ground by interweaving a few grains of sand, or a few particles of whatever soil it happens on, with silken threads. * * * * There are two broods of this insect each year, the second brood of worms appearing in the latitude of Saint Louis from the middle of August along into October, and in all probability passing the winter in the chrysalis state, though a few may issue in the fall and hibernate as moths, or may even hibernate as worms; for Mr. J. H. Parsons, of New York, found that some of the worms which were on his ruta-baga leaves stood a frost hard enough to freeze potatoes in the hill without being killed. I have noticed that the spring brood confines itself more especially to young cruciferous plants, such as cabbages, beets, spinach, etc., but have found the fall brood collecting in hundreds on the heads and flower-buds of asters, on the white berry or snow-berry (*Symphoricarpus racemosus*), on different kinds of honeysuckle, on mignonette, and on asparagus; they are also said to occur on the flowers of clover, and are quite partial to the common lamb's quarter or goosefoot (*Chenopodium album*). On account of their gregarious habit when young, they are very easily destroyed at this stage of growth.

Description.—I have observed this caterpillar in different stages at Amherst, Mass., in September, 1876, when it was ravaging the ruta-bagas. *In the young, before the first molt,* the head is as wide as the body, pale greenish, while the body is pale greenish, with a double, dark, livid, dorsal stripe divided by a pale median line and three lateral dark stripes, the uppermost of which is the narrower; five pairs of abdominal feet, the first pair one-half as large as the fourth pair. The body is tuberculated, being much smoother in the fully-grown larva. Length, a little over a line. *After the first molt,* when the worm is a little over three lines in length, the colors are much as in the fully-fed larva, being deep yellow, with a broad, black, dorsal band, sometimes entire and sometimes divided by a median pale line. A lateral area is marbled with transverse, short, black and white lines, and with a row of conspicuous black spots. A row of dark spots down on the sides. Head reddish testaceous; abdominal feet reddish. *After the third molt,* when the caterpillar is one inch long (observed September 16,) the markings are nearly the same as the mature caterpillar. The fully-fed larva is unusually long, cylindrical, about two inches in length, the body tapering slightly toward the head, which is orange-red. A broad, dorsal, dark line, edged with yellow, with two white dots in the middle of each ring. A broad, lateral, white band, traversed by runelike black lines, inclosing a line of large black dots, one in the lower edge of each ring. A lateral line of yellow, below which is a marbled line of white and black dots. Legs, both thoracic and abdominal, and under side of the body, tinged with orange. The *moth* is clear reddish-brown, with a purplish tint, on the head, thorax, and fore wings, while the hind wings are whitish, contrasting strongly with the rest of the body. The hind body, or abdomen, is dull ash-gray. Fore wings with a conspicuous, light, round spot in the middle of the ring, beyond which is a kidney-shaped light spot, containing a dark ring. The veins are darker than the rest of the wing, and firmly spotted with light scales. It expands a little over an inch and a half.

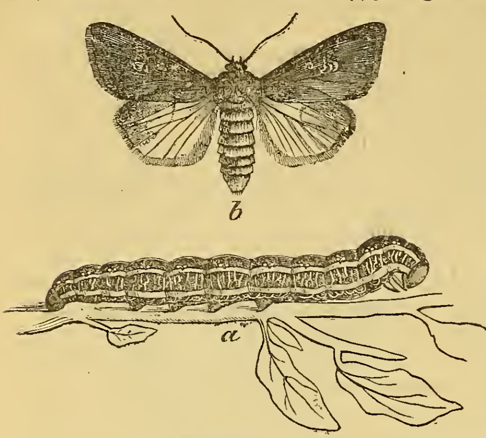

FIG. 26.—Painted Mamestro. *a*, larva. After Riley.

THE CABBAGE-PLANT LOUSE, *Aphis brassicæ* Linn.—Sometimes gathering in immense numbers on the outer leaves; a woolly, greenish louse, the winged ones spotted with black, disfiguring the heads.

This insect is called by Curtis, in his "Farm Insects," the cabbage and Swedish turnip-leaf plant louse; the species that I have observed in Maine and Massachusetts is without much doubt the same as the European.

It has not yet been known to be specially injurious in the New England States, though liable at any year to be so. In New York, however, in one case it has proved very destructive, as in the following case cited by Dr. Fitch: "J. L. Edgerton, of Waverly, N. Y., states (Country Gentleman, July, 1857, p. 80) that his patch of cabbages the year before, comprising three hundred and fifty large, thrifty plants, were attacked by lice just as they were beginning to head, and in three weeks every plant was covered by these vermin and he lost the whole, neither ashes nor salt having any effect upon them." From July, says Fitch, to the close of the season it may be found on the plants, either solitary or in clusters, inhabiting for the most part the upper sides of the inner leaves and the under sides of the outer ones. It is in the former case that it is most pernicious by sucking the juices from and weakening this part, whereby it heads tardily and imperfectly, or, if thel ice are numerous, no head is formed and the plant is worthless. The ruta-baga, or Swedish turnip, is also in this country, says Dr. Fitch, subject to its attacks, "the under side of the curled leaves being sometimes densely covered with them, of all sizes." Dr. Fitch shows that it was known in this country as early as 1791.

Description.—These *winged females* measure 0.075 in length to the tip of the abdomen, and 0.14 to the end of the closed wings, and their width from tip to tip of the extended wings is 0.18. They are of a dull greenish color, varying to pale, dull yellowish, and largely varied with black. The head, neck, and fore body on its upper side are black and shining. The horns, or antennæ, are two-thirds the length of the body, more slender toward their tips, and black. On the neck one or two pale yellowish bands are sometimes perceptible. The hind body is usually pale green, with dark-green or black bands on the back, which are often narrowed or somewhat broken asunder in the middle, and have one or two dots or small spots at their outer ends in a longitudinal row; the honey-tubes scarcely equal the distance to the tip and are black, with their bases pale yellowish. The legs are black; with the basal half of the shanks and of the thighs pale yellowish. The wings are hyaline and iridescent, their stigma pale greenish, and their veins black or dark brown. The distance between the first and second veins at their base is a little more than half that between them at their tips; third vein farther from the second at the tip than at the base, and a little nearer to the second at the base than the second is to the first; first fork a little nearer to the second fork than to the third vein, and a little nearer to the third vein than the third is to the second; second fork very little nearer to the fourth vein than to the first fork; fourth vein slightly curved, and very little nearer to the second fork than to the tip of the rib-vein.

Remedies.—When specially destructive, Dr. Fitch recommends driving short stakes and spreading a sheet, a large piece of canvas, or old carpeting over as many plants as the cloth will cover, and fumigating with tobacco until the space is filled with smoke. The plants may then be cleaned with water from a watering-pot. The remainder of the cabbage-patch can be treated in the same way. Soap-suds will only kill the young lice, leaving the old ones unhurt. "Watering the plants with equal parts of tobacco-water and lime-water is said to be the best mode of destroying the *Aphides* in gardens; and if plants be washed with tobacco-water alone—about half a pound of tobacco to a half-gallon of hot water—it will kill the *Aphides;* and if applied warm, it will kill them the sooner."—(Fitch.)

THE COMMON GARDEN PLANT-BUG, *Lygus lineolaris* (Beauvois); *Capsus lineolaris* Beauvois. (Plate LXVI, Fig. 14.)—Puncturing with its beak the cabbage and all sorts of succulent garden-vegetables and the shoots of shrubs and fruit-trees, causing them to wither and shrivel; flying from April to October, and clustering on the flowers of the cabbage in summer.

Though this plant-bug is indiscriminate in its attacks upon all sorts of garden-vegetables, more complaints have been made of its injuries to the cabbage than any other vegetable. It is especially abundant during warm, dry seasons. On examining the insect, a long, slender beak will be found resting on the breast; this it inserts in the leaf or shoot and sucks the sap. Frequent repetitions by great numbers of these bugs cause the leaves to wilt and die, and as they abound during a season of drought when the plants are weak, they are at times very destructive. Mr. Riley has found that it injures the tender shoots of pear-trees, while it has long been known to attack asters, dahlias, marigolds, balsams, and other flowers. The larvæ appear in the spring and acquire the rudiments of wings late in May or early in June in New York, becoming fully fledged by the 10th of June, according to Fitch. Mr. Uhler says that it is almost as common in the cultivated districts of Colorado as it is in the Eastern United States. I have found it to be common in Colorado and Utah. For remedies and other facts see page .

THE HARLEQUIN CABBAGE-BUG, *Murgantia histrionica* (Hahn).—Destroying, in the Southern States, by its punctures, cabbages, turnips, radishes, mustard, and other cruciferous plants; a bright black and orange-colored bug.

This pretty bug has been found to be very destructive in Texas by

Dr. G. Lincecum, who has given in the Practical Entomologist (vol. i, p. 110) the following account of its habits:

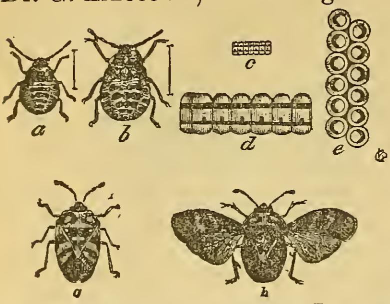

FIG. 27.—Harlequin Cabbage-Bug. *a*, larva; *b*, pupa; *c*, *d*, *e*, eggs, natural size and magnified; *g*, *h*, adult. After Riley.

"The year before last they got into my garden and utterly destroyed my cabbage, radishes, mustard, seed-turnips, and every other cruciform plant. Last year I did not set any of that order of plants in my garden. But the present year, thinking that the bugs had probably left the premises, I planted my garden with radishes, mustard, and a variety of cabbages. By the 1st of April the mustard and radishes were large enough for use, and I discovered that the insect had commenced on them. I began picking them off by hand and tramping them under foot. By that means I have preserved my four hundred and thirty-four cabbages, but I have visited every one of them daily now for four months, finding on them from thirty-four to sixty full-grown insects every day, some coupled, and some in the act of depositing their eggs. Although many have been hatched in my garden the present season, I have suffered none to come to maturity, and the daily supplies of grown insects that I have been blessed with are immigrants from some other garden.

"The perfect insect lives through the winter, and is ready to deposit its eggs as early as the 13th of March, or sooner, if it finds any cruciform plant large enough. They set their eggs on end in two rows, cemented together, mostly on the under side of the leaf, and generally from eleven to twelve in number. In about six days in April—four days in July—there hatches out from these eggs a brood of larvæ resembling the perfect insect, except in having no wings. This brood immediately begins the work of destruction by piercing and sucking the life-sap from the leaves; and in twelve days they have matured. They are timid, and will run off and hide behind the first leaf, stem, or any part of the plant that will answer the purpose. The leaf that they puncture immediately wilts, like the effects of poison, and soon withers. Half a dozen grown insects will kill a cabbage in a day. They continue through the summer, and sufficient perfect insects survive the winter to insure a full crop of them for the coming season. * * * * I have as yet found no way to get clear of them but to pick them off by hand."

It has spread northward from Texas into Missouri, appearing there, according to Riley, in 1870. Mr. Uhler (List of Hemiptera, p. 24) says that it inhabits Guatemala, Mexico, Texas, Arizona, Indian Territory, California, Nevada, Colorado, and from Delaware to Florida and Louisiana. "In the Atlantic region," he adds, "this species seems to be steadily but slowly advancing northward. Its introduction into Maryland has been effected since the late war, and now it is known as far north as the vicinity of the Pennsylvania boundary-line in Delaware. In the Mississippi Valley it appears to be equally common, particularly in the States of Illinois and Missouri." I found it to be not uncommon at Golden, Colo., in the summer of 1875, and it will probably be destructive there soon.

Description.—"The larva is of a uniform pale-greenish color, marked with polished black. The pupa differs from it only in some of the pale marks inclining to orange, and in the possession of conspicuous wing-pads; and they both differ from the mature bug, not only in the non-possession of wings, but in their antennæ being but four instead of five-jointed, as they afterward become." The mature bug is prettily marked with polished orange and blue-black, the relative proportion of the two colors being very variable and the orange inclining either to yellow or red (Riley). Uhler says that various patterns of markings and colors, ranging from yellow to steel-blue, are conspicuously exhibited in this pretty but unstable and pernicious insect.

Remedy.—The best and surest, though most costly, remedy is hand-picking.

THE COLORADO GREEN FLEA-BEETLE, *Orchestris albionica* Le Conte.—Very abundant in Colorado at different elevations, eating holes in the leaves of cabbages and radishes, etc.; a small green flea-beetle, about one-tenth of a line in length.

This little flea-beetle is very abundant in Colorado at all elevations, and is destined to become a great plague. At Denver it was very abundant in June and July on cruciferous plants, especially the cabbage and radish, eating holes in the leaves. At Golden it was extremely abundant on young cabbage and radishes. At Idaho it was abundant on young turnips and potatoes, eating holes in the leaves. At Manitou these little beetles swarmed on beds of radishes and cabbages; the plants were small, just coming up, and these little pests were eating them up. Multitudes of them were found on the summit of Pike's Peak, on the grass and Alpine flowers, among the patches of snow, having probably been borne up from the plains and parks below by currents of air. Its habits are probably nearly identical with those of the turnip flea-beetle, to the account of which the reader is referred. The larva is to be looked for in the roots of the plants on which it feeds.

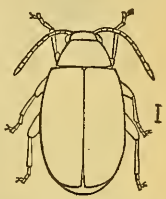
FIG. 28.—Colorado green Flea-Beetle.

Description.—It is a very small, green beetle, not quite one line in length; uniformly deep, shining olive-green. The surface of the body, especially the wing-covers, is coarsely punctured with little pits. Antennæ pubescent, dark, with the third, fourth, and fifth joints reddish-brown. Legs concolorous with the body; tarsi with a brownish tinge.

Remedies.—The use of Paris green on beds of young plants, and dusting ashes, or air-slacked lime over them, together with the planting of abundant seed.

THE PITCHY-LEGGED WEEVIL, *Otiorhynchus picipes* (Fabricius).—Damaging young cabbages, kale, broccoli, and other garden-vegetables; a pitchy-brown weevil, a quarter of an inch in length.

A weevil has for several years been not uncommon in Essex County, Massachusetts, which in England, from which it has been imported, is often, as Mr. Curtis says, "a dreadful pest in gardens, committing sad ravages on vines in hot-houses and on wall-fruit, during the night, when they emerge from their hiding-places in old walls, from under the bark, and clods of earth, to revel upon the branches of the new wood in April, or to feed upon the young shoots, which soon become black. They likewise injure raspberry plants in spring, by eating through the flowering stems and leaves, and they nibble off the bark, and eat out the buds of apple and pear trees as early as February or March." But they are said by Curtis to do still more damage to pease, turnips, and young winter-plants, as savoy, kale, broccoli, etc.

I have detected this weevil on the beach-pea during the last week in July at Salem, Mass., and it is not uncommon in gardens, and even, if I am not mistaken as to the identity of the insect, will enter ferneries and nibble the ferns and make considerable havoc among the plants before its presence is suspected.

On July 16 I found one in a thin silken semi-transparent cocoon attached to a leaf of *Lathyrus maritimus;* the cocoon was large and full, being nearly half an inch long, cylindrical, both ends being rounded alike.

FIG. 29.—Pitchy-Legged Weevil, enlarged.

Description.—This insect (Fig. 29, enlarged) is pitchy brown, and covered with microscopic, pale scales, resembling a scallop-shell, being marked with a few prominent ribs. Indeed, many of the weevils seem to be provided with scales like those of butterflies, Poduras, and a few other insects. The beak, so short and slender in the radish-weevil, is here broad and short, square at the end, from which the elbowed reddish-brown antennæ arise. The head is a little darker than the rest of the body, and is coarsely punctured. The prothorax is coarsely granulated, the granulations being arranged in irregular rows. The wing-covers are adorned with about eleven high, rounded, longitudinal ridges on each cover, and with coarse punctures along the furrows between them. There are also about twenty rows of pale dots along the wing-covers, consisting of scales. The legs, including the claws, are rather paler than the rest of the body. The body is also covered with scattered pale hairs bent down on the surface, especially on the top of the head; these hairs remain after the scales are rubbed off. It is a quarter of an inch in length.

WIRE-WORMS AND CUT-WORMS.—Larvæ of various snapping-beetles, *Elater*, *Agrotis*, etc.—Although these insects have been fully described among those preying on wheat, corn, and grass, they are very destructive to young cabbages and allied garden-plants. Wire-worms feed on the roots, and sometimes destroy the whole crop in Kentucky. In England wire-worms are destroyed for many successive years by sowing salt over the surface of the ground at the rate of six bushels per acre just as the small grain is coming up.

Cut-worms are more difficult to contend with than wire-worms. They are active at night, hiding by day in the soil around the roots of the plants they infest. It would be well, therefore, to examine the soil around the young cabbage-plants, or to inclose the plants in tubes of stout paper to prevent the attacks of the worm.

As a remedy for wire-worms, J. H. Charnock, of Canada, advised the use of rape-cake. "The remedy consists," says Mr. Riley, "in applying 3 cwt. per acre of rape-cake broken into small lumps, and not crushed into dust. It is spread on the land and plowed in before sowing the seed. The worms are said to be so fond of it that they leave all other kinds of food, while the cake is said to act upon them as a vermifuge and to kill them, as they are found in it afterward in all stages, 'from repletion to death and decay.' Rape-cake is extensively used in England as a fertilizer, and I have not the least doubt but that it attracts the wire-worms, and may be used as a trap for this purpose like sliced potatoes, etc."

Riley questions whether it is so efficacious as has been claimed, but considers that it "is, however, well worthy of further trial, for even if, as I suspect, it does not kill, it has the advantage over the other substances to be strewn as traps and then collected, in that it at the same time acts as a fertilizer. Where it can be safely done, rape-cake as well as sliced potatoes, turnips, etc., that can be used as baits for these insects, might be poisoned with Paris green, and the necessity of collecting the worms to destroy them thus avoided. I know of nothing manufactured in this country that has the character of rape-cake, or could take its place."

THE FLATTENED MILLEPEDE, *Polydesmus canadensis* Newport.—"Eating the roots of plants and other tender vegetations, and probably causing the anbury (club-root) disease in cabbages; small, slender, white and brown worms, from one to five-tenths of an inch long, flattened upon the back, and with numerous small legs appearing like a fringe along each side of the body; crawling everywhere over the damp surface of the ground by night, and withdrawing into the crevices under chips, stones, and similar situations during the day-time."—(Fitch.)

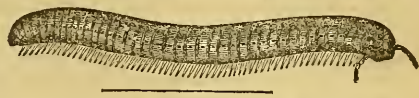

FIG. 30.—Many-lined Thousand-legs.

Although the myriapods are in general harmless, feeding either as in the case of the centipedes on other insects, or as in the millepedes on decaying vegetables or animal matter, one species of millepede (*Iulus multistriatus*) injures the roots of the strawberry in Illinois, and either this or another species, it is not known which, eats the bulbs of the carnation pink, according to a writer in the American Agriculturist. As it has been generally thought that the millipedes are harmless, feeding on dead and decaying animal and vegetable matter, I insert the statement of this writer, who lives at Montreal, Canada: "I planted out last spring a good-sized bed of carnations; two-thirds of them were cut down in about a fortnight, and I could trace it to nothing else than these worms, with which I found the bed to be infested. I removed the balance to another part of the garden, and saved them. I then examined some of the lily-bulbs in the next bed and found some of the living bulbs partly eaten, with the worms in them. I have destroyed large quantities this autumn, by slicing apples and turnips and laying them on the infested beds, the worms collecting under them in masses, which were removed and burned."

It is generally stated in systematic works on entomology that the millepedes feed on decaying vegetable or animal substances,* but there are some exceptions to this rule, which I will give.

Curtis in his "Farm Insects" tells that *Iulus londinensis* "infests the roots of wheat in Surrey," while of *Iulus latestriatus* Curtis, "thousands were infesting a garden at Nantwich." Of another species, *Iulus pilosus*, he remarks: "I have found it more than once infesting the roots of cabbages in gardens in March." A species of another genus, *Polydesmus complanatus* Linn., is, he says, "reported to be by far the most destructive species. In April, considerable numbers of the smaller ones were detected eating the roots of wheat, and in the spring and autumn they were injuring the roots of onions and pansies. They propagate rapidly when the earth is undisturbed; and specimens measuring three-quarters of an inch have been found under garden-pots at the roots of anemonies." The iuli, or snake-millepedes, Curtis adds, "seem to be both carnivorous and herbivorous, for they have been detected feeding upon small snails, as well as upon the pupa of a fly; and they are believed to live also upon larvæ, acari, earth-worms, etc.; and there is such abundant evidence of their destroying the roots of many vegetables, being found clustered together in multitudes at the roots of corn, potatoes, turnips, cabbages, etc., that there can be little doubt of their doing great mischief to many crops of the gardener, and apparently to the farmer also. In order to confirm this generally received opinion, which appeared formerly to rest upon doubtful evidence, I shall enumerate the different proofs which have come to my own knowledge. A garden at Ledbury, Herefordshire, was infested by *Iulus pulchellus*, which congregated in masses at the roots of the Brassica tribe. On pulling up some

*Curtis says that *Iulus gattatus* of Fabricius has been observed feeding on a small *Helix*.

rotten cabbage-stalks in the beginning of March I found the *Iulus pilosus* among the roots; they were then of a large size, and had, as well as I could ascertain, one hundred and fifty-six feet, being thirty-nine pairs on each side. At the end of the same month *Iulus londinensis* was detected at the roots of wheat; they were at that time an inch long, and *Iulus pulchellus* was observed with them; these I buried at the roots of some potatoes and wheat, which I dug up in August, when the former were completely decayed, but the latter were not in the least injured; and I could not detect any of the snake-millepedes. I received some roots of the scarlet-bean from Ullswater, in Westmoreland, which were eaten through and through by the *Iulus pulchellus* and *Polydesmus complanatus*, which were still sticking in the holes formed by them in the cotyledons, and the party who transmitted them stated that thousands of those species infested his garden, destroying the pease and kidney-beans also. Near Nantwich, in Cheshire, the *Iulus latestriatus* was in countless myriads in January, 1844, destroying the potted plants in the green-houses by eating the rind just at or under the surface of the soil; and cauliflowers and cabbage-plants shared the same fate in the garden. Nearly at that period of the year the *Iulus londinensis* was doing great injury to the early potato-crops near Chester. My friend, Mr. W. W. Saunders, who is too able a naturalist to be deceived, has ascertained that the iuli are very destructive in his garden at Wadsworth, where they devoured the young shoots of the heart's-ease just below the surface. I have more than once observed the snake-millepedes and *polydesmi* in September infesting the roots of onions which had been attacked by the maggots of a fly; and the *polydesmus* injures the carrot-crops by eating various labyrinths in the roots. The iuli are also found in pears, apples, etc., but I believe not in sound fruit. A few similar proofs the reader will have observed appended to the descriptions of the various species. These animals are also found in considerable numbers under the loose bark of decaying trees, in company with wood-lice, earwigs, etc.; also among the moss which clothes the base and holes in the trunk and stumps of trees, and likewise under stones in humid situations.

In his "Entomologie horticole," Boisduval tells us that *Iulus sabulosas* Linn., "sometimes enters pots, gnaws the plants at the necks of the root, and, like the sowbugs, makes it die of feebleness." *Blanniulus guttulatus* "is usually found under the straw in strawberry-beds; it introduces itself into the fruit at the time of maturity, devours the pulp, and remains coiled up in the interior like a small snake. The hole by which it penetrates is not always very large; thus it often happens that strawberries are picked which undoubtedly contain iuli. We only know it when eating them by their cracking between our teeth. This small myriapod prefers the larger species of strawberry, but the small ones which grow on *Fragasia vesca* are not exempt; we have very often found them in autumn in the variety called *des quatre saisons*." The most authentative writer on the subject of the food of the millepedes is Prof. F. Plateau, of Gand, Belgium, from whose "Researches sur les Phénomènes de la Digestion et sur la Structure de l'Appareil digestif chez les Myriapodes de Belgique," Belgium, 1876, we quote as follows: "It is commonly understood that the iuli live on vegetable matters; but the notion is general, vague, and I have found nothing exact in the works devoted to this group of animals. This leads me to state with some detail what I have myself observed. I do not believe that any iulus feeds naturally on green leaves like a caterpillar. One of our smallest species, the *Blaniulus guttulatus* (Gervais, *Iulus fragariarum* of Lamarch), eats strawberries in spring-time. Before and after the season of strawberries it contents itself with a food less choice; thus I have found it in abundance in the decayed bulbs of *Gladiolus communis*. The *Iulus londinensis*, so common in heaps of dead leaves and decaying vegetables, feeds on decaying vegetable tissues, and if it has to choose between green and fresh vegetables and the *débris* of rotten vegetables, it selects the latter: an individual placed in a box with green leaves of the pear, lilac, grape-vine, and grass, gnawed exclusively an old, dry, and brown pea-leaf. The *Iulus sabulosus* lives under heaps of the dried leaves of the elm, ash, oak, beach, and is nourished by them. M. Gervais has found the *Iulus lucifugus* in the tan of the green-houses of the Museum of Paris." From this statement it will be seen that as a rule these millepedes are scavengers, and more beneficial than injurious, as they live principally on decaying vegetable matter.

Returning to Dr. Fitch's account of the *Polydesmus canadensis*, he states that it eats the skin of cucumbers, and he thinks that stunted, gnarly, deformed, and bitter cucumbers are the result of the wound of these millepedes. Onions, when thickly growing together, having attained but a third or half their growth, in many cases stop growing, and the tops gradually wither and die. "On pulling up those which are thus affected, it is found that most of the thread-like rootlets underneath have been severed at the point of their junction with the bulb as smoothly and evenly as though they had been cut off with a knife, only a few of the central ones retaining their connection with the bulb." He has no doubt but that the millepedes do this. He also thinks that the disease in cabbages called anbury, or club-root, is caused by the bite of these millepedes.

THE EARTH-WORM, *Lumbricus terrestris* Linn.—Drawing young cabbage, lettuce, and beans into their holes; the common earth-worm.

It is a well-known fact that earth-worms, in the main beneficial from their habits of boring into soil of gardens and plowed lands, and thus allowing the air to get to the roots of plants, occasionally injure young seedling-plants of the cabbage, lettuce, beet, etc., by drawing them into their holes or uprooting them, working by night. They are also sometimes known to eat large holes in the tender leaves of plants. Mr. R. P. Knight thus describes the habits of the earth-worm (American Naturalist, vol. 3, p. 388): "Last spring (and this) I was led to watch the common earth-worms in my garden, and on the plot of grass saw their manner of feeding. I was within ten inches of their bodies. I saw one prepare to feed on a young clover-leaf from a clover-stock; he kept his tail secured to the hole (as a base line) in the ground, by which he retreated quicker than the eye could follow him. Finding all quiet, he came again. Within a few inches of my eye the pointed head of the worm changed, and the end was as if cut off square. I then saw it was a mouth. He approached the leaf and by a strong and rapid muscular action of the rings of the whole body drew the leaf and one inch of the tender stock into his mouth, and then by a

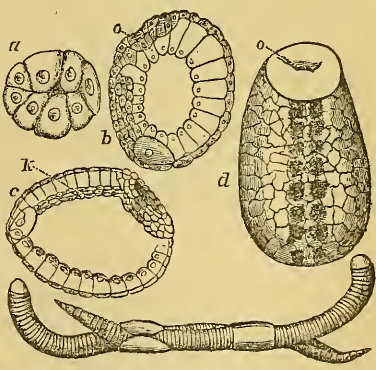

FIG. 31.—Earth-worms pairing. (After Curtis.) *a*, Embryo soon after segmentation of the yolk; *b*, embryo further advanced; (*o*, mouth); *c*, embryo still older; (*k*, primitive streak); *d*, embryo still older; (*o*, mouth, after Kowalevsky).

violent muscular action drew the whole stock of young and tender clover toward him, and when all the substance was sucked out he let the plant go and it (the stock) flew back to its former place. The leaf and stem were entire, but looked as though it had been boiled. I then laid a small piece of cold mutton down, and he appeared to feast both on the fat and lean, dragging them after him as his powers of suction could not act as well as if they had been held like the clover-leaf. I also find that when the male and female are together, they appear as one worm of double the size."

The earth-worm, like snails and slugs, is hermaphrodite. In *Lumbricus agricola* of Europe, the female sexual apparatus consists of two ovaries lying in the thirteenth segment, and two oviducts (segmental organs), which, beginning in a trumpet-shaped opening, collects several eggs into a small sac, which is ejected through an opening on each side of the ventral surface of the fourteenth segment. Moreover, we find in the ninth and tenth segments two pairs of pyriform seminal receptacles, which open into as many openings on the edges of the ninth and tenth, as well as the tenth and eleventh, segments, and during copulation are filled with sperm. The male sexual organs consist (1) of two pairs of testes, which, formed like the ovaries, lie in the tenth and eleventh segments, and (2) two seminal ducts, which begin with four trumpet-shaped openings, and terminate externally on the fifteenth segment, and (3) two seminal vesicles with several flaps and united by a cross-band and enveloped by the testes and trumpet-shaped mouths of the seminal ducts. Sexual union is reciprocal, each worm impregnating the other, and it takes place in June and July in the night-time. The worms lie with their ventral surfaces opposed, each stretched out so that the opening of the seminal receptacle of one is opposed to the girdle of the other. (See Fig. 31.)

During the act the sperm passes out to the opening of the seminal ducts, flows in a groove along the body to the girdle, and from thence into the seminal receptacle of the other worm. The eggs are very small, and contained in a capsule (Fig. 31); but, as a rule, only one egg develops a worm, the others addling. Fig. 31 illustrates the mode of pairing in the earth-worm and the development of the embryo from the egg of *Lumbricus rubellus* Grube, observed in Russia by Kowalevsky. The eggs of *Lumbricus rubellus* were found in dung, inclosed one in a single capsule. The European *L. agricola* lays numerous egg-capsules, each containing sometimes as many as fifty eggs, though only three or four embryos are to be found in a capsule (Kowalevsky).

INSECTS INJURING THE RADISH.

THE RADISH-FLY, *Anthomyia radicum* Bouché, *A. raphani* Harris.—Eating the roots of young radishes, particularly in old soils; small white maggots, which change to barrel-shaped, reddish pupa-cases, from which about the first of June emerge small, ash-colored flies, with a silvery-gray face, copper-colored eyes, and a brown spot on the front of the head, with faint brown lines on the thorax, and a longitudinal black line on the abdomen, crossed by narrower lines.

Soon after early-sown radishes come up, the roots are attacked by small white maggots, and when the plants grow in old soil the maggots are especially destructive, as I have found them in Maine over twenty years since, when the cup was badly infested. The plants were not always killed, but the roots were so worm-eaten as to be unfit for the table. Though we raised the fly in abundance, we made no notes of it at the time, and copy a description of the larvæ, pupa, and fly from Dr. Fitch's Eleventh Report. Our figures (Plate LXIII, Fig. 2) are copied from Curtis's "Farm Insects." Dr. Fitch regards our species (*A. raphani* Harris) as identical "in every particular with the European *A. radicum*." In Europe it gnaws the roots of the turnip. The larvæ appear in the spring as soon as the radishes get partly grown. "When full-grown, they change in the ground to reddish-brown pupæ, similar to those of the onion and cabbage maggots. The insect remains in this state two or three weeks, when the fly hatches and crawls up out of the ground, with its wings crumpled up, and climbing up the side of a clod or any perpendicular surface which it finds, these members expand and assume their proper form before they become dried and firm." (Fitch.)

Description of larva.—The larva is 0.20 inch long, elongating itself to 0.25 inch when crawling. It is about three times as long as thick, appearing to be more short and broad than larvæ of the onion-fly. It is white, shining, cylindrical, and tapering to a point anteriorly, where the jaws appear under the skin as a short, black, movable line, its anterior end when protruded forward becoming split, and then seen to be two sharp hooks, which are curved downward, and when the animal is crawling these hooks are pressed downward against the surface to aid in locomotion. The body is divided by transverse lines into eleven or twelve segments, and when the head is exserted thirteen segments can be counted. At the hind end of the back a pale, tawny-yellowish dorsal stripe is faintly visible. The hind end is abruptly cut off, obliquely downward and slightly backward, forming a flat surface, having above its center two conspicuous spiracles, or elevated dots, their surface opaque and rugose, and their color sometimes tawny-yellow, sometimes black. This flattened hind end has a number of small acute teeth around its outer margin, of which the two lower ones are thicker, of a brownish color, and slightly notched or two-toothed at their tips in the large but not in the smaller young larvæ. Above these on each side are three teeth, distant from each other, the middle one nearer to the upper than to the lower one.

The fly.—In these radish-flies the two sexes differ materially. The *male* is ash-gray and very bristly; the large compound eyes occupy most of the surface of the head and are almost in contact upon theer own. There are also three minute eyes at the base of the crown. The face is silvery-gray, almost white in some reflections of the light, with a long black streak on the forehead, which is pointed at its hind end. Below this streak are the black three-jointed antennæ, the basal joint being small, the second large, the third largest and oval, with a two-jointed pubescent bristle on the back, the first of the joints being very minute. The fore body is oblong, whitish on the sides, with three faint, interrupted dusky stripes upon the back. The hind body is shining gray, rather small and elliptical, tapering to the apex, with a black stripe down the back, the edges of the segments and the region of the scutel being also black. The two rings are large, transparent, iridescent, laid the one upon the other in repose, the longitudinal veins extending to the margin, with two transverse veinlets in the disk. The poisers are pale yellowish. The six legs are black and bristly, the feet five-jointed, ending in two little claws and two large pale leathery lobes.

The *female* is of a uniform ash-gray color, excepting the silvery-white face and pale sides of the fore body. The eyes are widely apart, with a broad black stripe between them, which is shaded into chestnut color in front. The hind body is larger than in the male and conical toward its apex. The wings have a tinge of yellowish at their bases. The species measures 0.22 inch in length and 0.45 inch in width across the extended wings.

Remedies.—The best preventive is undoubtedly early sowing and the rotation of crops; while infected roots should be pulled up and burned with the maggots in them, hot water should be poured on the roots, and salt and lime applied.

THE RADISH SEED-WEEVIL.—Devouring the seeds, gnawing a hole through the side of the pod; the small white grub of a pale-gray, broad, short weevil.

In the year 1857 I found in Maine upon the radish-leaves a specimen of a weevil, which I cannot distinguish by Curtis's description and figure from the European *Ceutorhynchus assimilis* Payk.

In Europe this weevil was first observed among turnip-seed, where, as a white maggot, it devours the seed in the pods; when fully fed it gnaws a hole through the side of the pod, out of which it escapes, and makes its way into the ground two or three inches below the surface, where it forms a brown, oval cocoon of grains of dirt. Here it remains three weeks in the pupa state, and by the third week in July the beetle appears. Mr. Curtis, whose account we have reproduced, thinks that the female lays its eggs in the embryo pods.

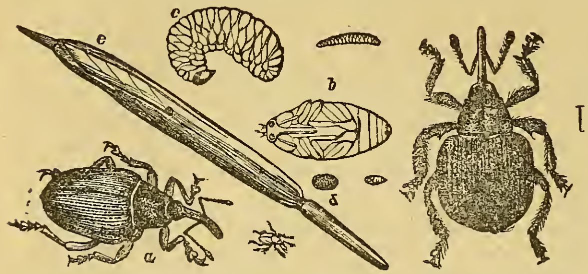

FIG. 32.—*a*, beetle; *c*, larva; *b*, pupa; *e*, pod with hole out of which the grub has come; *d*, earthen cocoon. From Curtis. The right-hand figure drawn from an American specimen.

As it has not before been noticed in this country, and may become in future years more or less of a plague, we give a brief description of the insect:

Description.—The beetle is minute and pale gray, with a remarkably long, slender, curved snout, from the middle of which arise the long elbowed, slender antennæ; the basal joint is long and slender and succeeded by seven spherical joints; the oval club pale at tip, consisting of four joints. The body is black, but so densely covered with gray, flattened hair and scales that it seems to be uniformly pale gray. These hairs become broad, flattened scales on the sides of the body. The prothorax is triangular, seen from above, swollen on the sides, and the head, exclusive of the snout, is very small. The body behind is unusually broad; the wing-covers have each nine (Curtis mentions only eight) longitudinal, fine, punctate furrows, the ridges between being much flattened. The legs are rather short, and pale gray, like the rest of the body. Curtis mentions that the hindermost thighs have a short, thick tooth beneath. I find one on the thighs of both the middle and hind legs. However, the insect may be considered identical with the European species, until proved otherwise by comparison of specimens, as it has probably been imported in radish and turnip seed.

INSECTS INFESTING LETTUCE.

THE LETTUCE EARTH-LOUSE, *Rhizobius lactucæ* Fitch.—On the roots of lettuce often in great numbers; very small, oval, white and pale-yellow lice, with dusky legs and antennæ, their bodies dusted over with a white powder.

These little lice belong to the family of true plant-lice (*Aphidæ*), but are always wingless, and with more of a white powder on the body than usual in the family, in this respect resembling the coccus or scale-insects. These little root-lice cluster about the roots of the lettuce, appearing soon after the plants are up, and becoming more numerous toward the end of the season. I have found them on the roots of the aster, and they also occur on those of the verbena. By watering the earth around the plants with tobacco-water they can be easily destroyed.

INSECTS INFESTING ASPARAGUS.

THE EUROPEAN ASPARAGUS-BEETLE, *Crioceris asparagi* Linn.—Eating irregular, rounded holes in the bark; an oblong, shining blue-black beetle a quarter of an inch long, with a red prothorax and head and three bright-yellow spots on each wing-cover; with a soft-bodied larva, thrice as long as thick, larger behind, of a dull ash-gray or obscure olive, with a black head and legs.

This beetle was first found in New York in 1858 or 1859, and in 1862 became very destructive on Long Island. Early in May, soon after the season for cutting the asparagus for the market has begun, these beetles, says Fitch, come forth from their winter-quarters and commence feeding upon it, gnawing and marring it, and scattering their eggs upon the stalks. The eggs are dark brown, small, and are attached to the stalk or leaves. They hatch in eight days, and the larva becomes fully fed in ten or twelve days. The grub feeds upon the asparagus, gnawing through the outer bark, "preferring the tender bark on the ends of the stalks and on the branches to the more tough and stringy bark toward the base of the stem." In about thirty days from the time the egg is laid the beetle appears, and is found through the summer and autumn, hibernating in the winter in crevices in fences, etc. The beetles "feed upon the bark, eating irregular oval or oblong holes through it, lengthwise of the stalks, and varying in size from about an eighth to a quarter of an inch in length. These holes are most numerous toward the top of the stalks and on the branches, where, frequently, nearly the whole of the bark is consumed."

Description of the larva.—It attains a length of about a quarter of an inch. It is of an obscure olive or dull ash-gray color, often with a blackish stripe along the middle of the back. It is soft and of a flesh-like consistency, about three times as long as thick, thickest back of the middle, with the body much wrinkled transversely. The head is black and shining, and the neck, which is thicker than the head, has two shining black spots above. Three pairs of legs are placed anteriorly upon the breast, and are of the same shining black color with the head. As will be seen when it is crawling, the larva clings also with the tip end of its body, and all along its under side may then be seen two rows of small tubercles, slightly projecting from the surface, which serve as prolegs in addition to the tip of its body. Above these tubercles on each side is a row of elevated shining dots like warts, above which the breathing-pores appear like a row of minute black dots.

The beetle is oblong, blue-black, the prothorax bright tawny-red; the wing-covers broadly bordered with orange-yellow, while along the middle is a row of three lemon-yellow spots. The legs and under side of the body are shining blue-black, and there is frequently a dull yellowish band below the knees, and a spot of the same color on the base of the hind thighs.—(Fitch.)

Remedy.—Hand-picking and the aid of hens and chickens.

INSECTS INFESTING THE CARROT AND PARSNIP.

THE PARSNIP-BUTTERFLY, *Papilio asterias* Drury.—Feeding upon the leaves of the carrot, parsley, and parsnips; a large yellow caterpillar, smooth, cylindrical, striped and spotted with black, and changing to a large and black swallow-tailed butterfly, spotted with yellow.

Our large, common asterias butterfly is not usually common enough to be injurious, but is liable in certain seasons to be locally so. It appears in the Northern States in June, when it lays its eggs on the leaves of the carrot, parsley, and parsnip. From this brood a new set of butterflies appear in August. The larva is yellow, striped and spotted with black, and when irritated, pushes out from a slit just behind the head a V-shaped, yellow, fleshy scent-organ, used as a means of defense. The chrysalis is free, attached by the tip of the abdomen and supported by a loose silken thread, which is passed over the back. It has two ear-like projections on each side of the head and a prominence on the back of the thorax. It lives in this state from nine to fifteen days.

The butterfly is black, with a row of yellow spots across the wing and a similar row near the hinder edge, with a row of large blue patches on the hind wings between the two rows of yellow spots. The female is larger and differs from the male in wanting the inner row of yellow spots on the fore wings. The wings expand from 3½–4 inches. The obvious remedy is hand-picking. A large ichneumon fly, *Trogon exesorius*, preys upon it.

The seeds of these umbelliferous plants are often infested by minute weevils, flies, and small moths, but we know as yet but little about them.

INSECTS INFESTING THE PEA.

THE PEA-WEEVIL, *Bruchus pisi* Linn. (Fig. 33).—Infesting seed-peas, living in the pea its whole life; a rusty black weevil-like beetle, spotted with lighter shades; a little over a tenth of an inch long.

The pea-weevil belongs to a small family of beetles called *Bruchidæ*, from *Bruchus*, the name of the principal genus, of which there are 300 species known. They differ from the true weevils in the proboscis being folded on the chest, the antennæ being short and straight and inserted in a cavity next to the eyes. The beetles are short and broad, and are noted for their activity and readiness to take flight when disturbed. The pea-weevil is oval in form, about an eighth of an inch long, rusty black, with a white spot on the hinder part of the prothorax, and four or five white dots behind the middle of each elytron and a T-shaped white spot on the tip of the abdomen.

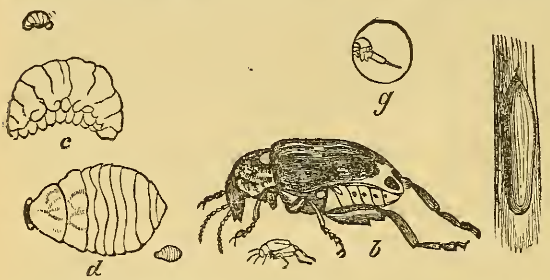

FIG. 33.—Pea-Weevil, natural size; *b*, much enlarged; *c*, larva, natural size and enlarged; *d*, pupa seen from above, natural size and enlarged; *g*, the beetle coming out of the pea (after Curtis); *f*, egg (after Riley).

They frequent the pea during and just after the flowering season. Harris states that "after the pea-vines have flowered, and while the pods are young and tender, and the peas within them are just beginning to swell, the beetles gather upon them, and deposit their tiny eggs singly in the punctures or wounds which they make upon the surface of the pods." Other authors state that with their beak they puncture the base of the flower and lay an egg in the puncture. Riley tells us in his Third Report (p. 47) that "the eggs are deep yellow, 0.035 inch long, three times as long as wide, fusiform, pointed in front, blunt behind, but larger anteriorly than posteriorly. They are fastened to the pod by some viscid fluid which dries white and glistens like silk. As the operation of depositing is only occasionally noticed during cloudy weather, we may safely assume that it takes place for the most part by night. If pea-vines are carefully examined in this latitude (Missouri) during the month of June, the pods will often be found to have from one to fifteen or twenty such eggs upon them, and the black head of the future larva may frequently be noticed through the delicate shell. * * * * The newly-hatched larva is of a deep yellow color with a black head, and it makes a direct cut through the pod into the nearest pea, the hole soon filling up in the pod, and leaving but a mere speck, not so large as a pin-hole, in the pea." The cylindrical, thick, fleshy grub hatches, and perforates the pod, entering the pea, and there lives until it changes to a weevil; and in stored peas, hibernates within them. Their presence in the pea may be detected by a discoloration made by the larva within, corresponding to a dark spot on the pea. The grub becomes fully grown by the time the pea ripens and dries. It then bores a round hole from the hollow in the center of the pea, leaving the hull and generally the germ untouched; hence infested peas will spring up and grow. The grub changes to a pupa within the pea in the autumn, and before the spring casts its skin, becomes a weevil, and gnaws a hole through the pea; it often does not appear until after the pea is planted. Sometimes every pea in a pod contains a grub. So numerous at times is it that the cultivation of the pea has been abandoned. By diminishing the weight of the pea it causes a great loss in the crop.

The pea-weevil is a native of this country, and has been introduced into Southern and Central Europe. It was first noticed by gardeners as injurious in Pennsylvania, but is now abundant all over the Northern and Western States.

Remedies.—The seed should be kept sealed up in tin cans over one year before planting. In this way the weevils, which live but a single year, would die before being liberated. It is also customary to soak peas in boiling water for a few minutes before planting; by so doing the sprouting of the seed will be hastened and the peas get their growth in part before the weevils attack them. As the weevils appear only once during the summer, at the time when the pea usually flowers, if a second crop is planted, they will be free from the attacks of weevils.

The crow blackbird is known to destroy great numbers of weevils in spring, and the Baltimore oriole splits open the green pods in search for grubs.

INSECTS INFESTING THE BEAN.

THE BEAN-WEEVIL, *Bruchus fabæ* Riley (Fig. 34).—Injuring beans in the same manner as peas, except that the beans are tenanted by several weevils; a similar but smaller weevil.

This very destructive weevil seems, according to Mr. Riley, to be indigenous, and has become injurious in the vicinity of New York, in Illinois, and in Missouri, bidding fair to become a most formidable pest of our bean-crop. Mr. Angus has been the first to detect its ravages, having found it to be already very destructive at West Farms, N. Y. Several years since he sent me specimens, and in 1870 wrote me more particularly about its ravages, as follows: "I also send you a sample of beans, which I think will startle you, if you have not seen such before. I discovered this beetle in the kidney or bush beans a few years ago, and they have been greatly on the increase every year since. I might say much on the gloomy prospect before us in the cultivation of this important garden and farm product, if the work of this insect is not cut short by some means or other. The pea bruchus is bad enough, but this is worse."

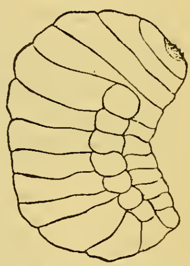

FIG. 34.—Grub of Bean-Weevil.

Description.—It closely resembles the pea-weevil (*Bruchus pisi*). It is rather smaller than the pea-weevil, measuring 0.15 of an inch in length, while the latter is 0.20 of an inch in length. Compared with that insect, it is lighter and more uniform in color, being of a tawny-gray, without the white spots so conspicuous in *B. pisi*. The uniform tawny-gray elytra are spotted with a few oblong dark spots, situated between the striæ; the antennæ also differ in having the four basal joints more reddish than in *B. pisi*, while the terminal joint is red, being blackish-brown in *B. pisi*. The fore legs are much redder, and the two hind pairs are reddish where they are dark brown in *B. pisi*. The spine on the hind femora is smaller but longer, and the antennæ are flatter, the joints being farther separated, and the whole body narrower than in *B. pisi*.

The larva (Fig. 33) is short, thick, fleshy, footless, and about ⅐ inch long. The pupa is white, and measures 0.17 of an inch in length. The head is laid upon the breast, the red tip of the mandibles reaching to the base of the tarsi of the first pair of feet. The two front pair of legs are folded on the breast at right angles to the body, the tarsi of the second pair reaching a little beyond the anterior third of the body, while the hind pair are concealed beneath the wings. The elytra are laid along the side of the body, directed obliquely downward, and are marked with deep longitudinal ribs; the under or hind pair of wings, which are much narrower than the elytra, project beyond the elytra, nearly meeting on the median line of the body. The eyes are dark and conspicuous, being red, horseshoe-like spots. The antennæ are laid upward and backward on the base of the elytra and behind the legs. The tip of the abdomen is smooth and unarmed. Length, 0.17 of an inch.

The chrysalis lies in a cavity in the bean just large enough to receive its body, there being as many as eight or twelve in a single bean. (Fig. —.) This cavity is indicated by a round, sometimes oval, semi-transparent spot 0.08 of an inch in diameter, the insect escaping through a thin orbicular, almost transparent, lid, previously gnawn by the larva, which falls off when the beetle emerges. The chrysalis is surrounded by a thin cocoon-like case, consisting of the castings of the larva (which are long, cylindrical, when highly magnified), closely packed together.

Though most of the pupæ had, November 25, changed to beetles, which had deserted the beans, many had not changed, and two or three out of the whole lot were in the semi-pupa state, the head and posterior part of the body being unchanged. By this we could determine that the larva closely resembled the larva of the true weevils in form. It is a short, thick, fleshy, cylindrical, footless white grub. The tip of its abdomen is rather blunt; its head is rather small, white, with a pale yellowish clypeus, while the mandibles are flat, short, and broad and red in color. The rudimentary antennæ form a flattened round area on each side of the clypeus. The segments of the body are not convex, being rather flattened, but the sutures are slightly impressed. The body is a little flattened beneath and very convex above, while the lateral or pleural region of the body is well marked. Length, 0.16; thickness, 0.07 of an inch.

Remedies.—The best remedy against its attacks is to carefully examine the beans in the autumn and before sowing time, when their presence can be easily detected by the transparent spots made by the larva. These should be burned, and such beans as are apparently uninjured should be soaked for a minute in boiling-hot water, so that no beetles be overlooked.

Another *Bruchus* which is not uncommon in Colorado has been sent me by Mr. F. G. Sanborn, and is *Bruchus prosopis* Le Conte (Fig. 35). As it is liable to attack the pea or bean in Colorado and the Western Territories, I add a description and figure of it. It resembles *Bruchus fabæ*, the body being of nearly the same proportions. It is larger than that species, but the markings are very similar. It may be distinguished, however, by the entire under side of the body being uniformly whitish. Length, 0.20 inch. Another species, like the other kindly identified for me by Dr. E. H. Horn, is *Bruchus amicus* Horn. It was inclosed in the same bottle with *B. prosopis*. It may at once be distinguished by its uniformly slate-gray color above and beneath, not being spotted as usual in the genus. It is slightly smaller than *prosopis*.

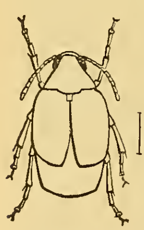

FIG. 35.—*Bruchus prosopis* Le C.

THE BEAN LEAF-HOPPER, *Empoa fabæ* (Harris).—Puncturing the leaves, causing them to wither and die, and the pods to become rough and scarred; a small pale-green leaf-hopper.

As I have had no personal experience with this insect, I copy Harris's account and description of it: "I have found that the Windsor bean, a variety of the *Vicia faba* of Linnæus, is subject to the attacks of a species of leaf-hopper, particularly during dry seasons, and when cultivated in light soils. In the early part of summer the insects are so small and so light-colored that they easily escape observation, and it is not till the beginning of July, when the beans are usually large enough to be gathered for the table, that the ravages of the insects leads to their discovery. A large proportion of the pods will then be found to be rough, and covered with little dark-colored dots or scars, and many of them seem to be unusually spongy and not well filled. On opening these spongy pods we find that the beans have not grown to their proper size, and if they are left on the plant they cease to enlarge. At the same time the leaves, pods, and stalks are more or less infested with little leaf-hoppers, not fully grown, and unprovided with wings. Usually between the end of July and the middle of August the insects come to their growth and acquire their wings; but the mischief at this time is finished, and the plants have suffered so much that all prospect of a second crop of beans from new shoots, produced after the old stems are cut down, is frustrated.

These leaf-hoppers have the same agility in their motions, and apparently the same habits, as the vine-hoppers; but in the perfect state they are longer, more slender, and much more delicate. They are of a pale-green color; the wing-covers and wings are transparent and colorless; and the last joint of the hind feet is bluish. The head, as seen from above, is crescent-shaped, and the two eyelets are situated on its front edge. The male has two long recurved feathery threads at the extremity of the body. The length of this species is rather more than one-tenth, but less than three-twentieths of an inch wide. It may be called *Tettigonia fabæ.* Probably it passes the winter in the same way as the vine-hopper.

INSECTS INJURING THE SQUASH AND PUMPKIN.

THE SQUASH-BORER, *Ægeria* (*Melittia*) *cucurbitæ* Harris (Fig. 36).—Often suddenly killing the vine; a borer in the stalk, short and thick, with a dark head and a dark horny patch just behind it; changing to a beautiful narrow-winged, orange-colored moth spotted with black.

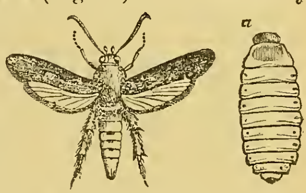

FIG. 36.--Squash-Borer; *a*, grub.

During the last of summer when the vines are nearly fully grown and the squashes have nearly attained their full size, they suddenly die as if cut off at the roots. This is the work of the caterpillar of the beautiful moth here figured. This *Ægerian* appears in New England from July 10 to August 15, when it deposits its eggs on the stalk of the vine close to the roots. The larva on hatching bores into the stalk, and when nearly grown occupies the center near the ground, devouring the interior, and thus killing the plant. Here it lives until the last of September or early in October, when it either deserts the vine and spins a rude earthen cocoon near the roots, or, as is often the case, remains in the hollow it has made in the stalk, and then changes to a chrysalis. From this fact the means of prevention against its attacks are comparatively easy, for if the vines are collected and burned in the autumn, in many cases the worms or chrysalides will be destroyed with them.

Description.—The larva is a short, thick, fleshy, white caterpillar, with short legs, and a dusky head, with a horny dark scale on the segment next behind it. The moth is exceedingly beautiful, being a member of the family of *Ægerians,* in which the wings are very narrow. The body, for one of this family, is unusually thick. It is dark green with a bluish tint. The antennæ are steel-blue. In the male the antennæ are pectinated, and the abdomen dark above. In the female the abdomen is orange-red above and beneath, except on the basal segment; on the upper side are five large dark spots. The legs in both sexes are thick, with dense stiff hairs, black and orange, forming brushes, some white hairs, and four stiff spines; a large white spot at the base of the hind legs and on the breast. Head in front white; palpi, orange. It expands nearly an inch and a half.

THE STRIPED SQUASH-BEETLE, *Diabrotica vittata* Fabricius (Fig. 37).—Appearing on the squash pumpkin, cucumber, and melon vines as soon as the leaves are up, eating holes in the leaves and killing the young plant; a small yellow-striped beetle, whose larva is a long, slender grub, which bores in the roots in June and July.

This universal pest is so familiar in the Northern States as to scarcely need description. The beetle hibernates under leaves or in the crevices in the bark of trees or in fences, appearing among the earliest insects of spring, at the time that the shad-bush (*Amelanchier canadensis*) is in blossom, on the pollen of whose flowers it feeds, afterward deserting wild flowers for the garden. As soon as the seed-leaves of the squash, pumpkin, melon, or cucumber are formed, and even before they appear above the surface of the soil, they devour them, and until the plant is about six inches high it is liable to be devoured by them. I take the following account in part from my "Guide to the Study of Insects." Dr. H. Shimer has given an account of the habits of this insect in its different stages. He states that the grub, in June and July, "eats the bark and often perforates and hollows out the lower part of the stem which is beneath the ground, and the upper portion of the root, and occasionally, when the supply below fails, we find them in the vine just above the ground." It hibernates in the pupa state. "The larva arrives at maturity in about a month after the egg is laid; it remains in the pupa state about two weeks, and the beetle probably lives several days before depositing her eggs, so that one generation is in existence about two months, and we can only have two, never more than three, broods in one season." Dr. Shimer has found them boring in the squash and musk-melon vines as late as October 1. A generation appears in two months, and there are two or three broods in a season.

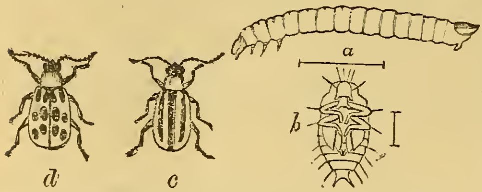

FIG. 37.—Striped Squash-Beetle; *a*, larva; *b*, pupa *c*, adult; *d*, 12-spotted Deabrotica.

In an article in the American Naturalist (vol. v, p. 217), Dr. Shimer gives further information concerning the habits of this beetle. The eggs, he says, are deposited on the root at the surface of the ground, or on the root just below the upper loose particles of earth, for although the perfect beetle does not burrow into the compact ground, yet it often is found down along the stem or root, just below the surface, under the loose, dry clots or finer particles of earth which are not pressed closely or beaten down by rains and hardened in drying.

Description of the larva.—It is a long, slender, white, cylindrical grub, with a small, brownish head. The prothorax is coreous. The thoracic legs are very slender, pale brown; the end of the body is suddenly truncated, with a small prop-leg beneath. Above is an articular brown space, growing black posteriorly and ending in a pair of upcurved, vertical, slender, black spines. It is 0.40 of an inch long. In its boring habits, and its remarkably long, cylindrical, soft, white body this larva widely differs from that of *Galleruca*, to which the beetle is closely allied. The *pupa* is 0.17 of an inch long, white, with the tip of the abdomen ending in two long acute spines arising from a common base.

A Tachina parasite (*Melanoshora diabroticæ* Shimer) preys upon this beetle in the adult state, materially reducing its numbers. A single maggot fills almost the entire cavity of the abdomen of its host, the beetle. When about to transform into the pupa, the maggot leaves the body of the fly, and its pupa-case is found in the surface of the ground, the fly appearing late in July.

Description of Melanosphora diabroticæ Shimer.—Pitch black. Eyes and proboscis light brown. Halters pale brownish. A crescentic line on each side of the face bordering the eye, almost meeting in the medial line, silvery-gray. Anterior portion and sides of the prothorax in some lights give the same lustrous gray reflections as the face; in others, blackish. Body moderately clothed with stiff black spines. Wings hyaline, iridescent, with a smoky yellowish shade toward the base. Expanse of wings, 0.24 of an inch; width of wing, 0.06 of an inch; length of body, 0.13–0.15 of an inch; described from five dry specimens.—(Shimer.)

FIG. 38.—Tachina parasite of the Squash-Beetle.

Dr. Shimer has also found a small red mite attached to the posterior end of the body of the beetle, which is very annoying to its host.

Remedies.—Covering the vines with cotton or a high frame covered with muslin or millinet is the only sure preventive, while powdered charcoal, hellebore, or lime may be sprinkled on the leaves. Mr. Gregory, says the American Agriculturist, "relies upon plaster or oyster-shell lime, which may be shaken from a small sieve while the leaves are wet with dew or rain; to be applied as soon as the plants are up. He objects to the use of air-slacked stone-lime as it is apt to be too caustic and injures the plant."

THE SQUASH-BUG, *Coreus tristis* De Geer (Fig. 39).—Sucking the sap of the stems; large black bugs, often surrounding in large numbers the stems of squash-vines in August.

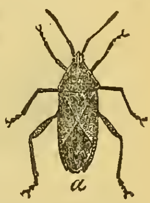

FIG. 39.—Squash-Bug, nat. size.

While the squash-beetle is a coleopterous insect, the large black bug which is so abundant and destructive to the squash is a hemipterous insect, not having free-biting jaws as in the beetles, but a long, slender, sharp beak, lying, when at rest, on the breast, which it thrusts into the stem or leaf-stalks of its food-plant.

I extract the following account of it from the "Guide to the Study of Insects." The squash-bug is very destructive to squash-vines, collecting in great numbers around the stem near the ground and sucking the sap with its stout beak. It is a large, blackish-brown insect, six-tenths of an inch long, and dirty yellowish beneath. It hibernates in the adult condition, leaving the plants in October. About the last of June the sexes meet, and the females "lay their eggs in little patches, fastening them with a gummy substance to the under side of the leaves. The eggs are round and flattened on two sides and are soon hatched. The young bugs are proportionally shorter and more rounded than the perfect insects, are of a pale ash color, and have quite large antennæ, the joints of which are somewhat flattened. As they grow older and increase in size, after molting their skins a few times, they become more oval in form, and the under side of their bodies gradually acquires a dull ocher-yellow color." (Harris's Treatise). The young attack the leaves, causing them to wither. Successive broods are said to appear during the summer. The odor of this bug is very offensive. Professor Verriel has found, with the assistance of Prof. S. W. Johnson, of Yale College, that the odor of this and other hemipterous insects bears the most resemblance to that of the formate of amylic ether. It is probable that this substance is its most essential and active ingredient.

Remedies.—This insect is so conspicuous that it can readily be controlled by hand-picking, especially when fully grown.

THE SQUASH LADY-BIRD, *Epilachna borealis* Thunberg (Fig. 40).—Feeding on the leaves of the squash and pumpkin; a yellowish grub, with long branched spines.

FIG. 40.—Squash Lady-Bird.

While all the other species of the family of "lady-bird" (*Coccinellidæ*) are carnivorous, preying on other living insects, as plant-lice, etc., the present species is injurious to cucurbitaceous plants. The beetle is yellowish, with seven large black spots on each wing-cover. "The larva is yellow, with long, brown, branched spines, arranged in rows of six on each segment, except the first thoracic segment, which has only four. The pupa instead of spines has short bristles, especially on the thorax."—(Ostensacker.) Besides this beetle, the common black flea-beetle, *Haltica* (*Epithrix*) *cucumeris* Harris, punctures the seed-leaves, causing at times a great deal of mischief.

THE PICKLE-WORM, *Phacellura nitidalis* Cramer (Fig. 41.)—Boring cylindrical holes in cucumbers, causing the fruit of the cucumber, melon, or squash to decay; a pale, greenish yellow caterpillar, with a pale reddish head.

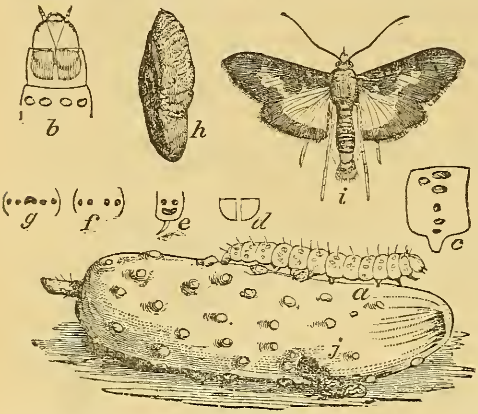

FIG. 41.—*a*, pickle-worm; *b*, head and prothoracic segment, enlarged; *c*, *d*, *e*, *f*, *g*, markings; *h*, cocoon; *i*, male moth.—(After Riley.)

According to Riley, the pickle-worm begins to appear in the latitude of Saint Louis, Mo., about the middle of July, and continues its destructive work until the end of September. "They bore cylindrical holes into the fruit and feed on its fleshy parts. They are grass-feeders, and produce a large amount of soft excrement. I have found as many as four in a medium-sized cucumber, and a single worm will often cause the fruit to rot. They develop very rapidly, and come to their growth in from three to four weeks. When about to transform they forsake the fruit in which they had burrowed, and drawing together portions of some leaf that lies on or near the ground, spin a slight cocoon of white silk. Within this cocoon they soon become slender, brown chrysalides, with the head parts prolonged, and with a very long ventral sheath which incloses the legs. If it is not too late in the season the moths issue in from eight to ten days afterward. The late individuals, however, pass the winter within their cocoons; though from the fact that some moths come out as late as November, I infer that they may also winter over in the moth state." (Riley.) The moth is yellowish-brown, with golden, yellow spots on the fore wings, and the hind wings yellow, with a broad, dark border.

Remedies.—The cucumbers, melons, or squashes can be examined and the infested ones destroyed with the worm within.

INJURING THE HOP.

THE APHIS OF THE HOP.—Clustering often in vast numbers on the branches and leaves of the hop-vine; small, greenish, wingless or winged plant-lice.

The most destructive insect of the hop at times in New England is an aphis, which it is very difficult to exterminate. The best remedy is, when possible, to turn a powerful stream of water upon the leaves, or to shower them with soap-suds. So abundant is it in certain years in New Egland that the hop-crop has almost been cut off. The following figure of the apple aphis is introduced to illustrate the usual form of the plant-louse.

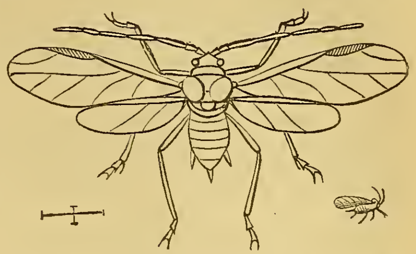

Fig. 42.—Apple Aphis, natural size and enlarged.

THE HOP CATERPILLAR, *Hypena humuli* (Harris).—Devouring the leaves in June, and again in July or August; active, slender, glass-green caterpillars, with but four false legs and nearly half an inch long.

The following account of this destructive caterpillar is taken from my "Guide to the Study of Insects." Late in May or in June, as soon as the leaves expand, they are often devoured by the caterpillar of a gruntmoth, which, on being disturbed is very active, wriggling off the leaf to the ground. It is double-brooded, the first lot of caterpillars appearing late in May and early in June, the moths flying about late in June and early in July. A second brood of caterpillars appear in July and August, in Massachusetts, the moth flying in September. When the caterpillar is fully grown it forms a loose silken cocoon within a folded leaf or any crevice, the moth appearing three weeks after. I have raised a species of parasitic fly (*Tachina*) from the chrysalides, which probably somewhat reduce the number of the moths.

Fig. 43.—Hop-vine caterpillar, pupa, and moth, natural size.

Remedies.—Hand-picking and shaking the vines vigorously twice a day would, if systematically pursued, be sufficient; while, in addition, showering the leaves with whale-oil soap, or a similar wash, would be efficacious.

Description of the caterpiller.—Body long and slender, with the segments rather convex, and with long, sparse hairs. It is uniformly of a glassy, pea-green color. The head is rather large, and deeply divided into two lobes by the median suture; it is a little more yellowish-green than the body, which tapers gradually toward the tail, while the last pair of legs are long and slender. As there are but two pairs of abdominal legs, the caterpillar walks with a looping gait like the span or measuring worms. The body is striped with a narrow whitish line, edged broadly below with dusky, and with two white lines on the sides of the body, though specimens vary in the number of lines, some having no lateral whitish stripes. It is nearly half an inch (0.45) in length. When half-grown the caterpillar is of a pale, livid, flesh color, not greenish, with a broad, dark, dorsal line, bounded on each side by a whitish line.

Description of the moth.—It has remarkably long feelers (palpi), and when the wings are folded is triangular in outlike like the Greek letter Δ. It is marbled with gray beyond the middle of the fore wings, with a distinct oblique gray stripe at the apex; and the fore wings are crossed by two wavy blackish lines formed of elevated black tufts, while there are two similar black tufts in the middle of the wings; the hind wings are paler than the rest of the moth. It expands one inch and a quarter.

THE HOP-VINE HAIR-STREAK BUTTERFLY, *Uranotes melinus* (Hübn.); *Thecla humuli* Harris.—Frequently feeding on the heads of the hop; a small, short, thick, green and downy caterpillar with very short legs, transforming into a small, delicate, brown butterfly with four linear tails, two on each hind wing.

As I have never seen this caterpillar, my account is taken from that of Harris. All he says of the larva is given in the preceding paragraph.

Description of the butterfly.—The wings on the upper side are dusky brown, with a tint of blue-gray; and, in the males, there is an oval darker spot near the front edge;

the hind wings have two short, thread-like tails, the inner one the longest, and tipped with white; along the hind margin of these same wings is a row of little pale-blue spots, interrupted by a large orange-red crescent inclosing a small black spot; the wings beneath are slate-gray, with two wavy streaks of brown edged on one side with white, and on the hind wings an orange-colored spot near the hind angle, and a larger spot of the same color inclosing a black dot just before the tails. It expands one inch and one-tenth. (Harris.) It ranges, according to Scudder, from the Atlantic to the Pacific, and from the Canadian border to the Gulf of Mexico and southward to Venezuela. Besides the hop, it feeds on *Cratægus apiifolia*, *Hypericum auream*, and *Phaseolus*.

THE SEMICOLON BUTTERFLY, *Pylygonia* (*Grapta*) *interrogationis* (Fabr.).—A brown caterpillar with a red head and pale-yellow or brownish spines, sometimes defoliating the vine, and changing into a large tawny-orange butterfly with jagged and angular wings.

Though the caterpillars of this common butterfly lives on the American elm and lime trees, it is also at times quite destructive to the hop-vine, sometimes abounding "to such a degree as totally to destroy the produce of the plant."—(Harris.) The caterpillars are so conspicuous early in August that they can be easily plucked off with the hand. The chrysalides, which late in August suspend themselves beneath the leaves and to the stems of the vine, can be picked off, though Harris recommends that the vine "should be cut down, stipped of the fruit that is sufficiently ripened, and then burned."

Caterpillar.—"Browish, variegated with pale yellow, or pale yellow variegated with brown, with a yellowish line on each side of the body; the head is rust-red, with two blackish branched-spines on the top; and the spines of the body are pale yellow or brownish, and tipped with black."—(Harris.)

Chrysalis.—"Ashen brown, with the head deeply notched, and surmounted by two conical ears, a long and thin nose-like prominence on the thorax, and eight silvery spots on the back. The chrysalis state usually lasts from eleven to fourteen days; but the later broods are more tady in their transformations, the butterfly sometimes not appearing in less than twenty-six days after the change to the chrysalis."—(Harris.)

Butterfly.—Tawny orange, wings very angular, though less dentate than in *Polygonia comma* and *progne*, but the "tails" of the hind wings are longer and more pointed. The fore wings are tawny orange, but dark brown along the outer margin, with the extreme edge washed with violet. Beneath ash-colored like old unpainted pine wood, with a large heavy silver mark of interrogation. It is much larger than *P. comma* and *progne*, expanding over two and a half (2.60) inches.

Harris states that "great numbers of the chrysalides are annually destroyed by little maggots within them, which, in due time, are transformed to tiny four-winged flies, (*Pteromalus vanessæ*,) which make their escape by eating little holes through the sides of the chrysalis."

THE COMMA BUTTERFLY, *Polygonia* (*Grapta*) *comma* (Harris).—This is a smaller butterfly than the preceding, appearing in May and laying its eggs on the leaves of the hop-vine, as well as other plants (the elm, nettle and *Baehmeria cylindrica*). The caterpillars change to chrysalides in the middle of July, their butterflies lay eggs for a new brood of caterpillars, which change to chrysalides the first of September and the butterflies hibernate.

FIG. 44.—Progne Butterfly.

Description.—The caterpillar closely resembles that of *G. interrogationis*. The butterfly is much smaller than *P. interrogationis*, and the fore wings of much the same shape, but the hind wings are more toothed, with a broad, less sharp "tail." The spots and color are much the same but darker. Hind wings with an angular, slender, silvery mark, somewhat like a comma. The inner half of both wings darker wood-ash color than in *P. interrogationis*. Expanse of wings, $2\frac{1}{4}$ inches. It is very closely allied to *P. progne* (Fig. 44).

THE HOP VINE ROOT-BORER, *Hepialus mustelinus* Packard.—This moth is closely allied to the *Hepialus humuli* of Europe, which bores in the roots of the hop. No borer has yet been detected in our vines, but it is not improbable that the above-named species will be found to attack this plant. It flies in Maine from the middle of July to the middle of August.

Description of the moth.—Female with the body and wings sable-brown. Fore wings with three broad silvery spots on the costa, margined with black; a broad silvery line along the internal margin, which is continued as a submarginal oblique straight line, dislocated near the middle of the wing, and margined with yellowish-brown with some black scales. A marginal series of triangular spots. Fringe dark at the base, spotted externally with silver. Beneath, the body is yellowish-brown, as is the front edge of the fore wings, which is banded with three dusky patches, the middle of the wing is dusky, while the legs are dark externally. It expands a little over one and a quarter (1.30) inches.

Hepialus pulcher of Grote is a species which is common in the foothills and mountains of Colorado during July, August, and September. It may prove destructive to the hop when cultivated in Colorado.

INJURING THE COTTON-PLANT.

THE COTTON ARMY-WORM, *Aletia argillacea* Hübner; *Anomis xylina* Say (Fig. 45).—Feeding often in vast numbers upon the leaves of the cotton-plant; a caterpillar with a looping gait, hairy, green, dotted with black along a subdorsal yellowish line, and with black dots beneath, changing to a pale reddish-brown moth.

Although this moth, and especially the caterpillar, are so abundant and destructive in the cotton-growing States, there is much that needs to be known about its habits and transformations, as good authorities differ. The following account and illustrations are taken from my "Guide to the Study of Insects," with some additions from Riley's Second Report on the Noxious Insects of Missouri, and Mr. Grote's account in Smith's Report on the Geology of Alabama for 1875, p. 199.

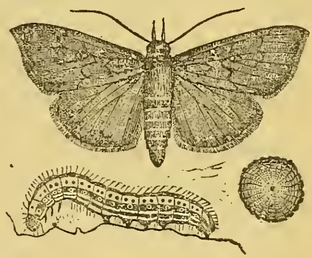

FIG. 45.—Cotton Army-Worm, Egg, and Moth.

The parent of the cotton-worm is a reddish brown moth, with a dark discal oval spot centered by two pale dots. She deposits, according to Mr. Glover, a low, much-flattened, vertically-ribbed egg upon the surface of the leaf. "Each female moth deposits from 400 to 600, and, according to the late Thomas Affbek, of Brenham, they hatch two days after being deposited, if the weather be moist and warm. The worms at first feed upon the parenchyma or soft, fleshy parts of the leaves, but afterward devour indifferently, not only any portion of the leaves, but also the blossom-bud and blossom, together with the calyx leaves at the base of the boll, thus causing the lobes which hold the cotton to fall entirely back and allow the cotton to drop at the slightest touch. While young these worms readily let themselves down by a web when disturbed, but when older they make less use of this web, and jerk themselves away to a considerable distance when suddenly touched. They cast their skins at five successive periods, and come to their growth in the incredibly short space of fifteen or twenty days."

The larva is a looper, four (the two foremost pair) out of the sixteen abdominal legs usually present in the family being wanting, so that the caterpillar resembles the germetrid or measuring-worms in its gait. In this way it can readily be distinguished from either the northern army-worm or the boll-worm. Its body is thickest in the middle, very hairy, green, dotted with black along a subdorsal yellowish line, and with black dots beneath.

"In Central Alabama," says Grote, "I have watched the growth of the worms on the cotton-plant. The worm appears there in certain seasons, as early as the latter part of June. After feeding for a period of about fourteen days, the cotton-worms commence preparations for shedding their skin to pass into the chrysalis stage of growth. For this they spin a few loose threads of silk on the plant itself, which they rarely forsake for that purpose. Within this light web the lost larvæ skin is thrown off, and the brown chrysalis skin is exposed. In this state the worm passes from a week to ten days."

Riley states that, "according to the best authority, there are three different broods of worms during the year, the first appearing in June or July, and the last which does the most damage, appearing in August or September, or even later."

Like our northern army-worm (*Leucania unipuncta*), the cotton army-worm, the early stages of the caterpillar having been unnoticed, owing to the fact that it simulates the leaves on which it feeds and is so small, becomes suddenly visible in great numbers in a single day, committing the greatest havoc in a few hours. I extract the following account of an invasion of these cotton-worms, written by Prof. J. Darby, of Auburn, Ala., and quoted in my Guide: "Saturday, September 19, I was in the field examining the forms (buds before flowering) and the young bolls (fruit after the floral organs have fallen off). I examined all carefully, with no signs of eggs or worms. On Sunday I did not see it. On Monday I passed it as usual and observed nothing unusual. On Tuesday morning I passed it and noticed nothing unusual. On Tuesday noon every plant in the field was stripped of all its upper leaves, not one remaining as far as could be seen, and the plants were covered with millions of worms. I counted on one plant forty-six worms. They commence at the top of the plant, eating every leaf. When the leaves were gone they attacked the young bolls, eating through the perianth and consuming the young cotton. In the course of four days the work was done. They did not touch the grape. nor any other plant in the field. Many left the field and thousands were in the road and on the fences, but not one in a thousand thus escaped. To-day, September 23, there is scarcely one to be seen. Their disappearance is as mysterious as their coming. They have left no signs that I can see, either on the stalks or in the ground. They have extended over hundreds of miles, and nothing has proved a barrier to them, having been as destructive on islands in the river as elsewhere. One-third of the cotton-crop has been destroyed. Nothing of the kind has occurred in thirty years past to my knowledge."

In 1788 the cotton army-worm destroyed, at a low estimate, 200 tons of cotton in the Bahamas; in Georgia, the crop was destroyed in 1793, and it was very destructive in 1800, 1804, 1825, and 1826, and since then has been destructive in certain localities nearly each year, though not always in the same State. The average annual loss in this country is probably some years $50,000,000. So great is the annual loss that it would be well if the cotton States would each employ a salaried entomologist to investigate and report on the insects injurious to the cotton-plant. The United States Government should also employ competent entomological talent, and have the subject investigated from a broad, scientific standpoint, as it is a matter of national interest to arrest the immense annual loss resulting from the attacks of the army-worm.

As to the original habitat of this insect there is some question. Mr. Grote believes that it is "an imported insect, and not indigenous to the Southern States." He claims that, as in our climate cotton is an introduced plant, and has become an annual, the cotton-worm has been imported with it. As he says: "The first herald of the cotton-worm I have found to be always the flight of the parent moths. These would come to light in houses, and in a few days thereafter I found the young worms on the plants. This, in Central Alabama, was in June or July, and previously I had always heard of the appearance of the worm to the southward. Before it, the cotton in my vicinity had shown no signs of worm, and, had any existed in the country, it must have showed itself during the preceding three months, while the young cotton-plants were growing. In favorable seasons the broods were successive until frost, and the death of the cotton-plant. Where food failed on one plantation the worms wandered to another, and not till then. The first brood in one locality is irregular, skipping some plantations, invading others. Again, I have noticed that, while there was yet leaf enough left, and the season yet warm, whole sections would be forsaken by the freshly-disclosed moths. There is no doubt on my mind that the cotton-worm has a yearly migration northward, from the facts in the case. The cold weather finally kills the moths, without their being able to provide for a further brood. I have noticed the moth in the fall as far north as Canada and the great lakes, and on the coast of Maine.* Always arriving there late in the season, it must perish; there is no food for its progeny; it is too late for it to retrace its steps." This supposed migration northward of the cotton army-worm is an interesting and practical subject for further investigation. As yet I am hardly inclined to suppose that this particular species should not live in all its stages where it is now found, and I think that further research will prove that it is so. It should be remembered that the caterpillars of a good many species of this family do not hatch out until toward midsummer, for example, the northern army-worm. Its larva should be looked for in the Northern States where it occurs, and, if found, the food-plant ascertained. It is possible that the chrysalides have been carried north in cotton-bales, but under the circumstances in which I have seen the moth flying on an island in Salem Harbor, I do not doubt but that the caterpillar will be found. I have taken several specimens of this moth on Coney Island in Salem Harbor. Mr. Edward Burgess informs me that it flew aboard his yacht in Boston Bay, September 9, 1873. Mr. Grote records it from Buffalo, N. Y., and Mr. Riley from Chicago.

In the accompanying map showing the area of distribution of the cotton army and boll worm, I have indicated the area in which it is permanently destructive, being the cotton-growing portion of the Southern States, taken from Walker's Statistical Atlas.

Description of the moth.—Pale brown, with a slight reddish tinge; hind wings somewhat paler. Fore wings with three indistinct irregularly scalloped reddish lines, the basal one on the inner third of the wing composed of four or five scallops; the second is situated deyond the middle of the wing, and branches out behind the middle (transversely) of the wing, and sends a branch just beyond the discal dot, forming a third line. The scallops differ in size, but the line curves out most just below the costa, and again opposite the discal spot, which is large, dark, conspicuous, obliquely oval, and centered with two unequal bluish spots. Expanse of wings, 1.55 inches. Salem, Mass., Demopolis, Ala., and Waco, Tex., September 5, October 12, and November 15.—(Belfrage.)

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* This is most probably a mistake for Massachusetts, as I am quite sure it has not been observed north of Salem, Mass.

Remedies.—Picking the caterpillars off the plants by hand, ditching, and the use of burning straw when the caterpillars migrate from one field to another, are remedies that can be applied in the cotton States, when labor is cheap, to good advantage. By these means, and the use of Paris green, the evil can be stamped out, provided co-operation is practised among adjoining plantations. The same means should be used as with the northern army-worm and potato-beetle. The most serviceable remedy has been the use of Paris green, either dry, mixed with cheap flour, or in water, in proportions sufficient to kill the caterpillars without injuring the plants. This remedy has been successfully tried in the South. I take the following modes of using this poison from Mr. Riley's Sixth Report. In Texas, by the use of Paris green mixed with lime or plaster, or even fine sand, "a neighbor has picked already 10 bales of 500 pounds each from 13 acres, while freedmen on the same farm lost their whole crop by refusing to use it." Repeated applications should be made after the appearance of successive broods of worms. By some, it is said application should not be made after the bolls are open, lest it become dangerous to picker and ginner." Mr. J. R. Maxwell, of Alabama, writes to the Southern Farmer: "I have been successful in the use of Paris green on the cotton-worm. I had 100 acres of cotton on swamp-land that would have been ruined, but on their first appearance I commenced on them. I put eight hands on mules, with two-gallon watering-pots, and had ten more hands and two wagons engaged in keeping them supplied with water and poison, and went over my cotton twice, up one side of a row and down the other, going thus twice to each row. Poison, labor, and all cost me about $300. It has saved me at the very least 20 bales of cotton. I used the poison by putting to each canful of water half a table-spoonful of poison and three table-spoonfuls of flour, stirring it well. I tried it first without flour, but every shower would wash all the poison off." Another Alabama farmer successfully used the powder-mixture on 50 acres at a cost of 68 cents an acre. Mr. D. F. Prout says that the cost of material an acre "for two applications will not exceed $1.75, viz: 40 pounds of flour, at 2½ cents per pound, and 2 pounds of Paris green, at 37½ cents." He found, in his own experience, that an expenditure of $100 on about 80 acres increased the crop at least 10 bales.

THE BOLL-WORM, *Heleothis armigera* Linn.—Eating the boll of the cotton-plant, corn in the ear, tomato-fruit, etc.; a rather large, thick-bodied, pale-green or dark-brown caterpillar, with longitudinal light and dark lines, and with a broad yellow band below the breathing-pores, and marked with black spots, from which arise fine hairs.

This moth is a cosmopolitan, being injurious in Europe, and inhabiting Japan and even Australia. It feeds on a variety of plants, not only devouring the calyx of the flower but the boll, and corn in the ear as well as the stock, unripe and ripe tomates, green pease, string-beans, and young pumpkins. It bores into the stalks of the gladiolus, and in Europe is known to devour the heads of hemp and leaves of tobacco and of lucern, as well as chick or coffee pea.—(Riley.)

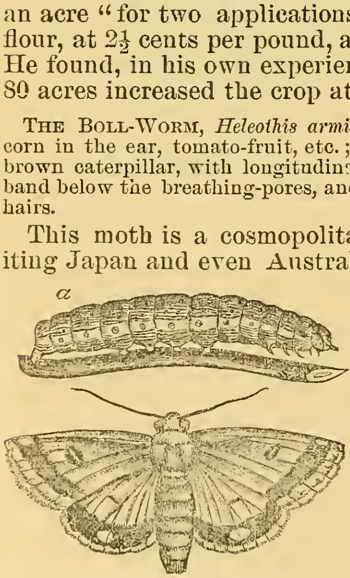


FIG. 46.—Boll-Worm and Parent Moth. (After Glover.)

"The egg from which the worm hatches is ribbed in a somewhat similar manner to that of the cotton-worm, but may readily be distinguished by being less flattened and of a pale straw color instead of green. It is usually deposited singly on the outside of the involucel or outer calyx of the flower or young boll, and each female moth is capable of thus consigning to their proper places upward of five hundred eggs."—(Riley.)

"Some eggs of the boll-worm hatched in three or four days after being brought in from the field, the inclosed worms gnawing a hole through the shell of the egg, and then escaping. They soon commenced feeding upon the tender, fleshy substance of the calyx near the place where the egg had been deposited. When they had gained strength, some of the worms pierced through the calyx and others through the petals of the closed flower-bud, or even penetrated into the young and tender boll itself. The pistils and stamens of the open flower are frequently found to be disturbed and injured without any apparent cause. This has been done by the young boll-worm; when hidden in the unopened bud, it has eaten one side only of the pistils and stamens, so that when the flower is open the parts injured are distorted and maimed, and very frequently the flower falls without forming any boll whatever. In many cases, however, the young worm bores through the bottom of the flower into the immature boll before the old flower falls, thus leaving the boll and involucel, or envelope, still adhering to the foot-stalk with the worm safely lodged in the growing boll. The number of buds destroyed by this worm is very great, as they fall off when quite small, and are scarcely observed as they lie brown and withering on the ground beneath the plant. The instinct of the boll-worm, however, teaches it to forsake a bud or boll about to fall, and either to seek another healthy boll or to fasten itself to a leaf, on which it remains until at length it acquires size and strength sufficient to enable it to bore into the nearly-matured bolls, the interior of which is nearly destroyed by its attacks, as, should it not be completely devoured, rain penetrates through the hole made by the worm, and the cotton soon becomes rotten and will not ripen. * * * One thing is worthy of observation, and that is whenever a young boll or bud is seen with the involucre spread open and of a sickly yellow color, it may be safely concluded that it has been attacked by the boll-worm, and will soon perish and fall to the ground.

* * * * * * *

"The buds injured by the worm may be readily distinguished by a minute hole where it has entered, and which, when cut open, will be found partially filled with small black grains, something like coarse gunpowder, which is nothing but the digested food after having passed through the body of the worm."—(Glover, Monthly Agricultural Report, July, 1866.)

When fully grown, the worm descends into the ground, there forming an oval cocoon of earth interwoven with silk wherein it changes to a bright chestnut-brown chrysalis with four spines at the end of the body, the two middle ones being stouter than the others. In this state it remains three or four weeks when the moth escapes. Mr. Glover says that "there are at least three broods each year in Georgia, the last brood issuing as moths late in November. With us (Missouri) there are usually but two, though as already hinted there may be exceptionally three. Most of the moths issue in the fall and hibernate as such, but some of them pass the winter in the chrysalis state and do not issue till the following spring. I have known them to issue in this latitude after the first of November, when no frost had previously occurred."—(Riley.)

Description of the moth.—I regret that there is no good description of the caterpillar in existence and that I have no opportunity to study these caterpillars either in a state of nature or preserved in alcohol. Specimens in all stages would be very welcome. The moth is pale tawny, the hind wings whitish. The fore wings are uniformly pale tawny yellowish, with a small, not very distinct, oval, dark discal dot. Half-way between this and the outer edge of the wing is a row of whitish points, shaded with black within; fringe, flesh red. Hind wings whitish, blackish on the outer two-thirds, with a white fringe. Expanse of wings, 1.40 to. 1.60 inches. I have received specimens from Mr. Belfrage, of Waco, Tex., taken May 18, June 22, July 29, and August 6.

Remedies.—This caterpillar is difficult to manage, as it is hidden most of its life. Hand-picking, if thoroughly tried, will save much loss. The moths may be trapped by spreading a mixture of vinegar and sugar over foods or in plates, and moth-traps should be liberally used. A moth closely allied to this and which in the caterpillar as well as moth state may be easily confounded with the boll-worm, is the so-called phlox worm, originally described by Messrs. Grote and Robinson under the name of *Heliothis phloxophaga.* It occurs all over the South and west as far as California and Oregon. Professor Riley, in the Prairie Farmer, states that there are "two broods a year, the first appearing in July and becoming moths by the middle of August, the second passing the winter in the chrysalis state. The eggs are deposited singly on all portions of the plant, and the caterpillar when about to become a chrysalis enters the ground and interweaves grains of sand with a few silken threads, forming a very slight elastic cocoon."

Description of the moth.—It is usually a little smaller than *H. armigera* and with a large black discal spot fully twice as large as in that species. A dark tawny band runs from the discal spot to the inner edge of the wing. In front of the discal spot are two dark, small costal spots, and a third much larger, one near the apex. Hind wings with a very large, black lunate discal spot, almost entirely wanting in *H. armigera*, while as in that species the black border incloses a white spot, usually, however, much better marked than in *H. armigera.* Expanse of wings, 1.00-1.40 inches.

INSECTS ATTACKING THE TOBACCO-PLANT.

THE TOBACCO-WORM, *Sphinx* 5-*maculata* Haworth.—Devouring the leaves; a large green caterpillar as thick as one's little finger, with a stiff horn on the end of its body, and changing to a chrysalis in the earth, the moth flying in June to September.

About the only serious enemies of the tobacco-plant are the two species of *Sphinx* moths, *Macrosila carolina* Linn., and *Macrosila 5-maculata*, or the Carolina and five-spotted hawk-moth. The Carolina worm is confined to the Middle and Southern States, while the caterpillar of the five-spotted hawk-moth occurs in the Northern and Western States, as well as the Southern. I have received *M. 5-maculata* from Salt Lake City, through Mr. Joseph L. Barfoot, curator of the Salt Lake museum.

So far as my personal knowledge extends, the tobacco-worm is injurious to the tobacco-crop of the Connecticut Valley in Connecticut and Western Massachusetts, and is only kept under by watchfulness, being picked off by hand. In the Middle States, for example Tennessee, the ravages of the "tobacco-worm," as stated by the Scientific Farmer, which may refer either to this insect or the Carolina sphinx, is a great hinderance to the successful cultivation of tobacco in Tennessee. "But," adds the editor, "an enemy to it has appeared in the person of an ichneumon-fly, which destroys the worms in large numbers. It is thought if this ichneumon keeps at its work, that certain lands will possess a high value for the cultivation of tobacco." The accompanying cut (Fig. 48) represents an ichneumon-parasite, a species of *Microgaster*, bred by

Mr. J. H. Emerton, from *Macrosila 5-maculata;* the cross-lines represent the natural size, and *a*, the cocoon, natural size.

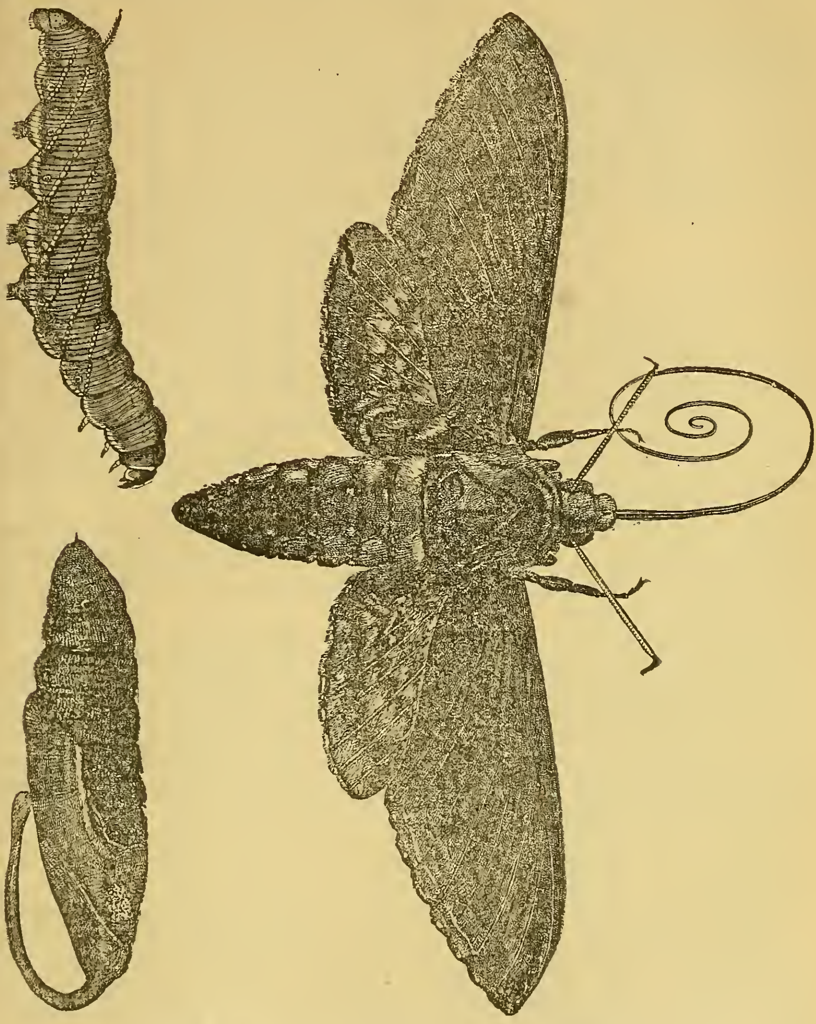


FIG. 47.—Tobacco-Worm, Chrysalis, and Moth.

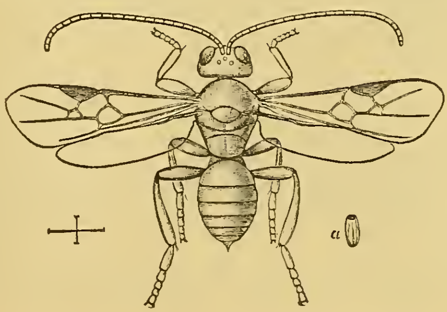


FIG. 48.—Ichneumon-parasite of the Northern Tobacco-Worm.

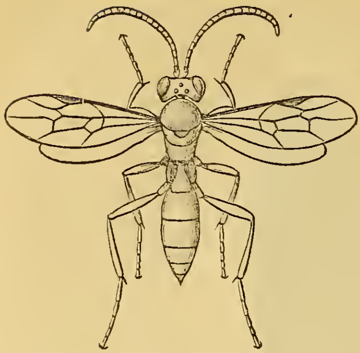


FIG. 49.—Ichneumon-parasite of Vine-Dresser.

Fig. 49 illustrates an ichneumon-parasite of the vine-dresser, *Chœnocampa pampinating*, reared at Salem, Mass., by Mr. Emerton, by whom the drawings of both were made. Professor Riley notices a species of *Microgaster* and ichneumon, an undescribed species of *Blacus*, a braconid ichneumon, which preys on the five-spotted sphinx.

The moth in the Northern States appears in June, without doubt, though I have not personally seen them, lays its eggs on the leaves, probably the under side, and the caterpillar lives about six weeks, attaining its full size from the middle of August until the first of September, going under ground in September and early October. During this month I have frequently seen the moths at twilight in Amherst, Mass., flying about the flowers of the petunia, probing their deep tubular corollas with their long tongue. Our figure, (47,) copied from Harris, will sufficiently indicate the size and transformations of this common moth, the caterpillar of which, in the Northern States, often passes under the name of the tomato or potato worm.

The caterpillar is rather dark green, with seven oblique greenish-yellow stripes on the side of the body. The chrysalis may be known by the large, conspicuous tongue-case which projects from the body like the handle of a pitcher.

In the *Macrosila 5-maculata* there is no white spot at the base of the fore wings, and on the hind wings are two distinct angulated bands.

The Carolina moth is ash-colored, with a white spot at the base of the fore wings, while the central band of the hind wings is indistinct. The caterpillar feeds on the tobacco and the tomato. It is dark green, with lateral, oblique, white bands, edged above with bluish and short transverse black stripes. The tongue-case is shorter and less curved than in the five-spotted sphinx.

INSECTS INJURING THE GRAPE.

THE GRAPE PHYLLOXERA, *Pemphigus vitifoliæ* Fitch; *Phylloxera vastatrix* Planchon.—What the Colorado potato-beetle is to the potato, the Hessian fly to wheat, and the canker-worm is to the apple, the phylloxera is to the grape. This amounts to saying that the vine is in danger of extermination from the latter insect. My attention has been drawn for two years past, while spending a few weeks in September at the Agricultural College in Amherst, to the ravages of this pest, by Professor Maynard. In the autumn of 1875, we found it in abundance on the leaves of several varieties in the vineyard on the college farm, while this year, in company with Professor Maynard, I examined the roots and found the following varieties more or less infested by the root-variety of this plant-louse: Clinton, Agawam, Concord, Iona, Delaware, Adirondack, Israella, Isabella, Wilder, and the native grape under cultivation; the Clinton was affected more than the others, and the Concord much so when growing in a slightly damp, ill-drained and partially shady place.

I am not aware that this formidable pest, which has occasioned such consternation in Europe, has been detected before in New England, except in Connecticut, where it has been found by Mr. Riley. I received it several years ago from Philadelphia, and it has done much damage in the Middle and Western States, while it is known to affect vines in California. As we are destined to be greatly annoyed by it, a brief description condensed from the excellent account by Mr. Riley in his sixth, seventh, and eighth report of the insect in its two forms, may be timely. The insect was first found in this country, and was described by Dr. Fitch in 1856, under the name of *Pemphigus vitifoliæ.* Its proper name is *Phylloxera vitifoliæ*, though most authors speak of it as *Phylloxera vastatrix.* It exists in two forms, one raising irregular galls on the leaves, and the other forming small swellings on the rootlets. The root-form is both wingless and winged, the latter very rare. The leaf-form is said to be always wingless.

The wingless female of the leaf-form lays, on an average, 200 eggs, and sometimes 500. There are perhaps five generations in a year. This leaf-form produces round, irregular galls, sometimes as large as a pea, but it does little damage compared with the root-form, which is much more abundant than the leaf-form (especially on native vines) in France, where its ravages have been so alarming that the French government have offered a reward of 300,000 francs for a simple available remedy.

The leaf-form descends to the roots in the autumn, and there hybernates. The larvæ of the root-form are at first smooth and like the young of the leaf-form, but afterward molt and become warty, so as to become readily distinguishable from them.

Professor Riley and certain French observers have lately proved that the gall-producers (or the leaf-form) come from the impregnated or winter egg.

The winged females begin to appear in July, but are most abundant in August and September. Like the wingless females, they reproduce by budding (parthenogenesis), the eggs not being fertilized by males, no males being in existence. Having issued from the ground while in the pupa state, they rise in the air, and spread to new vineyards, where they lay two or three, sometimes eight eggs. These eggs are of two sizes, and, in about a fortnight, from the larger eggs are hatched wingless true sexual females, and from the smaller eggs wingless males. "The abdomen of the female, after impregnation, enlarges somewhat, and she is soon delivered of a solitary egg, which differs from the ordinary eggs of the parthenogenetic mother, only in becoming somewhat darker. This impregnated egg gives birth to a young louse, which becomes a virginal, egg-bearing, wingless mother, and thus recommences the cycle of the species' evolution. But one of the most important discoveries of Balbiani is that, during the latter part of the season, many of the wing-

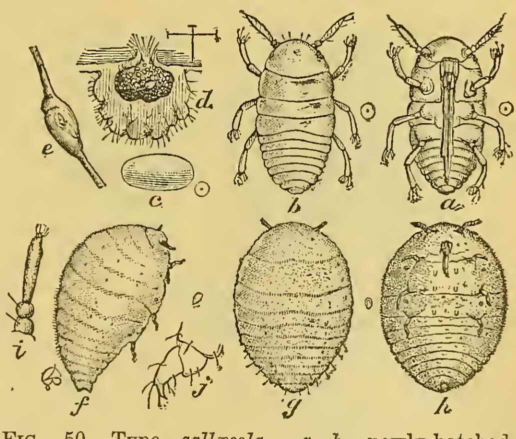


FIG. 50.—Type *gallæcola.* *a, b,* newly-hatched larva, ventral and dorsal view *c,* egg; *d,* section of gall; *e,* swelling of tendril; *f, g, h,* mother gall-louse, lateral, dorsal, and ventral views; *i,* her antenna; *j,* her two-jointed tarsus. The figure on the side of each enlarged drawing represents the natural size. (After Riley.)

less, hypogean mothers perform the very same function as the winged ones; *i. e.*, they lay a few eggs, which are of two sizes, and which produce males and females, organized and constructed precisely as those born of the winged females, and, like them, producing the solitary impregnated egg. Thus, the interesting fact is established that even the winged form is by no means essential to the perpetuation of the species; but that, if all such winged individuals were destroyed as fast as they issue from the ground, the species could still go on multiplying in a vineyard from year to year. We have, therefore, the spectacle of an underground insect, possessing the power of continued existence, even when confined to its subterranean retreats. It spreads in the wingless state from vine to vine, and from vineyard to vineyard, when these are adjacent, either through passages in the ground itself or over the surface; at the same time it is able, in the winged condition to migrate to much more distant points."—(Riley.)

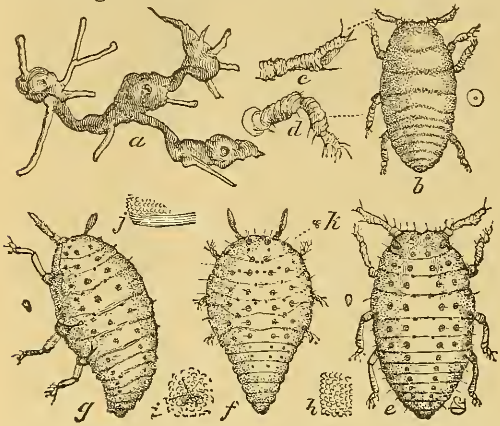


FIG. 51.—Type *radicicola*. *a*, roots of Clinton vine, showing the relation of swellings to leaf-galls, the power of resisting decomposition; *b*, larva, as it appears when hibernating; *c*, *d*, antenna and leg of the same; *e*, *f*, *g*, forms of more mature lice; *h*, granulations of skin; *i*, tubercle; *j*, transverse folds at border of joints; *k*, simple eyes. (After Riley.)

The solitary egg above referred to is the winter egg. As autumn advances, the winged individuals become more and more scarce, and only eggs, newly-hatched larvæ, and a few wingless, egg-bearing mothers are seen. The latter are said to die during the winter, and consequently the species in winter is represented by the larvæ and a few eggs. In spring the larvæ molt their winter coat, and, after attaining maturity, lay eggs. The eggs laid by the winged females are placed in the down of the leaf of the vine, but more commonly in the earth around the roots.

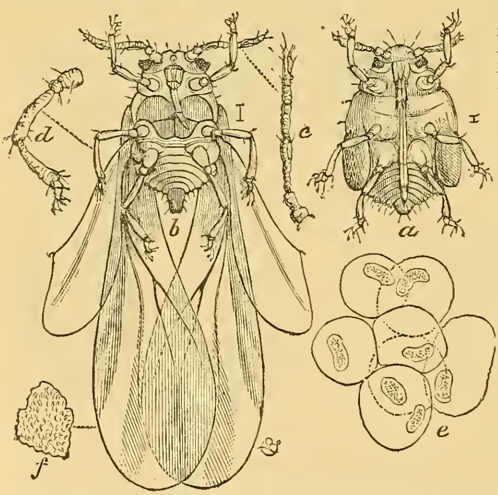


FIG. 52.—Type *radicicola*. *a*, *b*, pupa and imago of a problematic individual, or supposed male; *c*, *d*, its antenna and leg; *e*, vesicles found in the abdomen. (After Riley.)

As to remedies, one hundred and forty have already been proposed in France, but none are infallible. The best general remedy is flooding the vineyards in autumn or winter. The best specific application has been found to be the bisulphide of carbon, two ounces to be placed in a hole near the root, the earth becoming impregnated, the insects are killed. Mr. Riley has urged the use of resisting American vines as stocks, and this is undoubtedly one of the best preventive measures which can be adopted. The writer would like to know how extensive in the Eastern States is the distribution of the phylloxera. The galls are at once recognizable, and appear in midsummer, while the root-form may be detected by little swellings on the rootlets, in which the small greenish-yellow lice may be detected after close examination.

The following recapitulation of the different forms in the insect is taken from Professor Riley's article on the *Phyollexera* in Johnson's Cyclopedia:

1. The gall-inhabiting type (*gallæcola*), forming galls on the leaves, and presenting—
   a, The ordinary egg (Fig. 50, *c*), with which the gall is crowded;
   b, The ordinary larva, (Fig. 50, *a*, *b*);
   c, The swollen parthenogenetic mother, without tubercles (Fig. 50, *g*, *h*);
2. The root-inhabiting type (*radicicola*), forming knots on the roots, and presenting—
   a a, The ordinary egg, differing in nothing from *a*, except in its slight large average size;
   b b, The ordinary larva, also differing in no respect from *b*;
   d, The parthenogenetic, wingless mother, the analogue of *c*, but covered with tubercles (Fig. 55, *g*, *f*);
   e, The more oval form, destined to become winged;
   f, The pupa, (Plate LXVIII, Fig. 1 *e*);
   g, The winged, parthenogenetic female (Plate LXVIII, Fig. 1 *g*, *h*);
   h, The sexual egg deposited by *g*, being of two sizes, and giving birth to the two males and females;
   i, The male (Plate LXVIII, Fig. 2 *e*);
   j, The true female (Plate LXVIII, Fig. 2, *a*, *b*);
   k, The solitary impregnated egg deposited by *j*;
   b b b, The larva hatched from *k*, which, so far as known, does not differ from the ordinary larva, except in its greater prolificacy;
   l, The hybernating larva, which differs only from *b* in being rougher and darker.

THE GRAPE FORESTER, *Alypia octomaculata* Fabr. (Fig. 53).—Devouring the leaves; bright orange, blue and black banded caterpillars.

By the time the syringa is in blossom, the eight-spotted, or grape-forester moth flies about. It is easily known by its black hue, with eight large spots on the wings, two on each wing, those on the fore wings being yellowish, those on the hind wings white. The caterpillar is banded with whitish-blue, with black lines, and on the middle of each segment is a broader orange-yellow band dotted with black, with a conspicuous white spot on each side behind. It is an inch and a quarter long. By the middle of July it becomes fully fed, and pupates in slight webs on the ground or in earthen cocoons. Hand-picking is the best remedy. This insect is briefly mentioned here, from the fact that a similar caterpillar was very common at Golden, Colo., July 3, 1875, on the wild grapes by the side of the railroad, and when the cultivated varieties become reared extensively, it will probably transfer its affections from the wild to the cultivated varieties. The caterpillars of several species of similar moths which occur in California, the genus *Alypia* being more numerously represented on the Pacific coast than elsewhere, may ultimately be found injurious to the cultivated grape.

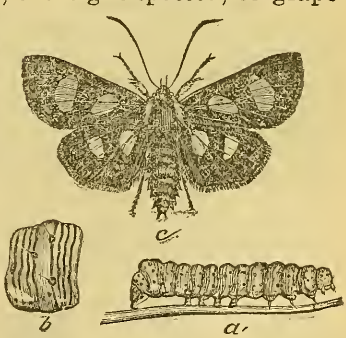


FIG. 53.—The Grape Forester. *a*, caterpillar; *b*, side view of a segment enlarged.

THE GRAPE-VINE COLASPIS, *Colaspis flavida*, Lay. (Fig. 54).—Eating the terminal buds and young leaves, also riddling the leaves. A cream-colored and black beetle.

This little beetle is one of the worst of the forty or fifty different insect-enemies of the grape-vine. The beetle ranges from New York to Illinois and Missouri. It is cream-colored and black, with long club-shaped feelers nearly a fifth of an inch long; the head and prothoray are reddish-yellow, while the wing-covers are black. Hand-picking is the best remedy. The larva (Fig. 57 *a*) has been found by Professor Riley to feed on the roots of the strawberry. It transforms in the ground.

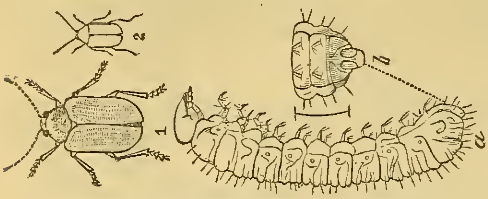


FIG. 54.—Grape-Vine *Colaspis*. 2 nat. size; 1, the same magnified; *a*, the larva; *b*, end of body enlarged. (After Riley.)

THE VINE-LEAF HOPPER, *Erythionenis vitis* Harris. (Fig. 55).—Swarming upon the leaves in August and early September; a small, pale yellow leaf-hopper, with two broad red bands on the wings, causing the leaves to wither.

This little insect, which I have seen abounding in the vineyard of the Massachusetts Agricultural College early in September, when the grapes were ripening, is pale yellow, with two broad red bands and a third dusky one at the apex. It is a little over a tenth of an inch long. It swarms on the leaves in August, puncturing them with its tiny beak and drawing out the sap until the leaves turn yellow and become dry and stiff. The young appear in June, and the leaves are thus depleted for a period of nearly three months. They wither, and hence the plant becomes enfeebled, little new wood is formed, the canes do not ripen well, and the fruit is stunted and easily mildews, while in a few years the vines become exhausted and barren. The leaf-hoppers hibernate, and lay their eggs in the spring. As a remedy, wash the vines with soap-suds in June, and, if possible, fumigate the leaves with tobacco.

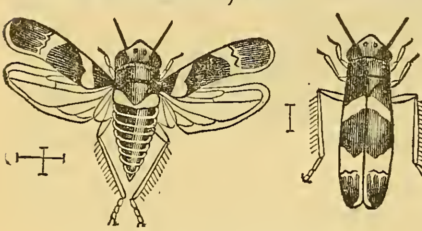


FIG. 55.—Vine-Leaf-Hopper.

THE RED-SHOULDERED SINOXYLON, *Sinoxylon basillare* Lay. (Fig. 56).—Boring under the bark and into the middle of grape-stems; a short, thick maggot.

This blight insect sometimes bores under the bark of the grape, as well as in the heart of grape-stems. It also tunnels in apple-trees and in the shag-bark hickory, boring holes straight toward the heart of the tree, and changing to the pupa state at the inner ends of their burrows. (Harris.) As a remedy, burn the infested twigs or stems.

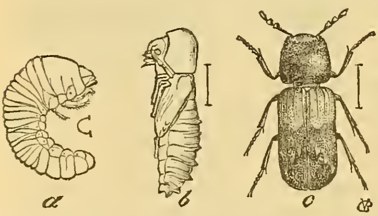


FIG. 56.—Red shouldered *Sinoxylon*. *a*, larva; *b*, pupa; *c*, beetle. (After Riley.)

INJURING THE CURRANT.

THE EUROPEAN CURRANT SAW-FLY, *Nematus ventricosus* Klug. (Figs. 57–59).—Devouring the leaves from June until August; a green false caterpillar, changing to a pale honey-brown saw-fly.

This destructive insect was imported from Europe into nurseries at Toronto, Canada, and was detected at Rochester, N. Y., during the year 1857. It seems since that time to have spread westward and eastward, arriving in Eastern Massachusetts about 1865, as I am informed by Mr. F. G. Sanborn. For eight seasons past it has been very destructive in gardens in Massachusetts as well as in Illinois and Michigan, where it seems destined to spread farther west.

The parent of this worm is a saw-fly, so named from bearing a saw-like sting, or ovipositor, with which it pierces the leaves or stalks of plants, cutting a gash, in which it deposits an egg, the egg passing out from the ovary through the oviduct, and thence through the blades of the ovipositor into the wound made in the plant. While most of the members of this family cut a gash in the leaf, into which an egg is pushed, a few, as in the present insect, simply place them on the under surface of the leaf, as seen in Fig. 59. (1.) The fly has four wings, and belongs to the same group of insects (*Hymenoptera*) that comprises the bee, wasp, and ichneumon-fly.

The following account of its habits is taken from the writer's Guide to the Study of Insects: "There are about fifty species of *Nematus* in this country, of which the most injurious one, the gooseberry saw-fly, has been brought from Europe. Professor Winchell, who has studied this insect in Ann Arbor, Mich., where it has been very destructive, observed the female on the 16th of June, while depositing her cylindrical, whitish, and transparent eggs in regular rows along the under side of the veins of the leaves, at the rate of about one in forty-five seconds. The embryo escapes from the egg in four days. It feeds, molts, and burrows into the ground within a period of eight days. It remains thirteen days in the ground, being most of the time in the pupa state, while the fly lives nine days. The first brood of worms appeared May 21; the second brood, June 25." Fig. 57 shows the eggs deposited along the under side of the midribs of the leaf; 2, the holes bored by the very young larvæ; and, 3, those eaten by the larger worms.

FIG. 57.—Currant-leaf with (1) eggs; 2, 3, holes eaten by the larvæ. (After Riley.)

Fig. 58 (*a*, enlarged) represents the worm when fully grown. It is then cylindrical, pale green, with a pale-green head, with the segment next behind the head, and the third segment from the end of the body, together with the last or anal segment yellow; the 16 false or abdominal legs are also yellow; the six thoracic legs are horn-colored. The body is transversely wrinkled, especially on the back, and is slightly hairy. The eyes are black, and the jaws (mandibles) are black, and on the inner side of the edge reddish. It is about three-quarters of an inch in length.

Previous to the last molt, however, and before it had gained its full size, preparatory to passing into the adult or winged condition, the body is covered with black tubercles; from each of which arises a stiff black hair. There is also a supraanal or dorsal black patch on the last segment of the body, from which arises a pair of black spines. On the back of the false caterpillar the tubercles become smooth and transversely oval, and arranged in two regular rows. Moreover, a still more important characteristic of the worm in this stage is the jet-black head, which in the fully-grown insect is pale pea-green.

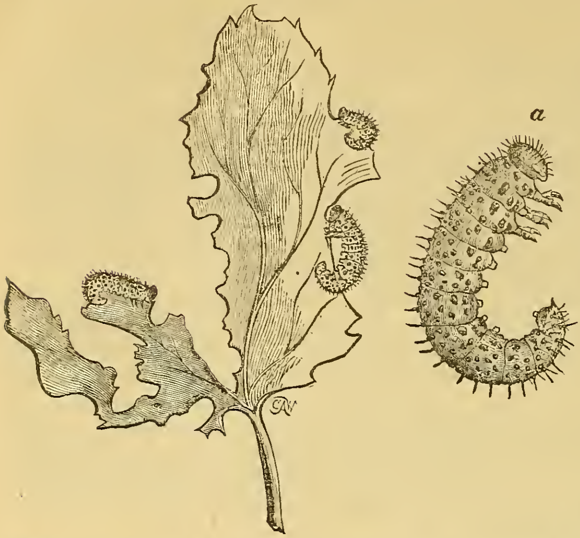


Fig. 58.—Currant saw-fly larva, natural size; *a*, enlarged.

In Salem, my attention was drawn to the ravages of this worm by Dr. William Mack, who found them feeding on the currants in his garden June 8. At this time they were spinning their cocoons, which were of silk, tough, dense, like parchment, and at first green, then becoming blackish, and covered with particles of dirt, and attached to the leaves in the breeding-box. Out of doors they may be found the first week in June, and again during the first week in July among the leaves and stalks on the bushes, or among the leaves lying on the ground, or perhaps more frequently a little under the surface of the ground. Here they remain between two and three weeks in June, the adult flies (in Salem) appearing June 25. At nearly the same date (June 29) the worms of the second brood were spinning their cocoons. These cocoons (belonging to the second brood) remain under ground or on the leaves about the roots through the winter, the flies appearing in the spring and laying their eggs as soon as the leaves unfold.

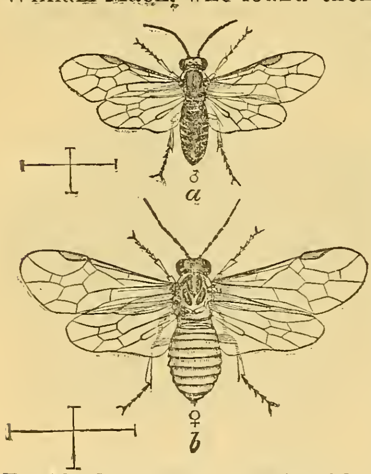


Fig. 59.—European Currant Saw-Fly. *a*, male. *b*, female. (After Riley.)

Not having specimens of both sexes of this saw-fly at hand, I compile the following description (often using their own words) from Messrs. Walsh and Riley's account in the American Entomologist, vol. ii, p. 16, from which these illustrations (Fig. 59 *a*, *b*) are taken.

The female (Fig. 59 *b*) is a quarter of an inch long ($\frac{22}{100}$–$\frac{28}{100}$), and is of a bright honey-yellow color. The head is black, with all the parts between and below the origin of the antennæ, except the tip of the mandibles (jaws), dull honey-yellow. The antennæ are brown-black, often tinged with reddish above, except toward the base, and beneath entirely dull reddish, except the two basal joints. They are four-fifths as long as the body; the third joint, when viewed sideways, is four times as long as wide; the third, fourth, and fifth joints are equal in length, the remaining joints slowly diminishing in length. On the thorax are four conspicuous black spots and other smaller ones. The legs are bright honey-yellow; the basal or hip-joints (coxæ and trochanters) whitish, while the extreme tips of the hind shanks (tibiæ) and the whole of the hind toe-joints (tarsi) are blackish brown. The wings are glossy, with dark veins, and expand a little over half an inch.

The male (Fig. 59 *a*) is rather smaller ($\frac{20}{100}$ inch in length), and is black. The head is dull honey-yellow. The antennæ are brown-black, often a little reddish beneath, except toward the base; they are as long as the body, and while longer than in the female, are also somewhat flattened out. The thorax has the wing-scales and the prothorax, or collar, honey-yellow. The under side and tip of the abdomen are honey-yellow.

The injury done to currant-bushes during the past year was very great. In June, we saw them in great numbers in a garden at Lawrence, where they had stripped the bushes, eating the leaves down to the leaf-stalk, myriads clustering upon the branches. The birds evidently do not feed upon them, and thus, in dealing with this insect, we are deprived of one of the most powerful agencies in nature for restraining a superabundance of insect-life.

As this is an important and practical subject, let us digress for a moment to notice some facts brought out by Mr. J. J. Weir, of the London Entomological Society on the insects that seem distasteful to birds. He finds by caging up birds whose food is of a mixed character (purely insect-eating birds could not be kept alive in confinement), that all hairy caterpillars were uniformly uneaten. Such caterpillars are the "yellow bears" (*Arctia* and *Spilosoma*), the salt-marsh caterpillars (*Leucarctia acræa*), and the caterpillar of the Vaporer moth (Orgyia), and the spring larvæ of butterflies; with these may perhaps be classed the European currant saw-fly. He was disposed to consider that the "flavor of all these caterpillars is nauseous, and not that the mechanical troublesomeness of the hairs prevents their being eaten. Larvæ which spin webs and are gregarious, are eaten by birds, but not with avidity; they appear very much to dislike the web sticking to their beaks, and those completely concealed in the web are left unmolested. When branches covered with the web of *Hyponomenta evonymella* (a little moth of the *Tinea* family) were introduced into the aviary, those larvæ only which ventured beyond the protection of the web were eaten." "Smooth-skinned, gaily-colored caterpillars (such as the currant *Abraxas*, or span worm), which never conceal themselves, but on the contrary appear to court observation", were not touched by the birds. He states, on the other hand, that "all caterpillars whose habits are nocturnal, and are dull-colored, with fleshy bodies and smooth skins, are eaten with the greatest avidity. Every species of green caterpillar is also much relished. All *Geometræ*, whose larvæ resemble twigs, as they stand out from the plant on their anal prolegs, are invariably eaten." Mr. A. G. Butler, of London, has also found that frogs and spiders will not eat the same larvæ rejected by birds, the frogs having an especial aversion to the currant span-worms (*Abraxas* and *Halia*).

The natural enemies of the currant saw-fly are three kinds of ichneumon-flies, of which one is a minute egg-parasite. Mr. Lintner, of New

York, states that of fifty eggs laid by the parent saw-fly, only four or five hatched out the currant-worm. We see, then, that though the birds apparently destroy none, an immense number are carried off, even before they have a chance of doing any mischief, by minute insects of their own order.

One of the best remedies next to picking them off by hand, and which is really the most practicable method of getting rid of them, is to dust powdered white hellebore over the bushes, by sprinkling it from a muslin bag tied to a stick, as it otherwise excites violent sneezing. Used in this small quantity it is not poisonous. This is the remedy used with most success in the West, and recommended by Messrs. Walsh and Riley. I have used it with good success in my own garden, and it is a thorough remedy if thoroughly and persistently applied. Dr. W. Mack, of Salem, tells me that he has used a solution, consisting of a pound of copperas to six gallons of water, with much success. It blackens the leaves, but does not injure them permanently.

Dr. E. Worcester, of Waltham, according to the Boston Journal of Chemistry, finds that this worm "may be fully and almost immediately destroyed by the use of carbolate of lime. The doctor tried the powder in many instances during the past summer, and found that while it was fully as effective as hellebore, it was less disagreeable, less costly, and perfectly safe. The method of using it is to sprinkle it over the vines as soon as the worm makes its appearance, bringing it well in contact with the leaves, and soon the insect is destroyed. It will need but two or three applications, and the work is done."

This worm attacks the gooseberry as well as the currant, though in Massachusetts its ravages have been more confined to the latter shrub. As a preventive measure against its further spread, in buying or transporting gooseberry and currant bushes, Walsh recommends that the roots be carefully cleaned of dirt, so that the cocoons may not be carried from one garden or nursery to another.

THE NATIVE CURRANT SAW-FLY, *Pristophora grossulanæ* Walsh.—As this species may be confounded with the European saw-fly, though belonging to a different genus (*Pristiphora*), the following brief account of it is extracted from my Guide to the Study of Insects:

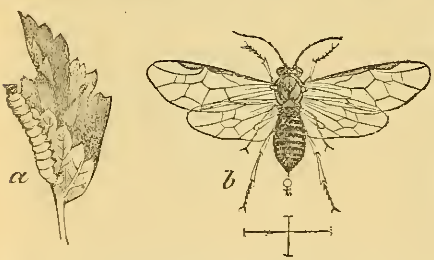


FIG. 60.—Native Currant Saw-Fly. *a*, larva; *b*, female.

This saw-fly (Fig. 60 *a*, larva; *b*, female, from the "American Entomologist"; *P. grossulariæ* of Walsh) "is a widely diffused species in the Northern and Western States, and injures the currant and gooseberry. The female fly is shining black, while the head is dull yellow, and the legs are honey-yellow, with the tips of the six tarsi, and sometimes the extreme tips of the hinder tibiæ, and of the tarsal joints, pale dusky for a quarter of their length. The wings are partly hyaline, with black veins, a honey-yellow costa, and a dusky stigma, edged with honey-yellow. The male differs a little in having black coxæ. Mr. Walsh states that the larva is a pale grass-green worm, half an inch long, with a black head, which becomes green after the last molt, but with a lateral brown stripe meeting with the opposite one on the top of the head, where it is more or less confluent; and a central brown-black spot on its face. It appears the last of June and early in July, and a second brood in August. They spin their cocoons on the bushes on which they feed, and the fly appears in two or three weeks, the specimens reared by him flying on the 26th of August." This worm may at once be distinguished from the imported currant-worm by the absence of the minute black warts that cover the body of the latter. The same remedies should be used for this worm as are recommended for the preceding insect.

THE CURRANT SPAN-WORM, *Eufitchia ribearia* Fitch. (Fig. 61, moth; Fig. 62, 1, 2, caterpillar; 3, pupa, from the "American Entomologist.")—Devouring the leaves; a span-worm, about an inch long, bright yellow, spotted, being nut-black.

FIG. 61.—Moth of Currant.

Many persons, in speaking of the "currant-worm," confound the caterpillar-like saw-fly larva with the well-known geometer caterpillar, which is a native species, and was long since described by Dr. Fitch, under the name of *Abraxas ribearia.* As soon as the leaves of the currant are fairly expanded, late in May or early in June, the young caterpillars, scarcely thicker than a horse-hair, may be found eating little holes in them. In about three weeks after hatching it becomes fully grown, being about an inch long, and bright-yellow in color, the body being covered with large, black dots. The chrysalis is shining reddish-brown, about half an inch long, and may be found late in June, either upon the ground or just under the surface. In two weeks after entering the chrysalis state the moth may be observed flying about the garden or resting upon the leaves during cloudy weather. The moth is yellow ochreous, with dark, often nearly transparent, blotches on the wings. It is not easily mistaken for any other moth. Mr. Riley, in an article on this insect in the "American Entomologist," states that by sprinkling powdered hellebore upon the leaves, or applying a solution of eight or twelve ounces to a bucketful of water, the caterpillars will be killed. Hand-picking assiduously followed up, and a vigorous shaking of the bushes over a sheet or a newspaper, repeated twice a day, will keep the insect within moderate bounds.

FIG. 62.—Currant Span-Worm. (After Riley.)

INSECTS INJURING THE APPLE.

THE CANKER-WORM, *Anisopteryx vernata* Peck, and A. *autumnata* Packard. (Plate LXIX Figs. 1-4.)—Devouring the leaves; a dark-striped span-worm, varying in color to pale green, transforming in the earth, and with wingless females and winged males.

Next to the apple-tree borer, which has almost cut off the apple-crop of the Eastern States in certain localities, the canker-worm, always local in its distribution, is the most injurious. Originally confined, as an injurious insect, to Eastern Massachusetts and Connecticut, it is now injurious in Illinois and Missouri. It must originally, at least *A. vernata*, have occurred all over the United States east of the Mississippi, as I have received it from Texas. It may possibly be introduced into the Territories, and therefore I refer to it simply in this connection.

Let us now examine the life-history of a canker-worm. And here we will confine ourselves to a single species, the *Anisopteryx vernata* of Peck, which appears in the spring, not touching at present on the autumnal species. About the 1st of May, at the time when the leaves of the apple are unfolding, the young canker-worms break through the eggs, which have been laid earlier in the season, in March and April, in patches on the bark of the trunk and limbs. They may be soon found clustering on the terminal buds and partly unfolded leaves, and are then about a line in length, and not much thicker than a bit of thick thread.

How they grow and devour every green thing on the tree is too well known to the fruit-raisers in the eastern part of Massachusetts. Fortunately, owing to the want of wings, the female is exceedingly sedentary, and year after year the trees of particular orchards and towns are defoliated and turned brown, while adjoining orchards and towns scarcely suffer. By the 20th of June, in Essex County, Massachusetts, the orchard looks as if a fire had run through it. At that date the worms are fully fed, and they then descend to the ground, letting themselves down by a silken thread. At this time I have destroyed thousands by jarring the tree and collecting those which fall down. I have watched old and young robins busily engaged in eating them, and from the number of toads in my garden, gathered about under the trees, I feel confident that they eat multitudes of them.

The worms at once enter the ground, change to chrysalids several inches below the surface, near the trunk of the tree, and there remain until the early days of March and April, when the wingless females ascend the trees, and the winged males may be seen fluttering about.

I took pains one spring, in the middle of April, to count the number of these moths on my apple-trees, fourteen in number, averaging from 6 to 7 inches in thickness, besides three elms. They were more abundant on the apple-trees than the elms. But on those seventeen trees there were counted, adhering mostly to the tarred paper, 1,000 males and 200 females. The spring of 1875 was cold and backward, and few moths were seen before this date. From these data we can ascertain approximately the relative numerical proportions between the sexes, which seems to approximate five males to one female.

The species I have referred to is the spring moth, the *Anisopteryx vernata* of Peck, but not of Harris. The other species is much less abundant in the adult condition, and only appears in the autumn. The wings are thicker than those of *vernata*, and the caterpillar has an additional pair of prop-legs, though so short as to be useless. I find that most of the damage is done by the caterpillars of *vernata*. On June 15, 1875, I collected 557 caterpillars from the apple-trees in my garden. Of these 520 were *vernata*, and 27 were the young of the autumn species. Peck, in his account published in 1795, states that *vernata* does the principal damage.

As for remedies, the use of printer's ink laid on tarred paper is the cheapest, though the ink should be applied every day or two. The use of tin troughs of oil surrounding the tree is almost sure to stop the ascent of the females, while wooden troughs of oil built around the bottom of the trunk is almost equally efficacious. Care and attention, and, above all, co-operation among those suffering from these worms, would enable us to check their ravages.

Plate LXVIX, Fig. 1, *a*, represents the caterpillar of *vernata; b*, egg; *c*, *d*, side and dorsal view of a segment of the caterpillar. Fig. 2, *a*, the male moth; *b*, the wingless female; *c*, three joints of the antenna; *d*, dorsal view of an abdominal segment. Figs. 3 and 4 the different stages of the autumnal species (*A. autumnata*).

THE AMERICAN TENT-CATERPILLAR, *Clisiocampa americana* Harris. (Plate LXIX, Figs. 5, 6.)—Devouring the foliage and forming conspicuous tent-like webs or nests in the forks of the branches; a large, hairy caterpillar with a dorsal white stripe and numerous fine, wrinkled black lines on a yellow ground, united below into a common black band, with a blue spot on the side of each ring.

At the same time that the canker-worms are breaking out of their egg-shells, the young tent-caterpillars are following suit. This occurs usually about the 1st of May, in the region of Boston, or a month or six weeks earlier in the latitude of Saint Louis, just as the leaves are unfolding. At this time, if one will examine closely the conspicuous bunches of eggs on the twigs of the tree, he may be able to see the little caterpillars clustering about on the outside of the egg-mass. When hatched, they have large heads, and the body is provided with long, scattered hairs. They at once betake themselves to the opening buds, congregating at noon-time, when the sun is hot among the axils of the branches, there forming a tent of silk for protection from the sun and rain. As they increase in size, they make extended journeys over different branches, laying pathways of silk wherever they go. The tent or nest increases in size until it becomes the conspicuous, but by no means ornamental, object so noticeable on the grounds of slovenly farmers early in June. The caterpillars become fully grown by the middle of June. Then they spin dense, tough, white cocoons under loose bark, or under boards and rails of fences, and the moth appears about the 1st of July.

I once experimented with a worm to see how persevering it would be in spinning its cocoon. After one cocoon was finished I removed it, when by another day a new one was spun like the other. Upon my removing this, it spun a third one which was thin and slight, the supply of silk having been exhausted. The silk is secreted by two glands one-half longer than the body when drawn out, but which are folded up beneath the digestive canal, and open out on the under lip. The silk is fluid, becoming solid on exposure to the air.

The American tent-caterpillar is about two inches in length, with long, rather dense hairs. Along the back runs a white stripe, accompanied by numerous fine, wrinkled black lines on a yellow ground, united below into a common black line. On the side of each segment of the body is a conspicuous blue spot.

The moths hide by day about the garden, and when the lamps are lighted, in they dart and tumble about on the table under the light, in an insensate way, as if frightened out of their wits. So peculiar is their mode of entering a lighted room, that one can usually tell what moth is coming by its peculiar, noisy mode of entrance. The moth is reddish-brown, very thick-bodied, clothed in a thick coat of long hairs, and with short, broad, strong wings, as it flies swiftly. It is reddish-brown, with two oblique, dirty-white lines on the fore wings, which expand when outstretched, about an inch and a half. Early in July the female lays her eggs, in bunches of from three hundred to four hundred. They are placed side by side, in a mass surrounding the twigs (Plate LXIX, Fig. 5, *c*), and after they are thus stuck on so as to surround the branch like a collar, the entire mass is covered over with a gummy secretion, which hardens, and serves as a protection to the eggs.

Remedies.—In the early spring as well as late autumn the bunches of eggs should be picked off and burned. When the tents are formed in June the nest should be removed with a mop dipped in oil or kerosene, at noon-time, when the caterpillars are in the tent. By discharging a gun close to the nest it can be destroyed with a small charge of powder.

Plate LXIX, Fig. 7, represents the caterpillar of *Clisiocampa disstria* Hübner (*sylvatica* Harris), which rarely occurs on apple-trees, being more common on the oak. It is a light blue, with a dorsal rim of eleven white oval spots. The moth, with the eggs, is represented at Fig. 8. There are two species of *Clisiocampa* in California (*C. californica* Pack., and *C. constrictu* Stretch), and one is troublesome to apple-trees at Salt City, Mr. Barfort tells me, which may in time leave the oak on which it feeds and attack the apple. Both of the eastern tent-caterpillars origna ly fed on the oak.

THE FALL WEB-WORM, *Hyphantria textor* Harris. (Fig. 63.)—Forming large webs on fruit and forest trees in August; a hairy, slender, greenish-yellow caterpillar dotted with black, changing to a snow-white unspotted moth.

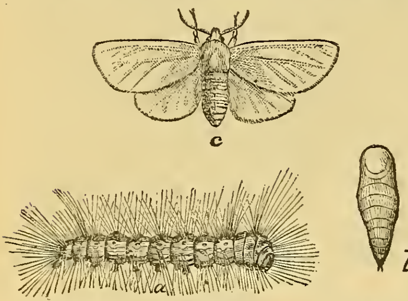


FIG. 63.—Fall Web-Worm. *a*, larva; *b*, chrysalis; *c*, moth. (After Riley.)

This common and annoying caterpillar is universally abundant, weaving its conspicuous web or tent-like structure on the branches of the apple, pear, and cherry, etc., in August, the worms remaining about until the leaves are nearly ready to fall. They usually eat the leaves on one entire branch and then pass to the next, tying the leaves together with silken threads. They are easily exterminated by hand-picking.

THE CODDLING MOTH, *Carpocapsa pomonella* Linn. (Plate LXIX, Fig. 9.)—Eating holes in apples, causing them to fall prematurely; a small flesh-colored worm, transforming into a small gray moth.

This moth, which is such a universal pest in the Eastern States, has for five years past, Mr. Barfort tells me, been injurious to the apples in Salt Lake City. Indeed, it is the only considerable pest of the apple in the Territory, but one that attracts a good deal of attention. Mr. Henry Edwards, of San Francisco, writes me that it has not yet occurred in California.

The moth lays usually one egg on the blossom end of the fruit early in summer, and the caterpillar hatches in a few days, burrowing directly into the core of the forming fruit. It attains its full size, becoming fully fed, in about three weeks, when the apple drops to the ground, and the larva transforms in a thin or sometimes quite thick cocoon in crevices in the bark of the tree, etc., and in a few days after another brood of moths appear, though most of them, as I have found in Maine, remain in their cocoons through the winter in the caterpillar state. In this condition I have found them under the loosened bark early in May. Many of the worms, Dr. Le Barm, in his Illinois report, says one-half, instead of waiting for the immature apples to fall, desert the apple and let themselves down by the web or walk down the trunk of the trees. The moth is gray, with numerous darker, transverse lines, and with a curved black line before the ocellated patch on the inner angle, which line is edged with a coppery tint. Plate LXIX, Fig. 9, represents the caterpillar, with the worm-eaten apple, the cocoon (*i*), and the chrysalis and moth.

Remedies.—This troublesome pest may be partially destroyed by gathering the "windfalls," though the larva often deserts the worm-eaten apples before it falls. The best remedy is that suggested by Dr. Trimble, who binds bands of hay about the trees from July until the middle of September. The larvæ crawl under these bands and there spin their silken cocoons, when every fortnight the bands can be removed and the worms destroyed. Dr. Le Barm recommends for Northern Illinois that the bandages be in place a month after the blooming of the trees; that they be examined seven weeks after the falling of the blossoms; that three subsequent examinations be made at intervals of twelve days, and a final one after the leaves of the tree have fallen. In the latitude of Saint Louis, Mr. Riley suggests that the first examination be made not later than six weeks after the falling of the blossoms; and that four subsequent examinations, at intervals of twelve days, be made between it and the final one in the autumn when the apples are gathered.

THE APPLE-WEEVIL, *Anthonomus quadrigibbus* Say. (Figs. 64, 65.)—Boring in the apple; a long, slender maggot, transforming in the apple into a weevil, with a snout nearly as long as the body.

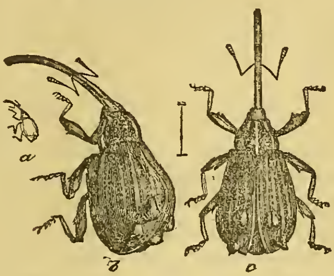


FIG. 64.—Apple-Weevil, adult. *a*, nat. size; *b*, *c*, enlarged. (After Riley.)

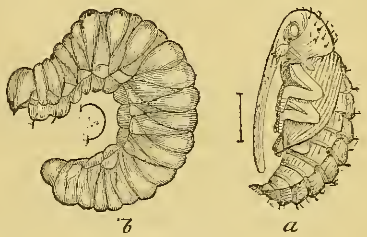


FIG. 65.—Apple-Weevil. *a*, pupa; *b*, maggot; both enlarged.

This weevil, which need not be confounded with the plum-weevil, is smaller, and has a longer beak. With its long snout it drills holes into the apple, deposits an egg, and the grub goes right to the heart of the apple, feeding around the core for nearly a month, when it transforms in the fruit, which does not fall. It remains two or three weeks in the pupa state, not leaving the fruit until it becomes a beetle.—(Riley.)

INSECTS AFFECTING THE PLUM.

THE PLUM-WEEVIL, *Conotrachelus nenuphar* Herbst.—Puncturing the young fruit; a weevil, like a dried plum-bud in general appearance, whose grub in the plum causes the fruit to prematurely fall.

The plum-weevil has nearly cut off the fruit in the Eastern States, so that comparatively little is raised. The following condensed account is taken from "The Guide to the Study of Insects:" "This beetle is a short, stout, thick weevil, and the snout is curved, rather longer than the thorax, and bent on the chest when at rest. It is dark brown, spotted with white, ochre-yellow and black, and the surface is rough, from which the beetle, as Harris says, looks like a dried bud when shaken from the tree. When the fruit is set, the beetles sting the plums, and sometimes apples and peaches, with their snouts, making a curved incision, in which a single egg is deposited. Mr. F. C. Hill shows that the curculio makes the crescent-shaped cut after the egg is pushed in, 'so as to undermine the egg, and leave it in a kind of flap formed by the little piece of the flesh of the fruit which she has undermined. Can her object be to wilt the piece around the egg, and prevent the growing fruit from crushing it?'—(Practical Entomologist, Vol. ii, p. 115.) The grub hatched therefrom is a little footless, fleshy white grub, with a distinct round light-brown head. The imitation set up by these lavæ causes the fruit to drop before it is of full size, with the lava still within. Now full-fed, it burrows directly into the ground and transforms during the last of the summer. In three weeks it becomes a beetle. It also attacks other garden-fruits, such as the cherry, peach, and quince.

Remedy.—The best remedy is jarring the trees, and catching the larvæ in sheets and burning them. Dr. Hall's "curculio catcher" is an excellent invention for destroying these insects; it consists of a large inverted white umbrella, fixed upon a large wheelbarrow, split in front to receive the trunk of the tree, against which it is driven with force sufficient to jar the curculios from the tree into the umbrella.

INSECTS INJURING THE STRAWBERRY.

THE JUNE BEETLE, *Phyllophaga fusca* (Fröhl.). (See Fig. 10, p. 720.)—Eating the roots; the large, fleshy white grub of the common May or June beetle.

The following account is taken from my third annual report as State Entomologist of Massachusetts:

"With the increasing attention paid to the culture of the strawberry, it has been found that several insects not before suspected to be inclined to feed on this plant, now habitually frequent it. Of these perhaps the most injurious is the strawberry saw-fly, which in this State, but more especially the Western States, as in Illinois, does in some cases the most grievous damage. Then a few moths which have been known to feed on fruit-trees, the currant, etc., have transferred their affections to the strawberry; such are the apple-leaf-roller or *Tortrix*, the saffron measuring-moth (*Angerona crocataria*), and several other caterpillars found in the Western States, and described in the entomological reports of Messrs. Walsh and Riley, and also in 'Harris's Treatise on the Injurious Insects' of this State, and the reporter's 'Guide to the Study of Insects.'

"Next, however, in importance to the strawberry saw-fly (*Emphytus maculatus*), is one of the most common and familiar of all these insects which everywhere force their attention upon us. This is the common May beetle, June beetle or 'dor bug,' the American representative in its abundance and injurious qualities of the European cockchafer.

"Dr. Harris has given a brief sketch of its habits and transformations in his Treatise, and referred to the injury the grub, sometimes called 'white-worm,' does to the roots of grass, remarking that 'in many places the turf may be turned up like a carpet in consequence of the destruction of the roots.' He, however, does not say that it attacks the strawberry-roots, which it has for several years been known to do in gardens about Salem. My attention was especially called to its ravages by Mr. D. M. Balch, of Salem, who has lost many strawberry-plants by the white grub. It seemed evident that they were introduced in the manure placed around the roots, as during July and late in summer a manure-heap near by swarmed with the well-known white grubs, in various stages of development, some apparently in the second year and others in the third year's growth. They eat the main roots of the plant, thus destroying one plant after another. From this it will be obvious that if we observe the plant to wilt and suddenly die, we may look for the white grub and at once kill it to prevent farther ravages. It is evident, so large and voracious are these worms, that one plant would be a mere trifle to one of them.

"It also eats down in much the same manner young squash-plants, as I am told by Mr. C. A Putnam, of Salem, who has been obliged to plant the seed over once or twice. They attack young plants at the time when they have thrown out three or four leaves. It is obvious that in dealing with this destructive insect we must become familiar with its habits. Every one knows the larva or grub of this insect, so that a detailed description is not necessary. It is a large, soft-bodied, thick, white worm, nearly as large as the thumb. Its head is yellowish or pale horn-colored. Its skin is so thin and transparent that the air-vessels and viscera can be seen through it, while, though it has three pairs of legs, it is so gross and unwieldy that it lies, when dug out of its retreat, flat upon its side.

"How many years the grub lives before changing into the beetle we do not know, but probably at least three. It arrives at maturity in the autumn, and early in May in this state the chrysalis may be found in little rude cells or chambers about six inches under the mold, in which position we have found it in Maine late in May. During the latter part of May and early in June, *i. e.*, for about a month, it flies about at night, especially on warm nights. By day it hides in fruit and other trees, clinging to the under side of the leaves by its long, curved claws, which are admirably adapted for the purpose. Here it does at times much injury, especially, as Harris remarks, to cherry-trees.

"Where it lays its eggs is not definitely known, but it is probable that it burrows in the soil and there lays its eggs, as does the European cockchafer, of whose habits Harris gives a summary, and also the goldsmith beetle, of which we give an account farther on. Riley, however, says that 'soon after pairing, the female beetle creeps into the earth, especially wherever the soil is loose and rough, and after depositing her eggs to the number of forty or fifty, dies. These hatch in the course of a month, and, the grubs growing slowly, do not attain full size till the early spring of the third year, when they construct an ovoid chamber, lined with a gelatinous fluid, change into pupæ, and soon afterward into beetles.'

"In the autumn at the approach of cold it descends to a considerable depth below the surface to avoid the frost, probably about two feet below the usual depth at which the ground is frozen in the winter. At the approach of warm weather, however, it makes its way up near the surface, where it forms a slight cell by wriggling about, and then passes into the pupa state. It is said to sometimes pupate and appear in the winged state in the autumn.

"As to remedies against this grub, the careful gardener will in the first place destroy all those that he sees by crushing them to death. When the manure is spread over the strawberry-bed, he must watch it narrowly for the grubs so easily seen, and kill them. When a vine is seen to die down suddenly in summer he must then dig around the roots and search for them, and go over the bed carefully, even if help has to be employed. It is better to spend even much time and money for two or three years in succession, in endeavoring to exterminate these grubs, than to yield passively to the scourge. The remarks of Mr. Lockwood, that we reprint in our account of the goldsmith beetle, are eminently practical as applied to this insect. As for special remedies, we have none to propose. Watchfulness and care in culture are better than any special nostrums.

"Undoubtedly the natural enemies of this grub are many, but we have no observations bearing on this point. A fungus attacks the grubs in certain seasons, often in considerable numbers. We have received specimens from Missouri of dead and dried grubs, with a long stem growing out from them, the result of the attacks of this fungus. It has been figured by Mr. Riley, who states that another fungus attacks this worm in Virginia. It is well known that caterpillars and even the common house-fly are sometimes attacked by a fungus which replaces the animal portion with its own vegetable substance.

"While many animals, such as skunks, moles, crows, etc., prey on the beetles, the only insect-enemy I have personally observed is the fierce carnivorous Calosoma beetle (*C. calidum*) which I have noticed on a blueberry-bush busily engaged in tearing open the hard, horny sides of one of these beetles, which was in vain struggling to escape; on taking up the May beetle a large hole had been eaten into its side, disclosing the viscera.

"Occasionally the beetles appear in immense numbers. It is then the duty of the agriculturist to pick them off the trees and burn them. If the French take the pains to practice hand-picking, as in one instance 'about eighty millions were collected and destroyed in a single portion of the Lower Seine' (Riley), our gardeners can afford to take similar pains.

"A description of the May beetle is scarcely necessary. Fig. 10 (p. 720) gives a good idea of its appearance and size. It is bay-colored, or chestnut and brown, with yellowish hairs beneath, and is nearly an inch in length. Its scientific name is *Lachnosterna fusca*, or, literally translated, the brown woolly-breasted beetle. The pupa is white."

THE GOLDSMITH BEETLE, *Cotalpa lanigera*, Linn.—Feeding on the roots as grub; very similar to that of the June beetle.

"We also have in the Eastern States an insect allied to the preceding, and with much the same habits, both in the adult and preparatory states. It is the *Cotalpa lanigera*. It is nearly an inch in length, bright yellow above, with a golden metallic luster on the head and thorax, while the under side of the body is copper-colored, and densely covered with white hairs.

"Dr. Harris says that it is very common in this State, remarking that it begins to appear in Massachusetts about the middle of May, and continues generally till the 20th of June. 'In the morning and evening twilight they come forth from their retreats, and fly about with a humming and rustling sound among the branches of trees, the tender leaves of which they devour. Pear-trees are particularly subject to their attacks, but the elm, hickory, poplar, oak, and probably also other kinds of trees, are frequented and injured by them.' Dr. Lockwood has found it on the white poplar of Europe, the sweet gum, and has seen it eating the Lawton blackberry. He adds that the larvæ of these insects are not known; probably they live in the ground upon the roots of plants.

"It has remained for the Rev. Dr. S. Lockwood to discover that the grub or larva of this pretty beetle in New Jersey devastates strawberry-beds, the larva feeding upon the roots, in the same manner as the May beetle. His account was first published in the American Naturalist (vol. ii, pp. 186, 441). He says that in the month of May in the ordinary culture of his garden the spade has turned up this beetle generally in company with the May beetle. He found that some of the beetles, as in the case of the May beetle, assume the adult beetle state in October and remain under-ground for seven months before appearing in the spring.

"*Larva.*—The larvæ he describes as 'whitish grubs, about one inch and three-quarters long and over half an inch thick, with a yellowish-brown scale on the part corresponding to the thorax.' I may add that it so nearly resembles the young of the May beetle that it requires a close examination to tell them apart. The proportions of the two are much the same; if anything the *Cotalpa* is slightly shorter and thicker, and its body is covered with short, stiff hair, especially at the end, while in the May beetle the hairs are much finer, sparse, and the skin is consequently shiny. They also differ in the head, being fuller, more rounded in *Cotalpa*, the clypeus shorter and very convex, while in the May beetle it is flattened. The upper lip (labrum) is in *Cotalpa* longer, more rounded in front and narrower at the base, and full convex on the surface, while in the young May beetle it is flat. The antennæ are longer and larger in the goldsmith beetle, the second joint a little over half as long as the third, while in the May beetle grub it is nearly three-quarters as long; the third joint is much longer than in the latter grub, while the fourth and fifth are of the same relative length as in the May beetle, but much thicker. The jaws (mandibles) are much alike in both, but not quite so acute in the *Cotalpa* as in the other, nor are the inner teeth so prominent. The maxilla is much longer and with stouter spines, and the palpi are longer and slenderer in the grub of *Cotalpa* than in the other, though the joints have the same relative proportion in each; the basal joint is nearly twice as long as in the May beetle. The under lip (labium) is throughout much longer, and the palpi, though two-jointed in each, are much longer and slenderer in the grub of *Cotalpa* than in that of the May beetle. The feet are much larger and more hairy in the *Cotalpa*. Both larvæ are about an inch and a half long, and a third (.35) of an inch thick at the widest part.

"As regards the number of years in the life of this insect, Dr. Lockwood remarks that 'when collecting the larvæ in May, I often observed in the same places grubs of the *Cotalpa* of at least four distinct ages, each representing a year in the life of the insect, judging from Renny's figures of the larvæ of the English cockchafer, or dor beetle (*Melolontha vulgaris*). But the cockchafer becomes an imago in January or February, and comes forth into active life in May, just four years from the deposit of the egg. Supposing our *Cotalpa* to take on the imago form in autumn, and to spend its life from that time to the next May in the ground, it would be five years old when it makes its *début* as an arboreal insect.' It is possible that Dr. Lockwood may be in error regarding the age of this beetle, as M. T. Reiset says in France this insect is three years in arriving at its perfect beetle state. The following remarks on the habits of the European chafer may aid observers in this country in studying the habits of our native species. M. Meiset says (see 'Cosmos' as translated in the American Naturalist, vol ii, p. 209) 'that this beetle in the spring of 1865 defoliated the oaks and other trees, while immense numbers of their larvæ in the succeeding year, 1866, devoured to a fearful extent the roots of garden-vegetables, etc., at a loss to the department of the Lower Seine of over five millions of dollars. This insect is three years in arriving at its perfect beetle state. The larvæ, hatched from eggs laid by the beetles which appeared in such numbers in 1865, passed a second winter, that of 1867, at a mean depth in the soil of forty one-hundredths of a meter, or nearly a foot and a half. The thermometer placed in the ground (which was covered with snow) at this mean depth, never rose to thirty-two degrees F. as *minimum*. Thus the larvæ survived after being perfectly frozen (probably most subterranean larvæ are thus frozen, and thaw out in the spring at the approach of warm weather). In June, 1867, the grubs having become full-fed, made their way upward to a mean distance of about 13 inches below the surface, where, in less than two months, they all changed to the pupa state, and in October and November the perfect beetle appeared. The beetles, however, hibernate, remaining below the surface for a period of five or six months and appearing in April and May. The immature larvæ, warned by the approaching cold, began to migrate deep down in the soil in October, when the temperature of the earth was ten degrees above zero. As soon as the snow melted they gradually rose toward the surface.'

"As regards the time and mode of laying the eggs, we quote from Dr. Lockwood as follows: 'On the evening of the 13th June last we caught in the drug-store, Keyport, whither they were attracted by the profusion of light, four *Cotalpas*, representing both sexes. These were taken home and well cared for. On the 16th a pair coupled. A jar of earth was at once provided, and the beetles placed on top of the dirt. In the evening the female burrowed and disappeared. Near midnight she had not returned to the surface; next morning she had re-appeared. The earth was then very carefully taken from the jar, and, as removed, was inspected with a glass of wide field but low power. Fourteen eggs were found, not laid (as we expected) in one spot or group, but singly and at different depths. I was surprised at their great size. Laid lengthwise, end touching end, two eggs measured very nearly three-sixteenths of an inch. They were like white wax, semi-translucent; in form, long-ovoid and perfectly symmetrical. On the 13th of July one had hatched; the grub was well formed and very lively. Its dimensions were about five-sixteenths of an inch in length and about three-thirtieths of an inch in thickness. It was a dull white, the head-plate precisely that dull yellow seen in the adult grub, the legs the same color, and the extremity of the abdomen lead-color, the skin being transparent. For food, a sod of white clover (*Trifolium repens*) was given them, roots downward, knowing that the young larvæ would come upward to eat. They were then left undisturbed until August 19, when the sod was removed, and it was found that the grubs had eaten into it, thus making little oval chambers, which were enlarged as the eating went on. They were carefully picked out and a fresh sod of grass and clover supplied. They had now grown five-eighths of an inch in length, preserving the same colors.

"It is quite possible that a few of the eggs escaped me in the search. I am of opinion, however, that from fifteen to twenty is the average number laid by one beetle. In short, the insect lays her eggs in the night, probably not more than twenty. The hatching of these required in the present instance twenty-seven days. It must be remembered that a large portion of this time was remarkably cold and wet. It is almost certain that with favorable thermal conditions this might be lessened fully seven days.

"Regarding its ravages in strawberry-beds, I cannot do better than quote from Dr. Lockwood's excellent account in the American Naturalist: 'When on a visit in September last to the farm of a celebrated strawberry-grower in Monmouth County, New Jersey, my attention was directed to certain large patches badly thinned out by, as the phrase went, "the worm." The plants were dead on the surface and easily pulled up, the roots being eaten off below. It was observable that the fields which presented the worst appearance were all of the same kind of plant—that known as Wilson's Albany Seedling. Besides this there were nine other varieties under culture, Barnes' Mammoth, Schenck's Excelsior, the Agriculturist, Triomphe de Gand, Cutter's Seedling, the

Jucunda, Pineapple, Early Scarlet, and Brooklyn Scarlet. While the Wilson stood second to none of these as a prolific fruit-bearer, yet it fell behind them in vigorous plant-growth. Hence, while every kind was more or less affected, the other varieties seemed saved by their own growth and energy from a destruction so thorough as was that of the Wilson. These patches were all planted in the spring and all received the same treatment, the ground being kept open and free from weeds. The amount of the spring-planting was seven and a half acres. Of the Wilsons there were three different patches in places quite separated from each other, and on not less than five different kinds of soil. These patches were among and contiguous to those of the other varieties. While all suffered more or less, the chief injury befell the Wilsons, of which not less than two acres were irretrievably ruined. An examination turned up the depredator, who was none other than the larva of the goldsmith beetle, now engaged in the first one of its allotted three-summer campaigns of mischief. These grubs were from the eggs deposited in June in the well-tilled and clean soil, which, I have said elsewhere, I thought the *Cotalpa* preferred to meadow or grass lands. Compared with others, the larva of this beetle is sluggish and easily captured. The black grub of the spring, which is such a pest, attacking almost indiscriminately the early tender plants, inflicts its injuries chiefly in the night, the exception being that of dull and cloudy days. The night's mischief done, it descends into concealment at early dawn. Knowing this, the wise farmer is in search of it at an early hour, ere the warmth of the sun gives it warning to retreat. But the goldsmith grub can be taken at any hour of the day simply by scratching away the earth from around the roots of those plants whose dark, shriveled leaves tell of the enemy's presence. It is my belief that this devastation might have been spared by an outlay of from $20 to $30 for labor, much of which, under proper direction, could have been done by children. Therein would have been saved a strawberry-crop for the ensuing summer, worth scarcely less than $2,500, for from this same farm the crop of a single acre has been sold for $1,500. Then, however valuable such labors are in the immediate results, that is but a fraction of their worth as respects the future. These *Cotalpa* grubs, with all their mischief, had not more than a third of their ultimate size; hence their real ravenousness is yet to come. Besides, what a prospect of increase of numbers, should even a moderate share of them reach maturity! Why should not our farmers seek to know something about their insect enemies, and, when practicable, put forth some energy to meet such?'"

THE STRAWBERRY CROWN-BORER, *Analcis fragariæ* Riley.—Boring from the crown of the plant down into and killing it; a small, soft, fleshy grub, transforming to a weevil.

From the middle of June until the middle of July in Southern Illinois, the grub hatches from an egg, supposed to be deposited by the parent weevil in the crown of the plant, and bores downward into the pith, where it remains until fully grown, "working in the thick, bulbous root, and often eating through the more woody portions; so that when frost sets in, the plant easily breaks off and is heaved out of the ground."—(Riley.) A remedy is difficult to apply, but infested plants should be burned.

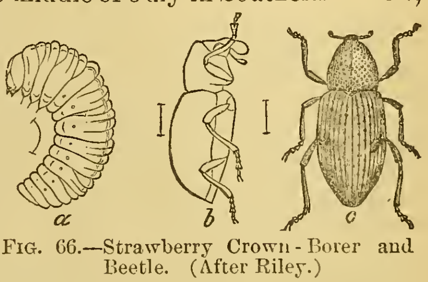


FIG. 66.—Strawberry Crown-Borer and Beetle. (After Riley.)

INSECTS INJURING SHADE AND FOREST TREES.

So important to the Western Territories is the preservation and cultivation of forest, as well as shade and ornamental, trees, that a slight sketch of what is known of the insects found in Colorado to be injurious to them will be of some importance until more definite information is obtained. On Plate LXX, I have given outline figures of a number of insects either found living in forest-trees in Colorado, or, from the habits of their allies in the Eastern States, supposed to be injurious.

INJURING CONIFEROUS TREES.

THE SPRUCE-TIMBER BEETLE, *Dryocœtes affaber*, Mannh. (Plate LXX, Figs. 1–3.)

This beetle occurred (July 7) in abundance in all stages in a growth of *Abies menziesii*,* the common spruce of the Rocky Mountains, at Kelso's Cabin, 11,200 feet elevation, on the road to Gray's Peak. It bores into the back and near the sap-wood in all directions, its burrows resembling those of *Tornicus pini*, with which it is associated, being irregular, but much smaller.

The larva (Plate LXX, Fig. 1) is of the usual form of those of the family, being cylindrical and of the same thickness throughout, with the end of the body full and suddenly rounded; segments convex, especially the thoracic ones, and slightly hairy. Head two-thirds as wide as the body, rounded, honey-yellow. Length, 0.15 inch.

The pupa is much like that of *T. pini*, with two anal soft, sharp tubercles. As my specimens are farther advanced than those of *T. pini*, the wings being free from the body, and the abdomen longer, it is impossible for me to draw up a good description. In one example, the pupa had retained the larval head, but it was split behind so as not to interfere probably with the development of the adult beetle.

The beetle (Plate LXX, Fig. 3) differs from *T. pini* in its much smaller and slightly slenderer body. The head and prothorax are two-thirds as long as the rest of the body. The abdomen is not scooped out at the end as in *T. pini*, but truncated, moderately rounded, and the end of the abdomen reaches to the end of the wing-covers, which are square at the end instead of excavated as in *T. pini*. Color reddish-brown, much as in *T. pini*. The body is covered with fine, stiff, straight hairs. Length, 0.14 inch.

THE PINE-TIMBER BEETLE, *Tornicus pini* Say. Pupa and beetle. (Plate LXX, Figs. 4, 5.)

This timber-beetle was common, boring irregularly into the inner bark of *Abies menziesii*. The burrows are like those made by the same insect in the white pines from Maine to North Carolina. On the Atlantic coast the more regular burrows radiate from a common center. Those observed on Gray's Peak were 0.08 inch in diameter.

In the pupa the body ends in two long, pointed, horn-like appendages arising from each side beneath. The ends of the hind tarsi extend to the terminal third of the wings. The antennæ are clavate, not extend-

* This tree was kindly identified for me by Mr. Sereno Watson, from specimens of the leaves and cones sent him for identification.

ing beyond the coxæ of the first legs. It is larger, more bulky than the adult. Length, 0.22 inch.

The beetle (Plate LXX, Fig. 4) is cylindrical, with the head and prothorax together three-fourths as long as the rest of the body; end of the abdomen suddenly truncated, slanting, forming a scoop, the declivity smooth, concave, and bounded by high walls, which are four-toothed on each side, the third from the top the largest. On each wing-cover are eight lines of fine, raised tubercles; prothorax with concentric rows of fine tubercles, but smooth on the posterior third. Seen from beneath, the wing-covers project well beyond the end of the abdomen. Color, pale tan-brown, a little paler on the thorax than on the wing-covers. Body covered with stiff, dense hairs. Length, 0.20 inch.

THE STOUT PINE-BORER, *Dendroctonus obesus* Mannh. (Plate LXX, Fig. 16.)

This beetle is not uncommon in Colorado. I met with it at Blackhawk and at Manitou. It probably bores in the pines and spruces of the mountains. It is short and stout, reddish-brown, the head and prothorax smooth and shining, though finely punctured, while the wing-covers are coarsely punctured and dull-colored, being a little darker than the rest of the body. Length, 0.35 inch.

It scarcely differs from the *Dendroctonus terebraus* of the Eastern States, which I have found in all stages in great abundance under the bark of the white pine, associated with *Pissodes strobi.* It mines the inner surface of the bark, slightly grooving the sap-wood, and pupates in April, appearing as a beetle in great numbers on warm days early in May. On a cursory examination I am unable to see any difference between the eastern species and *D. obesus*, except that the latter is slightly larger.

INJURING DECIDUOUS SHADE AND ORNAMENTAL TREES.

The following beetles are common in Colorado and the Rocky Mountains, and in most cases will probably be found ere many years to be injurious to the trees in towns and on farms. Knowing as yet nothing of their habits I have thought it well to select a few of the more common species and present such figures and brief descriptions of them as may prove useful to western gardeners and farmers hereafter. I will not attempt to coin English names for them. The localities are given in the List of Coleoptera collected by me in Colorado, at the end of this report.

PRIONUS EMARGINATUS Say. (Plate LXX, Fig. 6.)

"Body castaneous; head, thorax, and breast covered with long yellowish-ferruginous hair; antennæ fourteen-jointed, glabrous, perfoliate, imbricate; the imbrications emarginate beneath; mandibles black at tip; thorax but slightly margined, one-toothed on the middle of the lateral edge; angles obtusely rounded; elytra somewhat unequal, punctured; feet and venter subglabrous. Length nearly seven-tenths of an inch. Female glabrous; antennæ simple. Length four-fifths of an inch. This species exhibits the general form of *brevicornis*, but the thorax is proportionally much narrowed, and the characters above detailed prove it to be very distinct from that species. The lepaceous processes of the antennæ are so profoundly emarginate beneath as to appear each bilobate. I obtained it on the Arkansas River near the mountains."—(Say.)

CRIOCEPHALUS PRODUCTUS Le Conte. (Plate LXX, Fig. 7.)

Varying from dark brown to black-brown; unspotted, with two high, thin, raised lines or ridges on each wing-cover. It is closely allied to the eastern *C. agrestis*, but is somewhat narrower, and the ridges are much more prominent. Length, 0.80–0.85 inch.

DECTES SPINOSUS (Say). (Plate LXX, Fig. 8.)

"Head deeply indented between the antennæ; labrum piceous; antennæ longer than the body, black, each joint gray at base; thorax cylindrical, immaculate; an acute, slightly-recurved spine near the posterior angles; elytra (wing-covers) with numerous small impressed punctures, at tip truncated; venter with a series of almost concealed black spots on each side. Length more than three-tenths of an inch."—(Say.) "I formed a special genus, *Dectes*, for this insect, but it seems to be scarcely distinct from *Liopus*."—(Le Conte.)

POGONOCHERUS MIXTUS Haldeman. (Plate LXX, Fig. 9.)

"Head sparsely hairy, black, with an indistinct yellowish spot before the eyes; frontal line impressed; antennæ testaceous, with the tip of the articulations blackish; scutel black; elytra hispid; base, middle, and apex brown; extreme tip and an oblique band before the middle running forward and outward, yellowish, with a few brown dots; extreme base testaceous; feet brown, varied with testaceous; 2½ lines long. Pennsylvania."—(Haldeman.)

MECAS PERGRATA SAY. (Plate LXX, Fig. 10.)

"Body black, covered with short, prostrate hair, which partially conceals the punctures; antennæ nearly as long as the body, annulate with cinereous and black; thorax slightly dilated in the middle; a transverse, arcuated series of four glabrous spots, and a longitudinal, abbreviated, glabrous line behind the middle; scutel whitish; elytra with a narrow white margin and suture; tip entire; thighs dull rufous. Length about nine-twentieths of an inch. Upon the middle of each elytron is a very indistinct rufous line, which is only visible upon close inspection, and is very probably often wanting; a similar spot is upon the anterior portion of the thorax; the white appearance of the margin of the elytra is occasioned by the more dense disposition of the hairs on that part. We captured but a single specimen on the Platte River (Nebraska) near the mountains."—(Say.)

CHRYSOBOTHRIS TRINERVIA (Kirby). (Plate LXX, Fig. 11.)

A rather small, short, broad species, dull blackish, with faint, metallic reflections. Surface of the body, especially the wing-covers, with irregular ridges, the inner one parallel to the inner edge of the wing-cover; wing-covers with smooth elevated areas, between which the surface is minutely pitted with dense golden punctures. Body clothed beneath with short, coarse hairs. Length, 0.45 inch.

BUPRESTIS RUSTICORUM Kirby. (Plate LXX, Fig. 12.)

Body brown, with an olive-green tint. Head and thorax punctured. Each wing-cover with five ridges, four of them well-marked and smooth, the interspaces with scattered punctures. On the head between the eyes are five yellow spots; two simple dots, two long spots on the orbits, sending two projections outward, and a line in front sending three projections upward. Two unequal yellow spots under the eyes. Labrum and labium yellow. Five orange-yellow spots on each side of the end of the abdomen beneath. Length, 0.84 inch.

DICERCA PROLONGATA Le Conte. (Plate LXX, Fig. 13.)

"Coppery gray, often pruinose; width of thorax twice its length, sides well rounded in front, behind somewhat sinuous, punctate, furrowed, each side with an oblique, deeply-impressed line; wing-covers with deeply-impressed lines; apex rounded, the wing-covers scarcely divaricate. Length, 0.77–0.85 inch."—(Le Conte.)

MELANOPHILA DRUMMONDI Kirby. (Plate LXX, Fig. 14.)

Body densely punctured, shagreened; shining, reflecting metallic colors, especially on the prothorax, with three bright yellow spots on the posterior two-thirds of each wing-cover, the anterior spot being the larger. Length, 0.40 inch.

THE GIRDLER, *Oncideres cingulatus* Say. (Fig. 67.)

Although this beetle is not known to inhabit Colorado or the Rocky Mountains, I have thought it well to introduce the following figure received from Prof. I. S. Haldeman, of Chickies, Pa., as illustrating its mode of cutting off hickory branches. Professor Haldeman's account is given at length in the "Guide to the Study of Insects", p. 498.

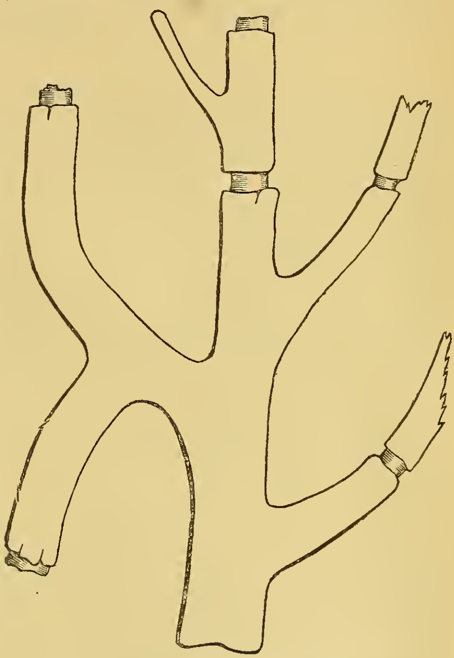


FIG. 67.—Work of the Girdler Beetle.

INSECTS NOT SPECIALLY INJURIOUS.

THE TRANSFORMATIONS OF PLEOTOMUS PALLENS Le Conte.

It is not improbable that this insect in its early stage as a larva is beneficial to vegetation, since so far as known the young of our fire-flies devour worms, other larva, and snails, but the individuals of this species are so rare, that they probably exert but a slight influence for good or evil, agriculturally speaking. I have received three specimens of this larva from Texas through Mr. G. W. Belfrage, on whose authority solely the above determination is given. For a specimen of the male, and of the exceedingly rare female, I am indebted to the kindness of G. D. Smith, esq., of Boston, who loaned them for the purpose of being drawn.

The larva is unsually long and narrow, and much flattened. The prothoracic segment is nearly as wide as long, much rounded in front; this and each following segment reddish, with three yellowish lines, viz, a faint, straight, median one, and two curved lateral ones; these lines on the abdominal segments more diffuse and indistinct. The mandibles are long, sickle-shaped, acute, much curved. The maxillary and labial palpi project considerably beyond the curve of the mandibles. Maxillary palpi long and stout, three-jointed; the two terminal joints long and slender, and of equal length; the terminal third joint projects its entire length beyond the end of the labial palpi. The latter are three-jointed, the third joint very minute. The terminal segment of the body is small, one-half as wide and one-half as long as the preceding joint. The feet are well developed, ending in a single claw. There are nine pairs of spiracles. Length, 0.50 inch.

The Transformations of Donacia proxima Kirby. (Plate LXX, Figs. 17–19.)

None of the species of *Donacia*, so interesting from their living in their early stages in the roots of aquatic plants, have been studied biologically as yet in this country. For the first information we have regarding the transformations of any of our species we are indebted to Mr. W. L. Wilder, of Clinton, Mass., who kindly sent me living specimens of the larva of *Donacia proxima*, found June 23 in the roots of the cow-lily (*Nuphar advena*). Mr. Wilder writes me under date of May 23, 1876: "I send you the life-history of an insect, except the egg, which I hope to add to as soon as I have the mud in which the larva first appears. As you open the inclosed box, if all is right, you will find the perfect insect, which I hope will remain alive; 2d, you will find a capsule-like body attached to a bit of lily-root; examine it by transmitted light, and you will see the perfect insect ready to emerge. You will next come to another capsule, in which a white maggot has inclosed itself while in my possession; and at the bottom of the box is a ball of mud inclosing a maggot, which has hatched out in the mud within a few days."

Afterward he writes, June 19: "I have not been able to find the eggs, but think I have found their place of deposit in small cavities in the large fleshy roots of the yellow lily, into which the larva burrows, and in which it feeds, excavating large chambers after it emerges, and almost invariably fixes itself on the tender rootlets beneath, where it covers itself with its cocoon and remains until mature. I have found the larvæ in the root and with no outlet but the small puncture where the eggs were deposited. I could have sent you hundreds of the pupæ just ready to emerge."

Afterward the cocoons containing the beetles were found October 24, 1876, attached to the roots of the cow-lily (*Nuphar advena*), in a pond at Salem, Mass., and presented by Mr. S. B. Buttrick to the museum of the Peabody Academy of Science, so that we probably have nearly the entire history of the insect. The females probably winter over in the dense, tough, parchment-like brown oval cocoons (Plate LXX, Fig. 17, natural size), and in the spring lay their eggs in such a position that the larvæ on hatching bore into the roots of the lily; the larvæ, becoming fully developed by the end of June, transform into chrysalides, previously spinning a cocoon much like that of the saw-flies, and assuming the beetle condition in the autumn.

The body of the larva (Plate LXX, Fig. 18, enlarged, seen from beneath) is white, thick, fleshy, cylindrical. The head is small, reddish, one-third as wide as the segment behind it; it is thick, and about as long as broad. The antennæ are short, conical, three-jointed; the maxillary palpi are short, projecting but slightly beyond the ends of the labial palpi; they are three-jointed; the first but slightly shorter than the second; third but half as wide and half as long as second. Labial palpi minute, consisting of but a single joint, while the labium itself is large and fleshy. Three pairs of well-developed legs, which are two-jointed, ending in a single stout claw. The end of the body is suddenly somewhat flattened and bent over onto the ventral side, and is armed above with two parallel, flat, blade-like chitinous appendages, a little curved and appressed to, though free from, the surface on which they rest, reaching to the tip of the body, and curved slightly backward. The segments of the body are quite convex, the sutures deeply impressed, and the exposed parts of the body are covered with fine hairs. The prothoracic segment is slightly reddish, pale brown posteriorly. Length of the body when curved, 0.56 inch; thickness, 0.20 inch.

DERMESTES MARMORATUS Say. (Plate LXX, Fig. 15.)

This is the common larder-beetle of Colorado and other Western Territories, and is noticed here as likely to be annoying in museums, and as a nuisance in pantries and kitchens.

"Antennæ reddish-brown; thorax indented before the scutel; pectus blackish; postpectus and coxæ with dense white hair; feet blackish; intermediate and posterior thighs with a white band before; spot on the lateral basal margin of the elytra large, angular; venter with dense white hair; anal segment and lateral spots black-brown. Length from three-tenths to nine-twentieths of an inch. This insect is of frequent occurrence is Missouri and Arkansas, and is a large species."—(Say.)

THE CALIFORNIAN LAPPER MOTH, *Gastropacha californica* Pack.

This and the following moth are somewhat annoying insects in California, feeding upon the oak, and at my request Mr. Henry Edwards has furnished me with the following account of them:

"The moth lays its eggs in June, and they must remain unhatched until the following spring. Just when the young shoots of the oaks (*Quercus agrifolia* Nee) begin to appear, the larvæ make their appearance also, spinning thin and irregular webs over the branches of the trees. In these webs they house mostly during the heat of the day, but sally forth in the evening and at night for food. In this way they will soon strip a tree of its leaves, though it is well to say that the oaks do not seem to be permanently affected, as they soon send forth fresh shoots, and toward the time that the caterpillars undergo their change to the chrysalis they are green and gay again. The larvæ retain the shelter of their web until after the third month, when they wander away singly, are found everywhere, becoming sometimes a complete nuisance in gardens and fields. They feed in their more mature stages upon many plants besides the oak, eating with avidity willows, ash, *Æsculus californica*, *Photinia arbutifolia*, *Arbutus menziesii*, as well as apple and pear trees. Toward the end of May they spin their cocoons, seeming to have no choice of locality, but fixing themselves wherever they may chance to be, either on walls, palings, trunks or branches of trees, stems of grapes, or among the leaves of herbaceous plants. The time in the chrysalis state is about eighteen to twenty-one days, so that the moths emerge and are in the greatest abundance about the middle of June. They come very readily to light, and are a pest to the entomologist in his nocturnal rambles. I regret that I cannot now send you descriptions of the larva and chrysalis. Mr. Stretch has them prepared for his forthcoming book on our *Bombycidæ*, and I am sure he will forward them to you. I will write and ask him to do so. I can send you the perfect insects if they are of value to you."

PHRYGANIDEA CALIFORNICA. (Plate LXX, Fig. 22, male.)

The following account has been furnished by Mr. H. Edwards:

"This insect is also very destructive to our young oaks, the caterpillars, which are perfectly naked and with the head almost monstrous in size, making their appearance about the same time as those of *Gastropacha.* They are restless little creatures, wandering incessantly over the trees, and feeding very rapidly. They spin no cocoon, but hang by the tail, like the larva of *Vanessa*, etc. The change to the chrysalis is undergone in April and May, and the moths appear in about fifteen or sixteen days. There is a second brood of these insects, the imagos of the latter appearing in September and October. Indeed, fresh specimens are now upon the wing, though the second brood is by no means so abundant as the first. I have observed that *Phryganidea* and *Gastropacha* never associate upon the same tree, and I think that the former has always the mastery. This is perhaps owing to some excretion from its body which is unpleasant to the *Gastropacha;* but of course I do not speak with certainty as to this fact. It is, however, sure that they are never found in large quantities on the same tree. I am inclined to think that *Phryganidea* is more destructive to the oaks than the other species, as it feeds solely upon *Quercus*, while the other, as I have said, is not so particular in the choice of its food. I inclose my published description of the egg of *Phryganidea.* I quote Mr. Edwards's description of the egg and larva:

"The egg is spherical, a little flattened above, shining, yellowish-white at exclusion, attached in clusters of about ten or twelve to the upper side of the leaves. The third day the apex of the egg assumes a dull orange hue, afterward changing to a bright reddish-purple and gradually to a duller shade as the young larvæ emerge. The eggs were laid by a female in my possession on July 5. In the young larva the head is very large, almost monstrous, pale olive-brown, with a narrow black line at base; body pale canary-yellow, with four rows of black spots arranged longitudinally in lines.

"The mature form of the larva is noticed in Stretch's '*Zygaenidæ* and *Bombycidæ* of North America,' but I subjoin the description of one of the many varieties to which it is subject, believing that all information with reference to this species (the position of which in classification has not yet been settled by entomologists) will prove to be of value: Yellowish-white, shining, head large, round, stone color, with a black point on each side of the mouth; a median stripe of reddish-brown and a narrow one of the same color on each side. A broad black stripe extends laterally across the second segment at base of the head and another across the thirteenth segment, which also contains a broken black dorsal line. In the middle of the black lateral stripe is a waved whitish line, inclosing a narrow black one. At the base of the abdominal legs is a waved interrupted yellow line, edged narrowly with black; under side yellowish-white, faintly marked with broken brown waved lines; feet pinkish, striped with black; abdominal legs yellowish-white."

Mr. Behrens, of San Francisco, writes me that three generations of the *Phryganidea* appear in a year. "In 1875 it, with the larva of the *Gastropacha californica*, ate our evergreen oaks to broomsticks. You could hear the caterpillars eat and their manure drop, the latter covering everything; it could be swept together by the bushelful. In the wake of both followed ichneumon parasites."

EXPLANATION OF PLATE LXII.

FIG. 1. Rocky Mountain locust.—*a*, *a*, *a*, female in different positions, ovipositing; *b*, egg-pod extracted from the ground, with the end broken open, showing how the eggs are arranged; *c*, a few eggs lying loose on the ground; *d*, *e* show the earth partially removed to illustrate an egg-mass already in place and one being placed; *f* shows where such a mass has been covered up.—After Riley.

FIG. 2. Rocky Mountain locust.—Front and side view of the embryo surrounded by the inner embryonal membrane or amnion. Original: drawn by J. H. Emerton.

FIG. 3. Rocky Mountain locust.—*a*, *a*, newly-hatched larvæ; *b*, full-grown larvæ; *c*, pupa.—After Riley.

FIG. 4. Rocky Mountain locust.—Process of acquiring wings; *a*, pupa with skin just split on the back; *b*, the adult extruding; *c*, the same nearly out; *d*, the same with wings expanded; *e*, the same with all the parts perfect.—After Riley.

FIG. 5. *a*, Rocky Mountain locust; *b*, the common red-legged locust.—After Riley.

FIG. 6. Rocky Mountain locust.—Terminal abdominal ring; *a*, side view; *b*, *c*, hind and top view of the same.—After Riley.

FIG. 7. Red-legged locust.—Lettering and explanations the same as in Fig. 6.—After Riley.

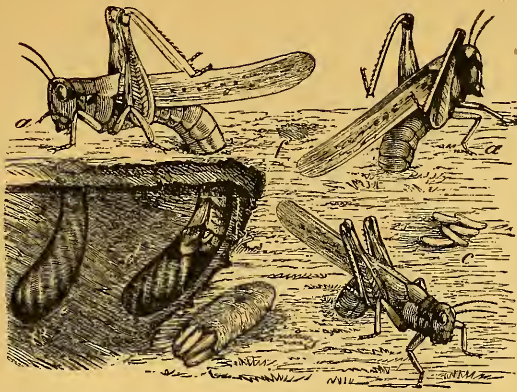


Fig. 1.

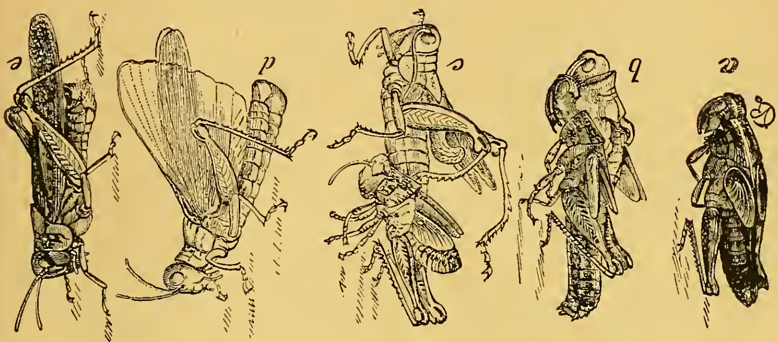


Fig. 4.

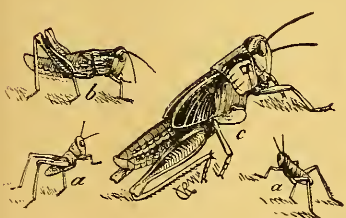


Fig. 3.

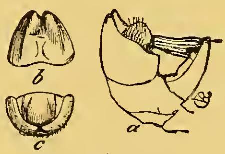


Fig. 6.

Fig. 7

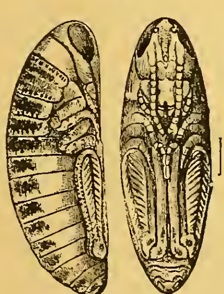


Fig. 2.

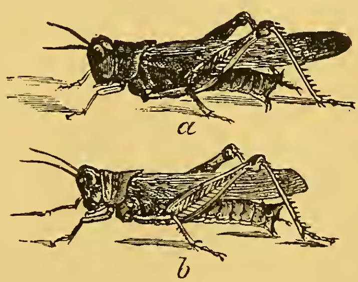


Fig. 5.

The Rocky Mountain Locust and its Young.

EXPLANATION OF PLATE LXIII.

FIG. 1. Larva of *Harpalus*, feeding on eggs of locust; enlarged. (Emerton del.)

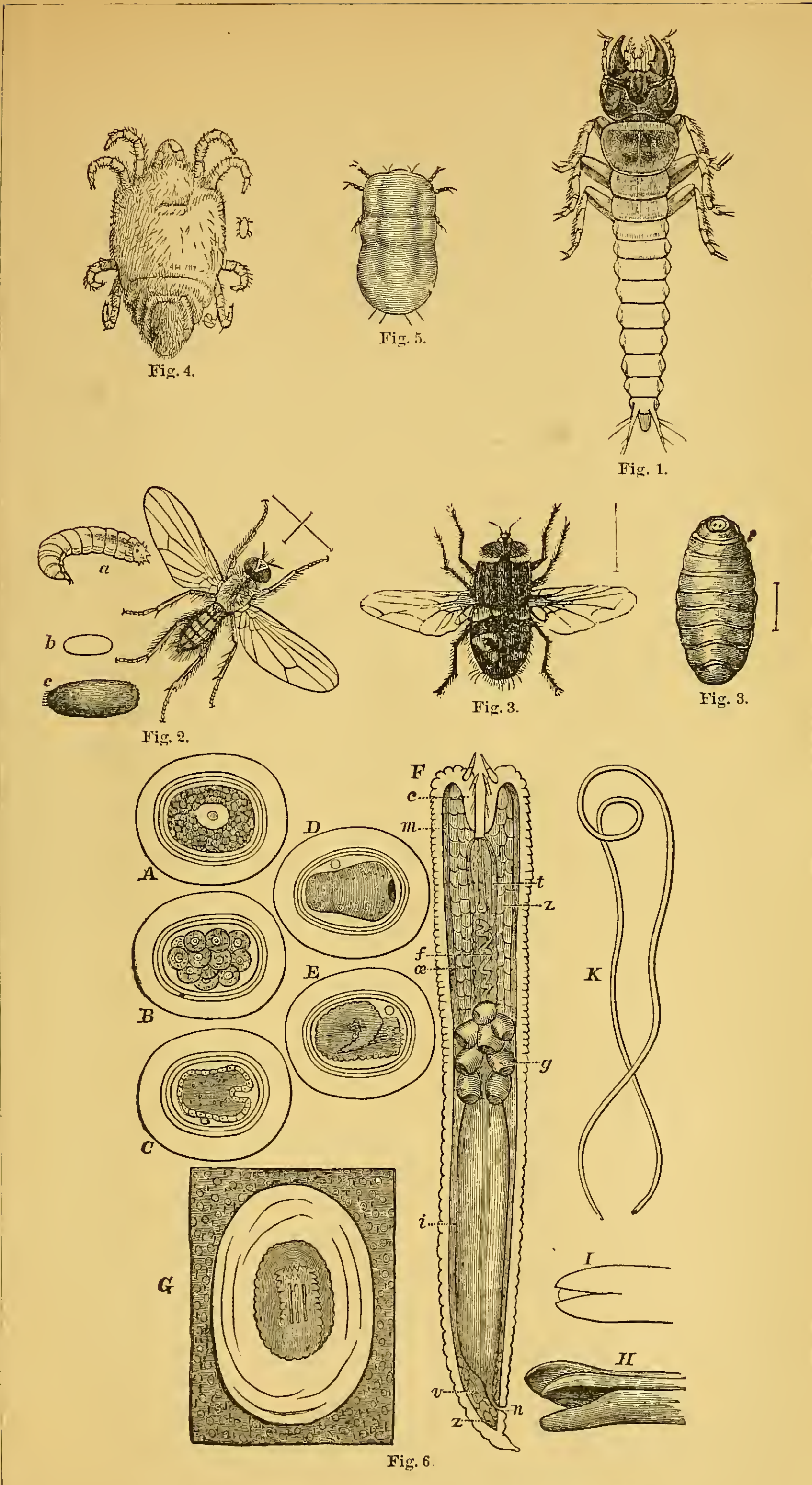
FIG. 2. Larva of *Anthomyia radicum*, var. *Calopteni* Riley, feeding on eggs of locust. *a*, larva, enlarged twice; *b*, pupa-case, natural size; *c*, the same magnified twice. The cross-lines represent the length of body and expanse of wing of the fly, which is magnified three times.—(After Curtis.)

FIG. 3. Red-tailed Tachina fly (after Riley). *a*, a larva of Tachina which preys on the European cabbage-butterfly, introduced to illustrate the maggot of Tachina.

FIG. 4. *Trombidium sericeum* Say, natural size and magnified.

FIG. 5. The Red mite, young of a species of *Trombidium* (*Astoma gryllaria* Le Baron); enlarged.

FIG. 6. *Gordius aquaticus*. A, egg; B, egg undergoing segmentation of the yolk; C, embryo (gastrula) with the primitive stomach an infold of the outer germinal layer of cells (ectoderm); D, embryo farther advanced; E, larva, with the three circles of spines retracted within the œsophagus; F, the same stage greatly enlarged to show the internal organs; *c*, middle circle of spines, the head being retracted; *m*, muscular layer (?); *t*, beak or proboscis; *i*, intestine; *z*, *z*, embryonal cells; *f*, excretory tube leading from *g*, the secretory glands; *œ*, œsophagus; *v*, rectum; *n*, anus. G, the second larva, encysted in a fish—(after Villot). H, *Gordius varius*, end of body of male, much enlarged. I, *Gordius aquaticus*, end of body of male, much enlarged. K, *Gordius aquaticus*, natural size. (H, I, K, drawn from nature by J. S. Kingsley.)



Parasites and Enemies of the Rocky Mountain Locust.

EXPLANATION OF PLATE LXIV.

FIG. 1. Larva of *Sarcophaga carnaria*, enlarged.
FIG. 2. Pupa-case of the same, enlarged.
FIG. 3. Adult of the same, enlarged. (Figs. 1–3, Emerton del.)
FIG. 4, Red-legged locust, engaged in laying its eggs; to the right, a hole containing an egg-mass, natural size.
FIG. 5. *Œdipoda* (*Camnula*) *pellucida* (*atrox*), Emerton del.
FIG. 6. *Acrydium americanum*, natural size, (after Riley).

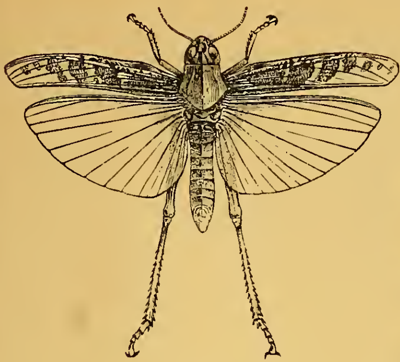


Fig. 5.

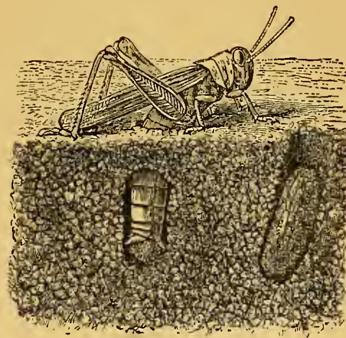


Fig. 4.

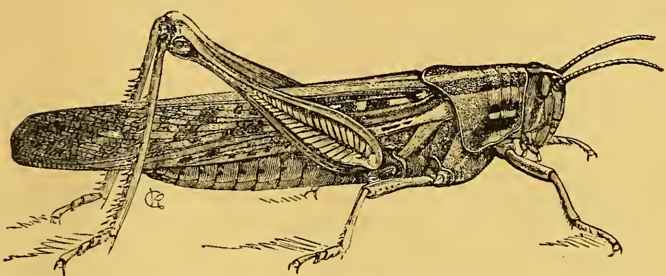


Fig. 6.

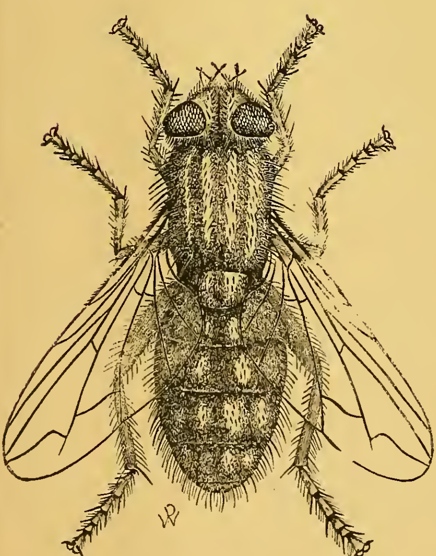


Fig 3.

Fig. 1.

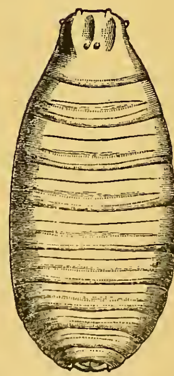


Fig. 2.

Destructive Locusts and the Flesh-Fly.

EXPLANATION OF PLATE LXV.

FIG. 1. Hessian Fly, *Cecidomyia destructor*.—*a*, larva; *b*, pupa; *c*, stalk of wheat, with three cavities containing the larvæ, their heads toward the ground.—(After Fitch.)

FIG. 2. *Agrotis suffusa* Denis and Schiffermüller, and Caterpillar or Cut-Worm.—(After Riley.)

FIG. 3. *Agrotis subgothica*.—(After Riley.)

FIG. 4. *Celæna renigera* Stephens, and Caterpillar.—(After Riley.) A Cut-Worm feeding on the roots of different flowers in gardens.

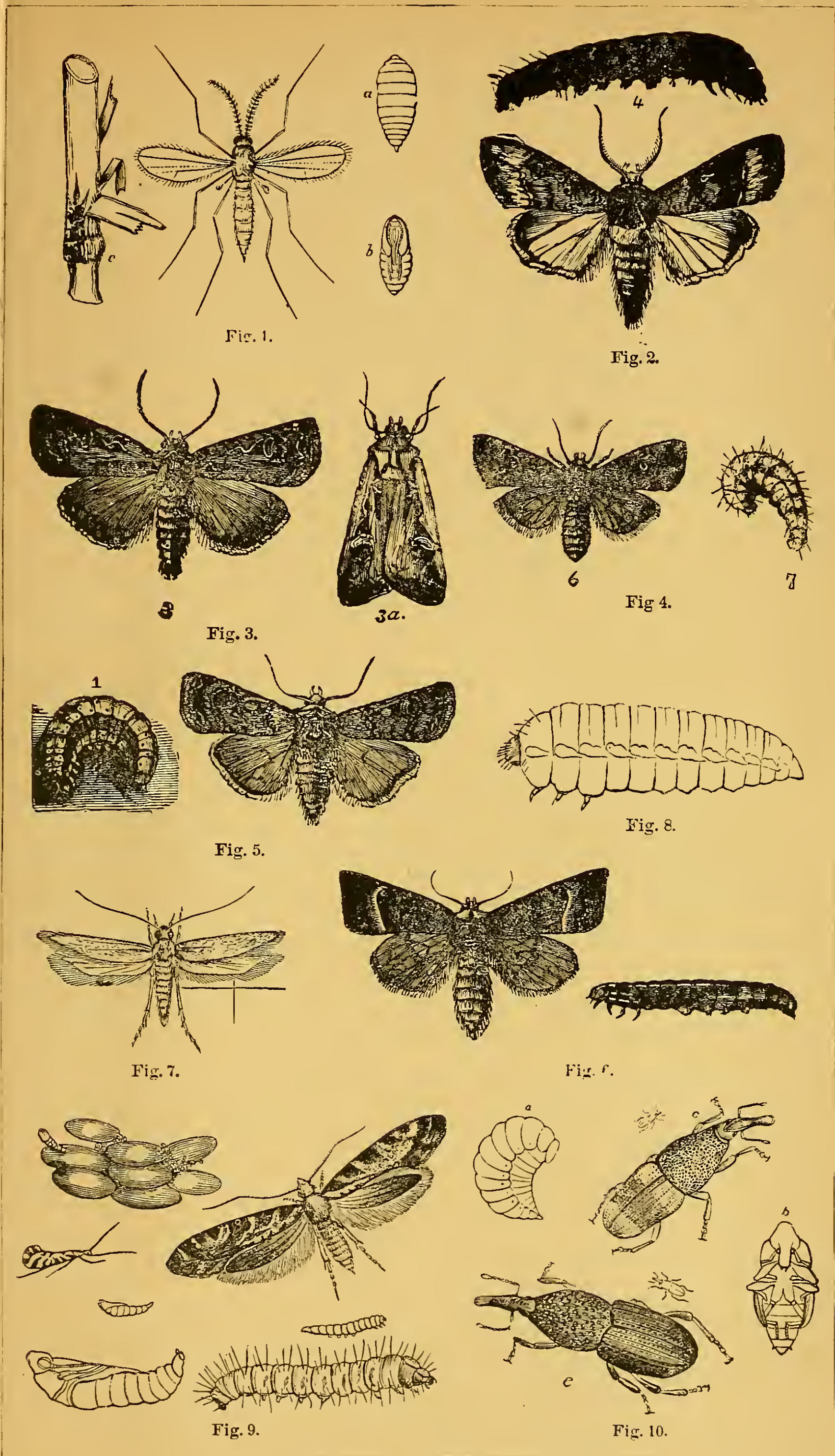
FIG. 5. *Agrotis cochrani* Riley, and Cut-Worm.—(After Riley.)

FIG. 6. *Gortyna nitela* Guenée, and Larva.—(After Riley.)

FIG. 7. Angoumois Moth, and FIG. 8, its Larva.—(From Guide to Study of Insects.)

FIG. 9. Wheat Tinea, and its larva and chrysalis, natural size and enlarged, with the grains of wheat tied together with silk threads.—(After Curtis.)

FIG. 10. *a*, larva; *b*, pupa; *c*, beetle of *Sitophilus oryzæ* (Linn.), Rice-Weevil; *e*, *Sitophilus granarius* (Linn.), Grain-Weevil.—(After Curtis.)



Insects injuring Wheat and Corn.

EXPLANATION OF PLATE LXVI.

FIG. 1. The Colorado Potato-Beetle (*Doryphora 10-lineata*).—*a*, *a*, eggs; *b*, *b*, *b*, larva in three stages; *c*, pupa or chrysalis; *d*, *d*, beetle; *e*, a wing-cover, enlarged twice.—(After Riley.)

FIG. 2. *Doryphora juncta*.—*a*, *a*, eggs; *b*, *b*, grub or larva; *c*, beetle; *d*, wing-cover, enlarged, showing two of the black stripes joined together.—(After Riley.)

FIG. 3. The Potato Systena (*S. mitis* Lec.), Kingsley del.

FIG. 4. *Lema trilineata*, Eastern Potato-Beetle.

FIG. 5. *Lema trilineata*.—*a*, *a*, small and mature larva; *b*, end of body of larva; *c*, pupa; *d*, eggs.—(After Riley.)

FIG. 6. *a*, *Macrobasis cinerea* (Fabr.).—*d*, male and female antenna, enlarged.—(After Riley.)

FIG. 7. *b*, *Macrobasis murina* (Lec.).—*c*, male and female antennae, enlarged.—(After Riley.)

FIG. 8. *Epicauta marginata* (Fabr.).—Blister-Beetle.

FIG. 9. *Epicauta vittata* (Fabr.).—Blister-Beetle.

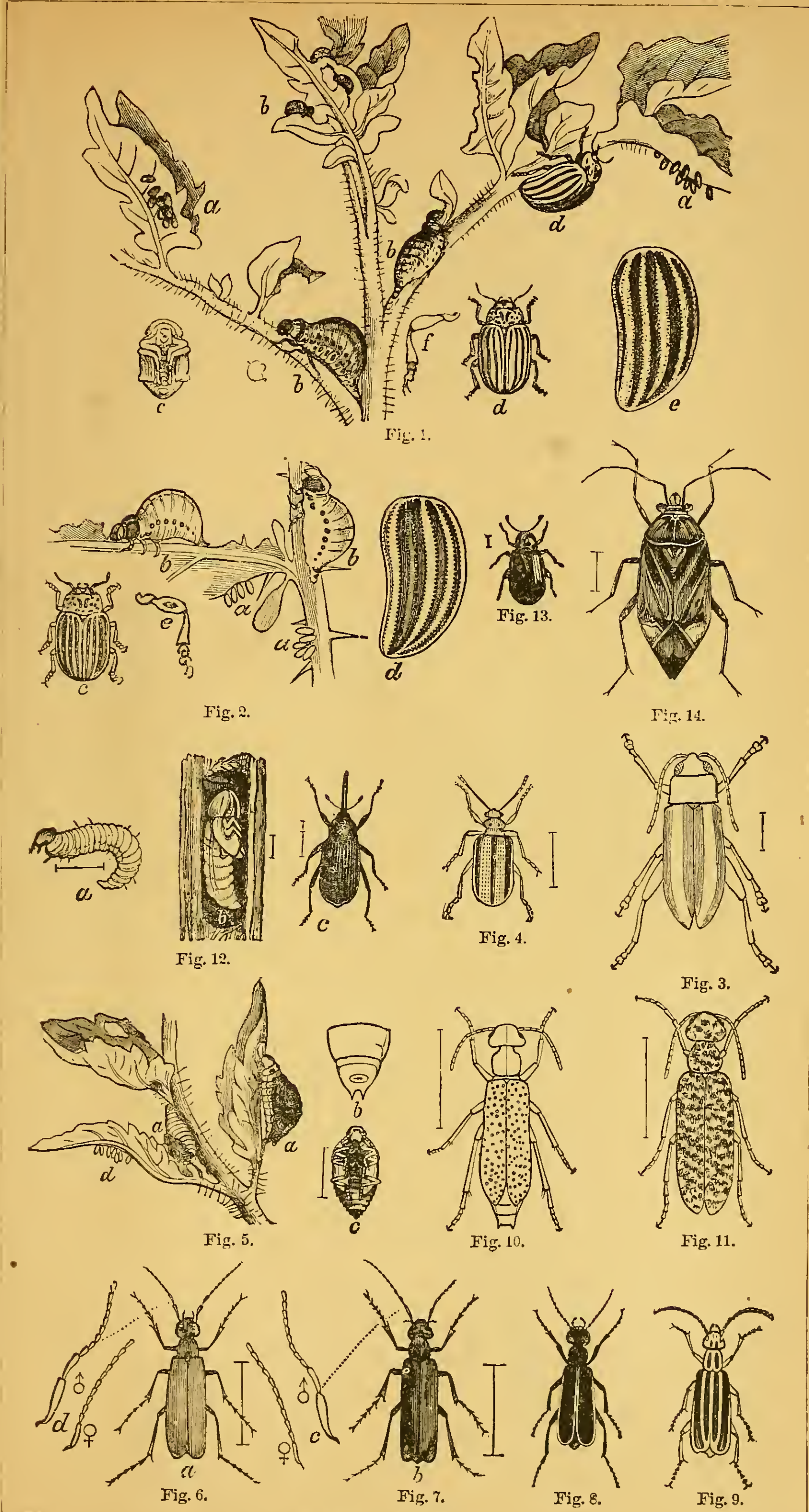
FIG. 10. *Epicauta maculata* (Say).—Blister-Beetle. (Kingsley del.)

FIG. 11. *Epicauta pardalis* (Lec.).—Blister-Beetle. (Kingsley del.)

FIG. 12. Potato-Stalk Weevil (*Baridius trinotatus* Say).—*a*, larva; *b*, pupa.—(After Riley.)

FIG. 13. Flea-beetle, *Epitrix cucumeris* (Harris).—(From Harris.)

FIG. 14. *Lygus lineolaris* Beauv.—(After Riley.)



Insects injuring the Potato.

EXPLANATION OF PLATE LXVII.

FIG. 1. *Anthomyia ceparum*, Onion Maggot and Fly.
FIG. 2. *Ortalis flexa* Wied., Southern Onion-Worm.
FIG. 3. *Limothrips tritici* Fitch. Female.
FIG. 4. *a*, Male; *b*, larva.
FIG. 5. End of antenna of male *Limothrips tritici*, Onion-Thrips.

Fig. 2.

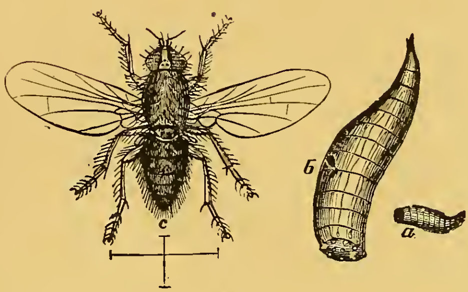


Fig. 1.

Fig. 3.

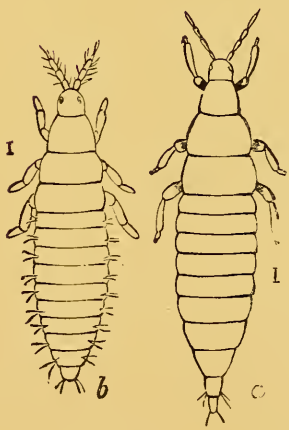


Fig. 4.

Fig. 5.

Insects injurious to the Onion.

EXPLANATION OF PLATE LXVIII.

FIG. 1. Grape Phylloxera.—*a*, shows a healthy root; *b*, one in which the lice are working, representing the knots and swellings caused by their punctures; *c*, a root that has been deserted by them, and where the rootlets have commenced to decay; *d, d, d*, shows how the lice are found on the larger roots; *e*, female pupa, dorsal view; *f*, the same, ventral view; *g*, winged female, dorsal view; *h*, same, ventral view; *i*, magnified antenna of winged insect; *j*, side view of the wingless female laying eggs on roots; *k*, shows how the punctures of the lice cause the larger roots to decay.—(After Riley.)

FIG. 2. Sexual Phylloxeræ.—*a*, female *vastatrix*, ventral view, showing the egg through the transparent skin of the body; *b*, dorsal view of the same; *c*, tarsus, greatly enlarged; *d*, shrunken anal joints as they appear after oviposition; *e*, male *caryæcaulis*, dorsal view; the dot in the circles indicates the natural size of the insect.—(After Riley.)

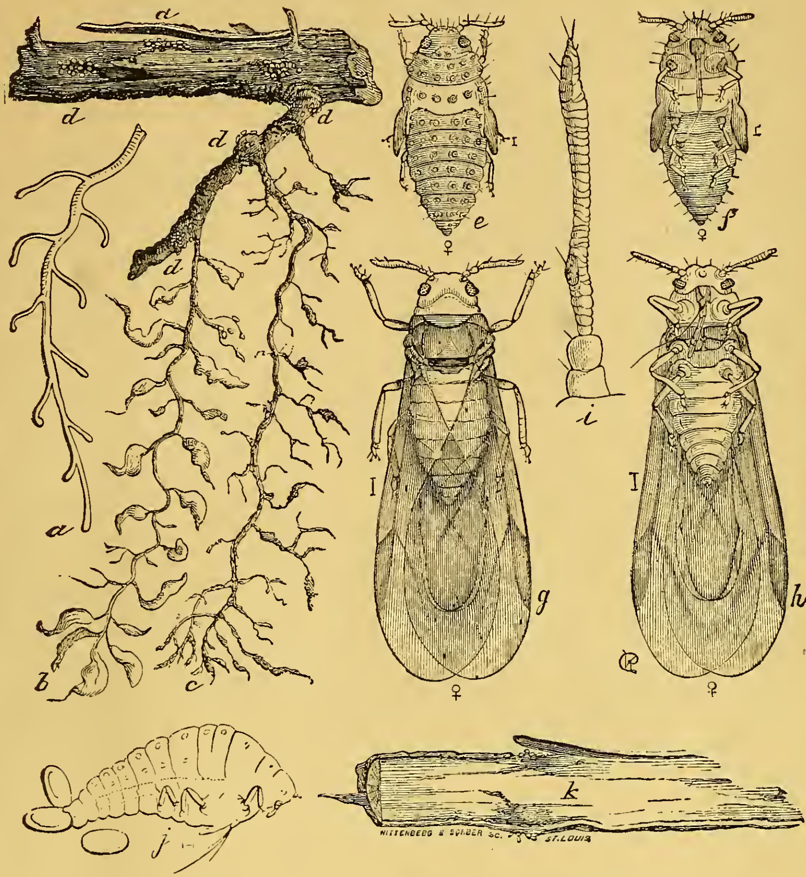


Fig. 1.

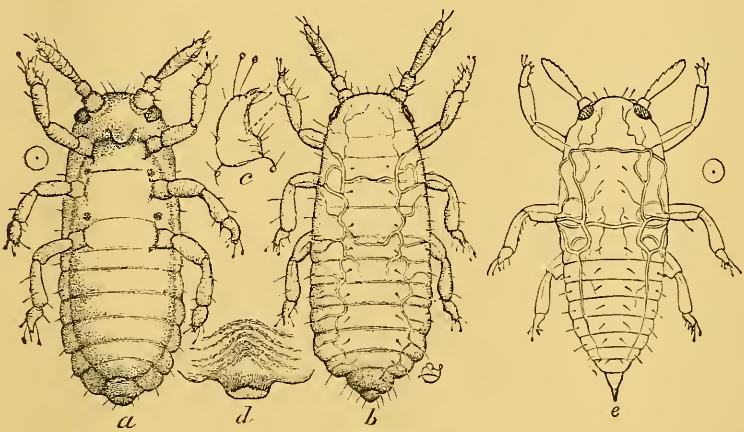


Fig. 2.

The Grape Phylloxera.

EXPLANATION OF PLATE LXIX.

FIG. 1. *Anisopteryx vernata* Peck. Canker-Worm.—*a*, caterpillar; *b*, a mass of eggs natural size, and one much enlarged; *c*, lateral, *d*, dorsal view of a segment enlarged.—(After Riley.)

FIG. 2. *Anisopteryx vernata* Peck.—*a*, male, *b*, female; *c*, three antennal joints; *d*, an abdominal segment showing the two rows of spines not present in the female of *A. autumnata*; *e*, ovipositor.—(After Riley.)

FIG. 3. *Anisopteryx autumnata* (*A. pometaria* of Morrison & Mann).—*a*, *b*, *e*, egg; *c*, *d*, *f*, caterpillar; *g*, *h*, female chrysalis.—(After Riley.)

FIG. 4. *Anisopteryx autumnata*.—*a*, male; *b*, female; *c*, portion of antenna enlarged; *d*, a female abdominal segment, dorsal view, enlarged.—(After Riley.)

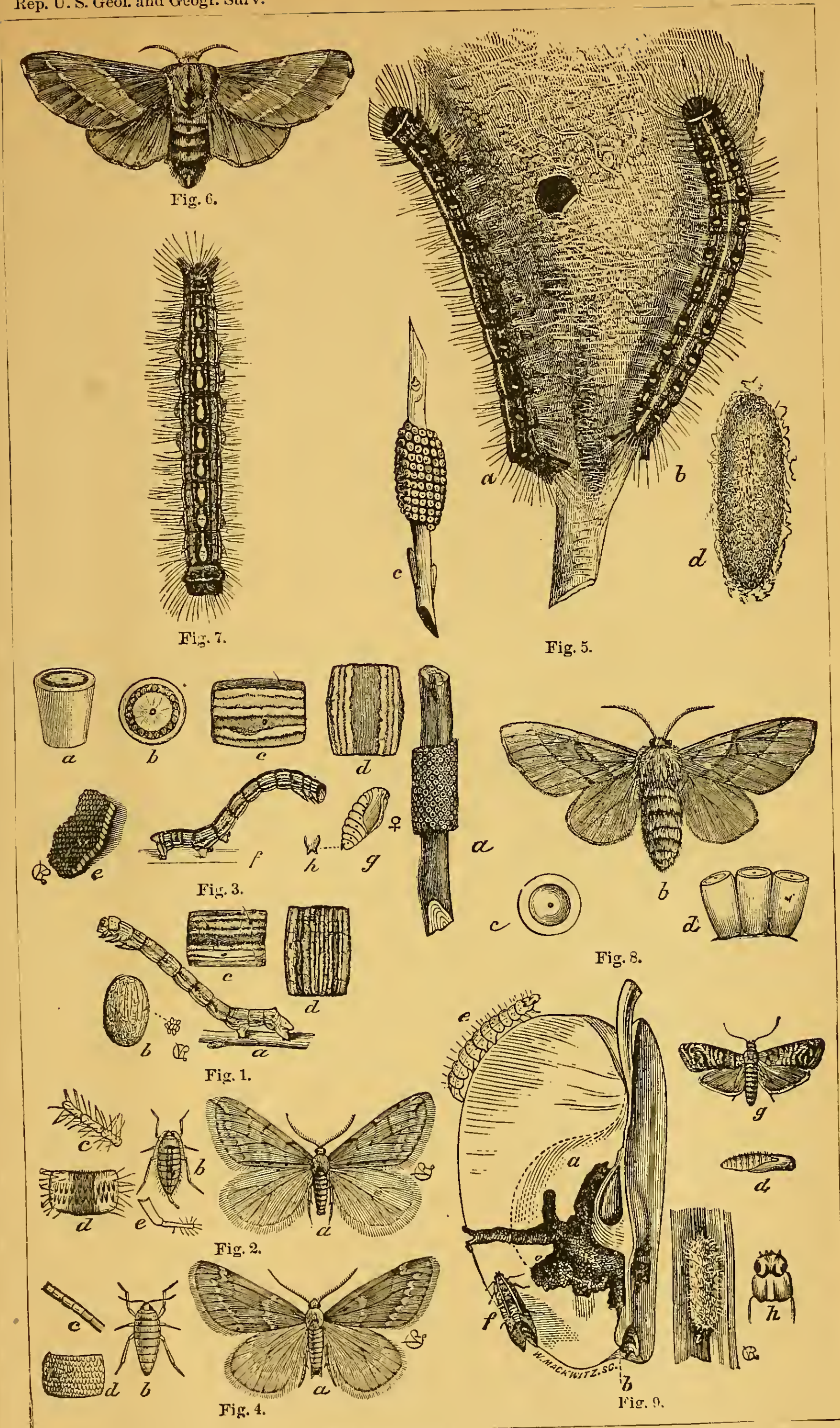
FIG. 5. *Clisiocampa americana*.—*a*, *b*, American Tent-Caterpillar; *c*. eggs; *d*, cocoon.—(After Riley.)

FIG. 6. Female moth of American Tent-Caterpillar.—(After Riley.)

FIG. 7. Caterpillar of *Clisiocampa disstria* Hübner.—(After Riley.)

FIG. 8. *b*, Female *Clisiocampa disstria*; *a*, *c*, *d*, eggs.—(After Riley.)

FIG. 9.—Coddling moth, *Carpocapsa pomonella* Linn.—*a*, apple injured by the caterpillar *e*, which hatches from an egg laid at the point *b*; *d*, chrysalis; *h*, head and next segment of the larva; *f*, *g*, moth; *i*, the cocoon.—(After Riley.)

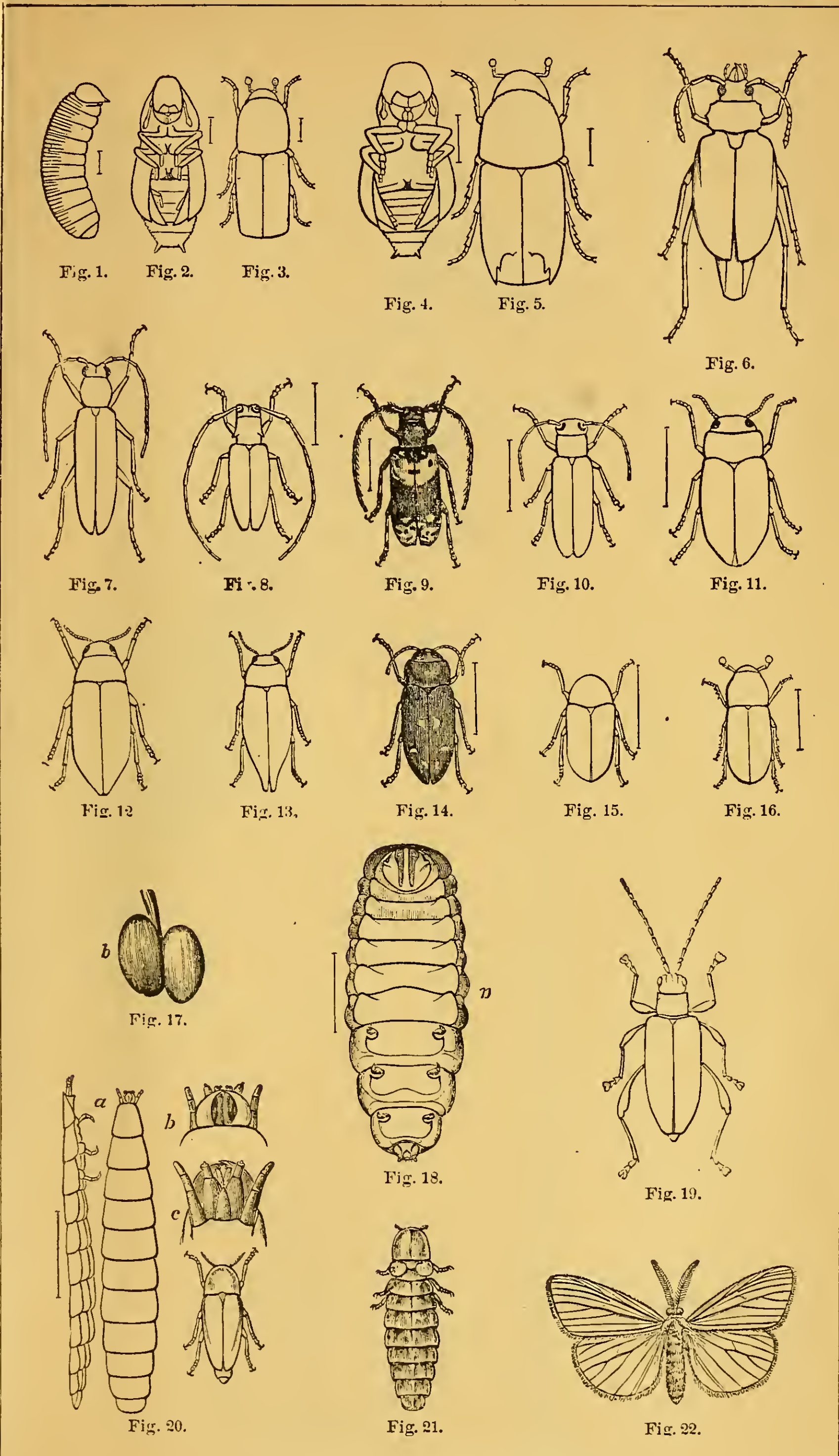


Insects injurious to the Apple.

EXPLANATION OF PLATE LXX.

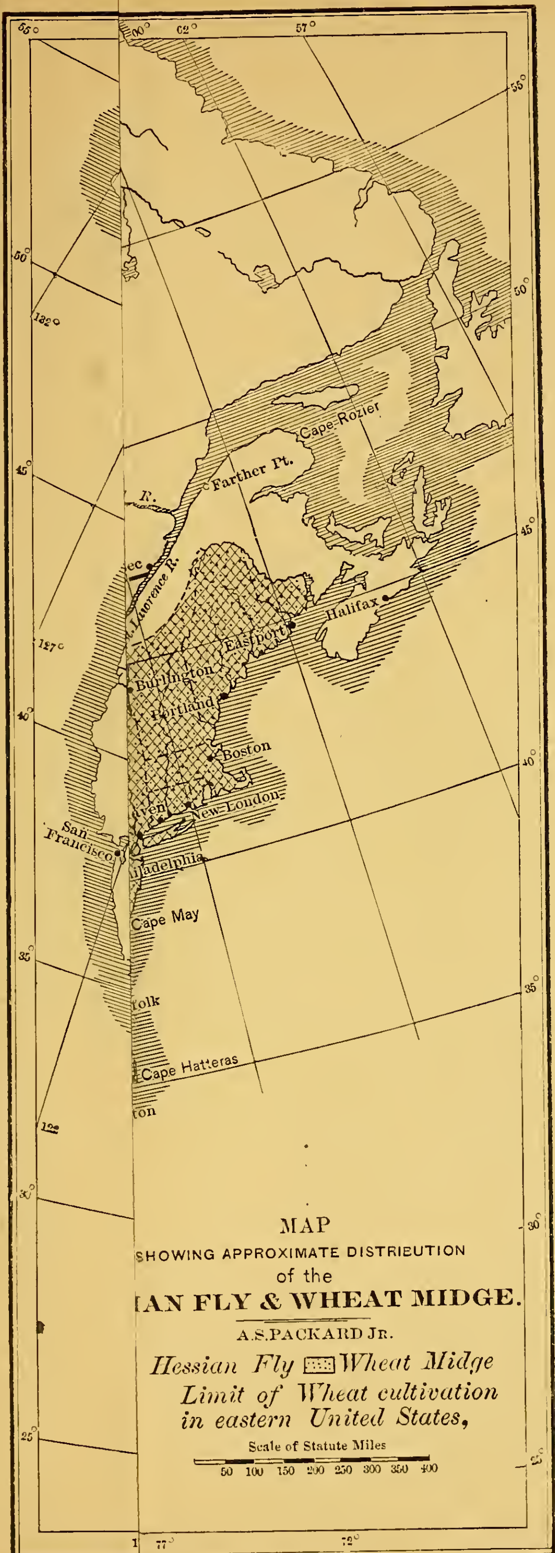
FIG. 1. Larva of *Dryocœtes affaber* Mannh.
FIG. 2. Pupa of the same.
FIG. 3. Adult of the same.
FIG. 4. Pupa of *Tomicus pini* Say.
FIG. 5. Adult of *Tomicus pini.*
FIG. 6. *Prionus emarginatus* Say.
FIG. 7. *Criocephalus productus* Le Conte.
FIG. 8. *Dectes spinosus* (Say).
FIG. 9. *Pogonocherus mixtus* Haldeman.
FIG. 10. *Mecas pergrata* Say.
FIG. 11. *Chrysobothris trinervia* (Kirby).
FIG. 12. *Buprestis rusticorum* Kirby.
FIG. 13. *Dicerca prolongata* Le Conte.
FIG. 14. *Melanophila drummondi* Kirby.
FIG. 15. *Dermestes marmoratus* Say.
FIG. 16. *Dendroctonus obesus* Mannh.
FIG. 17. Cocoon of *Donacia proxima.*
FIG. 18. Larva of *Donacia proxima.*
FIG. 19. Adult (enlarged twice) of *Donacia proxima* Kirby.
FIG. 20. *Pleotomus pallens* Le Conte, male.—*a*, dorsal and side view of the larva; *b*, dorsal, and *c*, ventral view of the mouth-parts.
FIG. 21. Female of *Pleotomus pallens.*
FIG. 22. *Phryganidia californica* Pack.; male.

NOTE.—Figs. 1–16 and 20 were drawn by Mr. J. S. Kingsley, and Figs. 17–19, 21, and 22 were drawn by Mr. J. H. Emerton.



Insects injurious to Western Forest Trees.

1

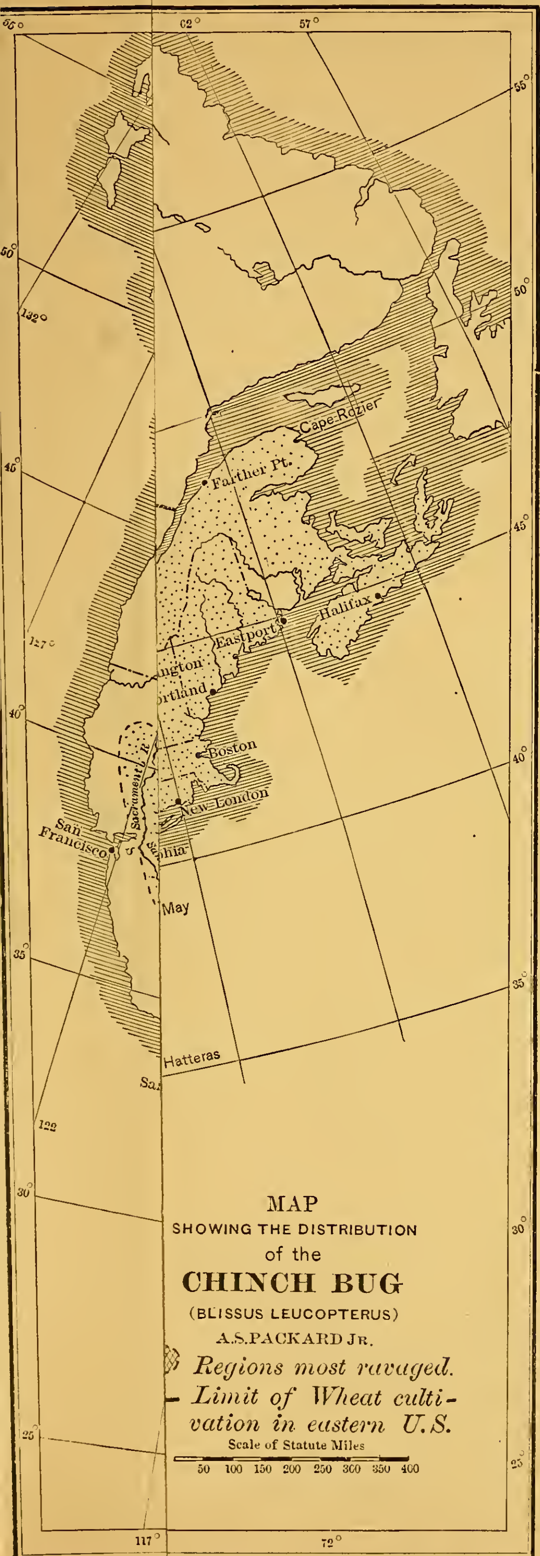


MAP
SHOWING APPROXIMATE DISTRIBUTION
of the
IAN FLY & WHEAT MIDGE.
A.S.PACKARD Jr.
Hessian Fly
Wheat Midge
Limit of Wheat cultivation in eastern United States,
Scale of Statute Miles
50 100 150 200 250 300 350 400
Cape Rozier
Farther Pt.
Halifax
Eastport
Burlington
Portland
Boston
New London
San Francisco
Cape May
Cape Hatteras


HUDSON BAY
LAKE SUPERIOR
Ft Garry
Bismarck
Missouri River
Duluth
Marquette
Quebec
Montreal
Kingston
Toronto
Halifax
Milwaukee
Dubuque
Detroit
Omaha
Cheyenne
Denver
Salt Lake
Cape May
Memphis
Atlanta
Augusta
Savannah
Jackson
Montgomery
MAP
HESSIAN FLY & WHEAT MIDGE.
Limit of Wheat cultivation
in eastern United States.

2

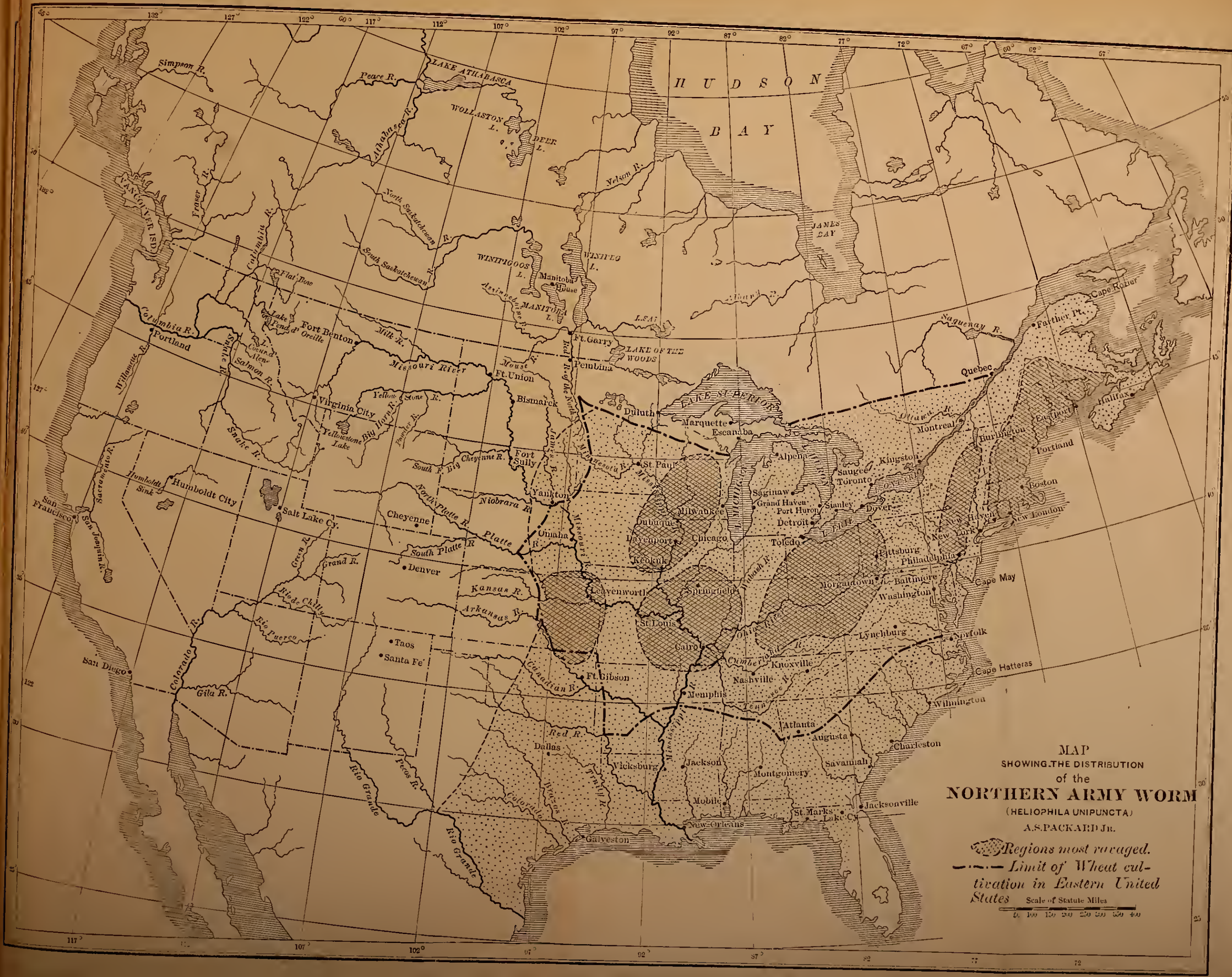
Ann. Rep



Russell & Struthers.N.Y.

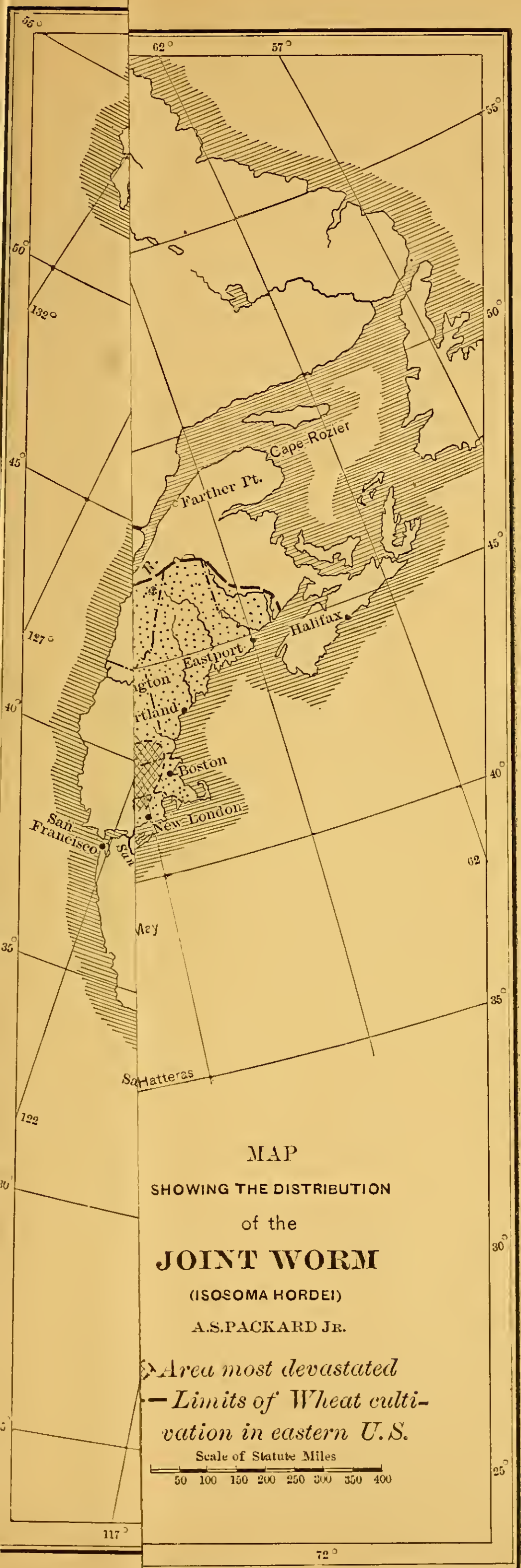

MAP
SHOWING THE DISTRIBUTION
of the
CHINCH BUG
(BLISSUS LEUCOPTERUS)
A.S.PACKARD JR.
Regions most ravaged.
Limit of Wheat cultivation in eastern U.S.
Scale of Statute Miles
50 100 150 200 250 300 350 400
HUDSON BAY
JAMES BAY
LAKE ATHABASCA
WOLLASTON L.
DEER L.
WINIPEG L.
WINIPIGOOS L.
MANITOBA L.
LAKE OF THE WOODS
LAKE SUPERIOR
Russell & Struthers, N.Y.


Cape Rozier
Farther Pt.
Halifax
Eastport
Portland
Boston
New London
San Francisco
MAP
HOWING THE DISTRIBUTION
of the
HERN ARMY WORM
(HELIOPHILA UNIPUNCTA)
A.S.PACKARD JR.
Regions most ravaged.
Limit of Wheat cul-
ion in Eastern United
Scale of Statute Miles
50 100 150 200 250 300 350 400


MAP
SHOWING THE DISTRIBUTION
of the
NORTHERN ARMY WORM
(HELIOPHILA UNIPUNCTA)
A.S.PACKARD JR.
Regions most ravaged.
Limit of Wheat cultivation in Eastern United States
Scale of Statute Miles
HUDSON BAY
JAMES BAY
LAKE ATHABASCA
LAKE SUPERIOR
LAKE OF THE WOODS
Missouri River
Columbia R.
Rio Grande
Portland
San Francisco
San Diego
Salt Lake Cy.
Denver
Cheyenne
Omaha
Chicago
St. Louis
Memphis
New Orleans
Galveston
Quebec
Montreal
Boston
New York
Philadelphia
Baltimore
Washington
Cape Hatteras
Charleston
Jacksonville


Cape Rozier
Farther Pt.
Halifax
Eastport
lington
Portland
Boston
New London
San Francisco
e May
pe Hatteras
MAP
SHOWING THE DISTRIBUTION
of the
TTON ARMY WORM,
(ALETIA ARGILLACEA)
and
BOLL WORM.
(HELIOTHIS ARMIGERA)
A.S.PACKARD JR.
ll Worm
Cotton Army Worm
Scale of Statute Miles
50 100 150 200 250 300 350 400 450
Limits of Cotton cultivation


MAP
SHOWING THE DISTRIBUTION
of the
COTTON ARMY WORM,
(ALETIA ARGILLACEA)
and
BOLL WORM.
(HELIOTHIS ARMIGERA)
A S PACKARD JR.
Boll Worm
Cotton Army Worm
Limits of Cotton cultivation
HUDSON BAY
JAMES BAY
LAKE ATHABASCA
WOLLASTON L.
DEER L.
WINIPIGOOS L.
WINIPEG L.
MANITOBA L.
LAKE OF THE WOODS
LAKE SUPERIOR
L. MICHIGAN
L. HURON
L. ERIE
L. ONTARIO
VANCOUVER ISL.
Simpson R.
Peace R.
Athabasca R.
Nelson R.
North Saskatchewan R.
South Saskatchewan R.
Albany R.
Saguenay R.
Columbia R.
Fraser R.
Missouri River
Milk R.
Yellow Stone R.
Big Horn R.
Snake R.
Platte R.
North Platte R.
South Platte R.
Niobrara R.
Kansas R.
Arkansas River
Ohio River
Red River
Rio Grande
Colorado R.
Gila R.
Green R.
Grand R.
Brazos R.
Trinity R.
Pecos R.
Mississippi R.
Ottawa R.
Portland
Fort Benton
Ft. Union
Bismarck
Virginia City
Fort Sully
Yankton
Omaha
Cheyenne
Denver
Leavenworth
St. Louis
Cairo
Ft. Gibson
Taos
Santa Fe
San Diego
San Francisco
Humboldt City
Salt Lake Cy.
Ft. Garry
Pembina
Duluth
St. Paul
Marquette
Escanaba
Milwaukee
Dubuque
Davenport
Chicago
Keokuk
Springfield
Toledo
Detroit
Saginaw
Grand Haven
Port Huron
Alpena
Saugeen
Toronto
Kingston
Montreal
Quebec
Burlington
Portland
Boston
New York
Philadelphia
Pittsburg
Baltimore
Washington
Morgantown
Lynchburg
Norfolk
Cape May
Cape Hatteras
Wilmington
Knoxville
Nashville
Memphis
Atlanta
Augusta
Charleston
Savannah
Montgomery
Jackson
Vicksburg
Mobile
New Orleans
St. Marks
Jacksonville
Dallas
Galveston
Halifax
Eastport
Cape Race
Farther Pt.



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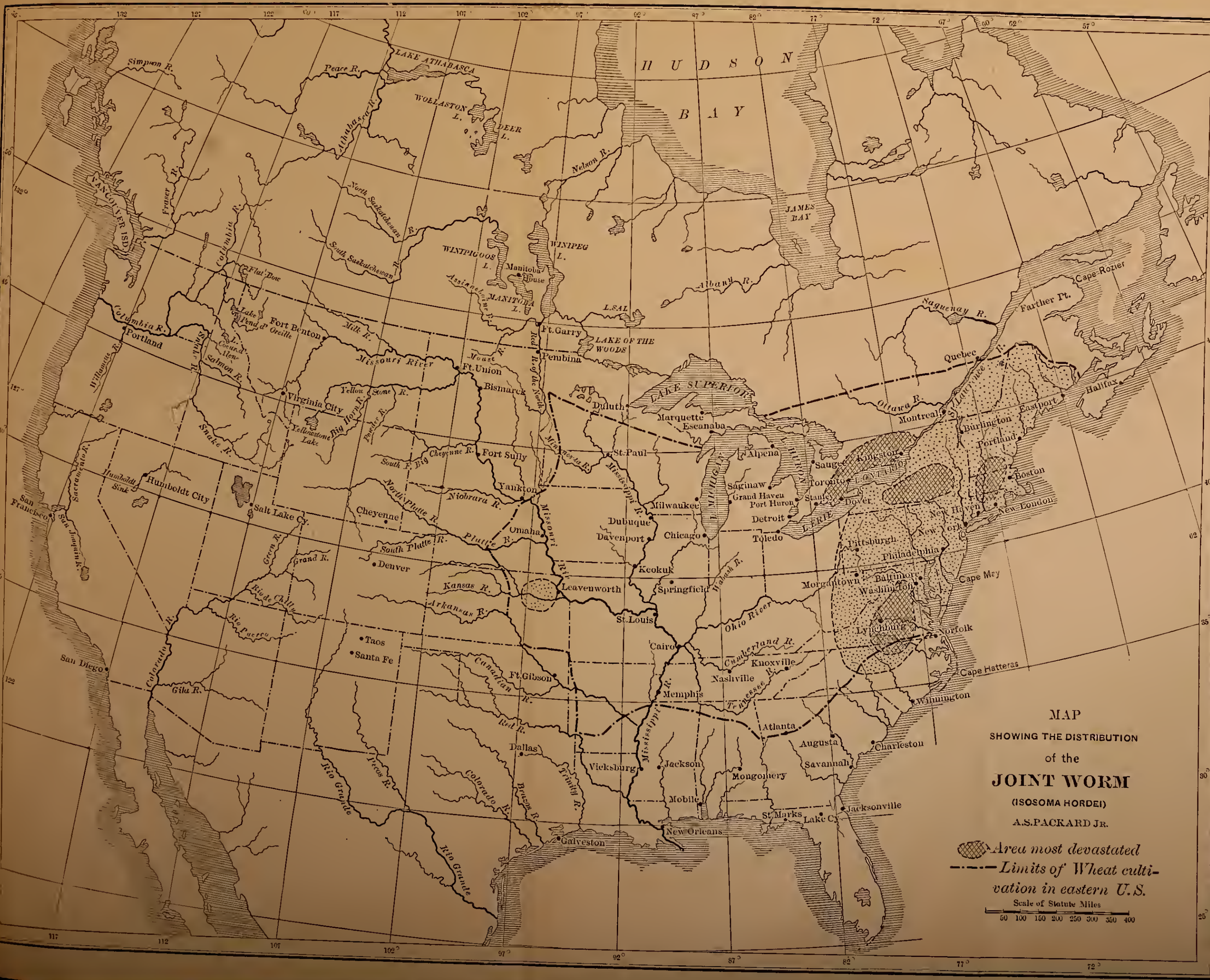

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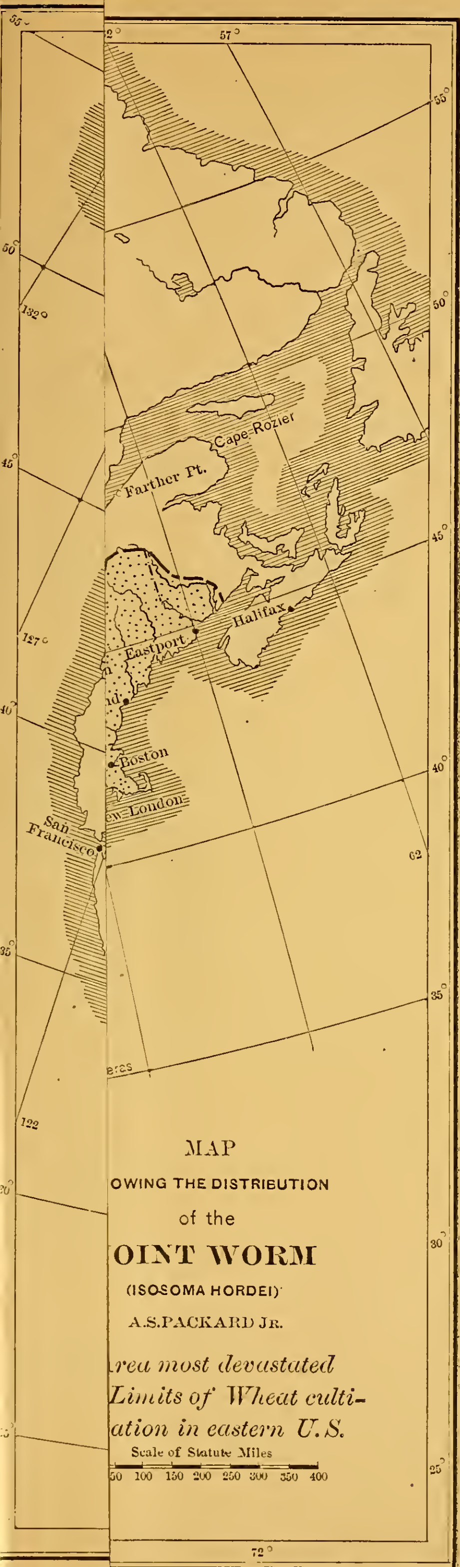

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APPENDIX.

LIST OF COLEOPTERA COLLECTED IN 1875, IN COLORADO AND UTAH, BY A. S. PACKARD, JR., M. D.

The collection of beetles which I made in the summer of 1875, while attached to Professor Hayden's Survey, was submitted to Dr. G. H. Horn for examination and identification.

CICINDELIDÆ.

Cicindela longilabris Say. Georgetown, Colo.
Cicindela punctulata Fabr. Garden of the Gods, Colo.
Cicindela repanda Dej. Boulder, Colo.
Cicindela hæmorrhagica Lec. Salt Lake Point.

CARABIDÆ.

Carabus tædatus Fabr. Kelso's Cabin, foot of Gray's Peak, elevation 11,200 feet; Idaho Springs, Colo.
Pasimachus elongatus Lec. Denver, June 27.
Brachinus minutus Harr. Denver, Colo.
Calathus dubius Lec. Idaho Springs, Colo.
Platynus placidus (Say). Idaho Springs, Colo.
Pterostichus luczotii (Dej.). Idaho Springs, Colo.; Georgetown, Colo., 9,000 feet elevation.
Pterostichus riparius (Dej.). Gray's Peak, at an elevation of about 12,000 feet.
Amara terrestris Lec. Idaho Springs, Colo.
Amara brunnipennis Dej. Arapahoe Peak, 11,000–12,000 feet elevation; summit of Pike's Peak and lower down, about 13,000 feet elevation.
Amara interstitialis Dej. Idaho Springs, Colo.
Amara obesa Say. Idaho Springs, Colo.; Manitou, July 12; Golden, Colo.
Amara avida (Say). Idaho Springs, Colo.
Dicaelus sculptilis Say. Manitou, Colo.
Nothopus zabroides (Lec.). Denver, Colo.
Harpalus pensylvanicus (Dej.). Denver, Colo.; Salt Lake City, Utah.
Harpalus furtivus Lec. Golden, Colo.; Idaho Springs, Colo.; Manitou, Colo., July 12.
Harpalus fallax Lec. Idaho Springs; Kelso's Cabin, Gray's Peak, 11,200 feet elevation, July 6.
Harpalus oblitus Lec. Idaho Springs, Colo.; Manitou, Colo.
Cratacanthus dubius (Beauv.). Denver, Colo., June 27.
Agonoderus comma (Fabr.). Denver; Idaho Springs, Colo.
Discoderus parallelus (Hald.). Shores of Great Salt Lake at Lake Point, Utah.
Patrobus longicornis (Say). Boulder, Colo.
Patrobus aterrimus Dej. Idaho Springs, Colo.

Bembidium bimaculatum (Kirby). Idaho Springs, Colo.
Bembidium rupestre Dej. Idaho Springs, Colo.
Bembidium bifossulatum Sec. Denver, Col.

DYTISCIDÆ.

Hydroporus vilis Lec. Colorado.
Hydroporus sellatus Lec. Denver, Colo.
Ilybius confusus Aubé. Denver, Colo.
Gaurodytes disintegratus Cr. Denver.

HYDROPHILIDÆ.

Helophorus lineatus Say. Arapahœ Peak, 11,000–12,000 feet elevation.
Tropisternus lateralis Hb. Denver.
Berosus styliferus Horn. Denver.

STAPHYLINIDÆ.

Creophilus villosus (Grav.). Georgetown, Colo.; Lake Point, margin of Great Salt Lake, Utah.
Philonthus californicus Mann. Margin of Great Salt Lake, Utah.
Philonthus pæderoides Lec. Colorado.
Philonthus sp. Idaho Springs, Colo.
Tachinus sp. Idaho Springs, Colo.

SILPHIDÆ.

Silpha lapponica Hb. Idaho Springs, Colo.
Catops sp.

DERMESTIDÆ.

Dermestes marmoratus Say. Utah. Mr. Barfoot.
Cryptorhopalum ruficorne Lec. Garden of the Gods.

NITIDULIDÆ.

Carpophilus pallipennis (Say). Denver.

COCCINELLIDÆ.

Coccinella 5-notata Kirby. Idaho Springs, Colo.
Coccinella 9-notata Hb. Denver, Colo.
Hippodamia 5-signata (Kirby). Denver; American Fork Cañon, Utah.
Hippodamia convergens Guér. Denver, Colo.
Hippodamia parenthesis (Say). Manitou, Colo.

HISTERIDÆ.

Saprinus lugens Er. Margin of Great Salt Lake, Utah.
Saprinus estriatus Lec. Margin of Great Salt Lake, Utah.

SCARABÆIDÆ.

Canthon hudsonias (Forst.). Denver, Colo.
Canthon ebenus (Say). Denver, Colo.

Rhyssemus scaber Haed.
Diplotaxis obscura Lec. Utah (Mr. Barfoot).
Polyphylla decemlineata (Say). Utah (Mr. Joseph L. Barfoot).
Cotalpa lanigera (Linn.). Utah (Mr. Barfoot).
Tostegoptera lanceolata (Say). Boulder, Garden of the Gods.
Liggrus gibbosus (De Geer). Denver, June 27; Utah (Mr. Barfoot).
Euryomia inda (Linn.).
Trichius piger Fabr. Manitou, Colo., July 15.

BUPRESTIDÆ.

Buprestis lauta Lec. Utah (Mr. Barfoot).
Buprestis rusticorum Kirby. Manitou, Colo., July 16.
Dicerca prolongata Lec. Denver, Colo.; Idaho Springs, on populus, July 6.
Melanophila drummondi (Kirby). American Fork Cañon, Utah.
Chrysobothris trinervia (Kirby). The Divide (on the railroad), Colorado, July 12.
Acmæodera mixta Lec. Manitou, and Garden of the Gods, July 15.

ELATERIDÆ.

Asaphes coracinus Cand. Golden, Colo.
Melanotus castanipes (Payk).

LAMPYRIDÆ.

Photinus nigricans (Say).

TELEPHORIDÆ.

Podabrus (near puncticollis Kirby). Gray's Peak, about 12,000 feet.
Podabrus (not determined). Georgetown, Colo.

MALACHIDÆ.

Collops vittatus Say? var. shore of Great Salt Lake, Salt Lake Point, July 26.
Dasytes hudsonicus Lec.
Pristocelis antennatus (Motsch). Golden, Colo.

CLERIDÆ.

Clerus ornatus (Say). Georgetown, Colo., on flowers, July 8.

PTINIDÆ.

Dinoderus cribratus Lec. Boulder, Colo.

CERAMBYCIDÆ.

Prionus californicus Motsch. Salt Lake City (Mr. Barfoot).
Prionus emarginatus Say. Salt Lake City (Mr. Barfoot).
Asemum moestum Hald. Mederland, Colo., June 30.
Criocephalus productus Lec. Colorado. Shores of Great Salt Lake.
Batyle ignicollis (Say). Golden; Garden of the Gods, July 13.

Batyle suturalis (Say). Denver; Garden of the Gods, July 13.
Neoclytus muricatulus (Kirby). Boulder, Colo.
Acmæops pratensis (Laich.). Manitou, Colo.; Georgetown, Colo., 9,500 feet elevation, July 8; Pike's Peak, summit and 13,000 feet elevation; Arapahoe Peak, 11,000–12,000 feet elevation.
Acmæops proteus (Kirby). Georgetown, Colo., 9,000 feet elevation, July 6.
Pachyta nitens Kirby. Georgetown, Colo.
Leptura chrysocoma Kirby. Manitou, July 15.
Leptura sanguinea Le Conte. Manitou.
Dectes spinosus (Say). Denver, Manitou.
Pogonocherus mixtus Hald. Idaho Springs, July 5, on populus.
Mecas pergrata (Say). Denver.
Tetraopes basalis Lec. Common in gardens in Salt Lake City, Utah.

CHRYSOMELIDÆ.

Coscinoptera dominicana (Fabr.).
Pachybrachys (not described), American Fork Cañon, Utah.
Chrysochus cobaltinus Lec. Denver, Colo., Salt Lake City (Mr. Barfoot).
Chrysomela 10-lineata (Say). Common; eggs, larva, and imago. Golden, Denver.
Chrysomela adonidis Fab. Georgetown, Colo., about 9,000 feet elevation.
Chrysomela scripta Fabr. (var. *confluens* Rog.). American Fork Cañon, Utah.
Chrysomela exclamationis Fabr. Denver, Colo.
Graptodera punctipennis Lec. Idaho Springs, Colo.
Graptodera plicipennis (Mann.). Manitou, Colo.
Graptodera (not determined).
Luperus meraca Say. (Does not appear to differ from "*meraca*" Horn.). Georgetown, Colo., 9,000 feet elevation.
Orchestris albionica (Lec.). Idaho Springs, Colo., July 6; Pike's Peak, on summit, abundant.
Orchestris ? Denver.
Systena mitis Lec. var. *ligata* Lec. Idaho Springs, Colo., July 5, on potato-vines.

TENEBRIONIDÆ.

Eusattus muricatus Lec. Utah (Mr. Barfoot).
Coniontis obesa Lec. Manitou.
Eleodes extricata (Say). Denver, Manitou, Idaho Springs.
Eleodes pimelioides Mann. Idaho Springs, Colo.
Eleodes suturalis (Say). Denver, June 27.
Eleodes nigrina Lec. Idaho Springs, Colo.
Eleodes planipennis Lec. Manitou, Colo.
Eleodes quadricollis Esch. Manitou.
Eleodes tricostata (Say). Kansas Pacific Railroad, Colorado, June 26.
Embaphion elongatum Horn. Utah (Mr. Barfoot).
Iphthimus serratus (Mann.) var. *Lewisii* Horn. Blackhawk, Colo.

MORDELLIDÆ.

Diclidia lætula Lec. "Mammoth Cave," Manitou, Colo.
Anaspis rufa (Say). Georgetown, Colo., about 9,500 feet elevation.
Mordella scutellaris Fabr. American Fork Cañon.

Mordellistena æmula Lec. Golden, Manitou, Colo.
Mordellistena unicolor Lec. Denver, June 27.
Mordellistena pustulata (Mels.). Denver, June 27.
Pentaria fuscula Lec. Manitou, Colo.

MELOIDÆ.

Epicauta pardalis Lec. Southern Colorado (T. M. Trippe).
Epicauta maculata (Say). Golden, Manitou, Colo., on beets.
Epicauta puncticollis Mann. American Fork Cañon, Utah.
Cantharis sphæricollis (Say). Blackhawk, Colo.
Nemognatha dichroa Lec. Denver.
Nemognatha sparsa Lec. Manitou, Colo.
Gnathium minimum (Say). Denver, Golden, July 3.

CURCULIONIDÆ.

Rhynchites bicolor Fabr. Georgetown, Colo., about 9,500 feet elevation.
Ophryastes latirostris Lec. Salt Lake City (Mr. Barfoot).
Dorytomus brevicollis Lec. Denver, Colo.
Anthonomus (not described). Golden, Colo.
Tychius lineellus Lec. var. Denver, Colo.
Baris transversus Lec. Golden, Manitou, Colo.
Sphenophorus pertinax Oliv. Salt Lake City (Mr. Barfoot).

SCOLYTIDÆ.

Dryocœtes affaber (Mannh). Gray's Peak, 11,200 feet elevation (Kelso's Cabin).
Tomicus pini (Say). Gray's Peak, elevation 11,200 feet (Kelso's Cabin).
Polygraphus rufipennis (Kirby). Gray's Peak, elevation 11,200 feet (Kelso's Cabin).
Dendroctonus obesus (Mann). Blackhawk, July 2; Manitou, July 15.

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