SIXTH ANNUAL REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY

OF

THE TERRITORIES,

EMBRACING

PORTIONS OF MONTANA, IDAHO, WYOMING, AND UTAH; BEING A REPORT OF PROGRESS OF THE EXPLORATIONS FOR THE YEAR 1872.

BY

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TABLE OF CONTENTS.

PART II.

LIST OF ILLUSTRATIONS.

WOOD-CUTS.

PLATES.

MAPS.

DIAGRAMS.

LETTER TO THE SECRETARY.

WASHINGTON, D. C., *March* 10, 1873.

SIR: I have the honor to present for your approval and for publication the sixth annual report of the United States Geological Survey of the Territories, containing a preliminary account of explorations made during the summer of 1872, about the sources of Snake and Missouri Rivers.

The liberal appropriation granted for the survey by the Forty-second Congress enabled the Chief Geologist to organize two large and well-equipped parties for field-work. These parties were each provided with a geologist, topographer, astronomer, meteorologist, with their assistants. A number of young men acted as collectors of objects in natural history.

One party, under my immediate direction, took Fort Ellis as its initial point. We spent several days at this point and at Bozeman purchasing our animals and securing supplies and other outfit. After our preparations were made, we passed over the divide to the Yellowstone Valley, traversing nearly the same route as last year. The Yellowstone River, from the lower cañon to its source in the Yellowstone Lake, was carefully surveyed. Some of the branches, as the East Fork, were more fully examined than at any time previously. From the lake the party passed over the divide into the Geyser Basin of Madison River, and explored that river and its branches to the Three Forks. We then ascended the Gallatin River and examined it to its sources. The interesting cañon of the Gallatin, which is about seventy miles in length, had never been explored previously, and was unknown even to the inhabitants of the lower part of the valley. From the Gallatin Cañon we passed over the divide into the Yellowstone Valley, near the second cañon, and made a more detailed survey of the Snowy or Yellowstone Range, then passed down the valley through the first or lower cañon, and then along the divide between the branches of the East Gallatin and Shields Rivers to Flat Head Pass; thence across the rugged hills to a point about ten miles below the Three Forks, on the Missouri River. We then returned to Bozeman along the base of the mountains on the east side of the East Gallatin Fork, and the field-work of this party was closed. The materials for an accurate map of the district examined were secured, and most important discoveries in geology and large collections in all departments were made.

The second party was placed under the general direction of Mr. James

Stevenson, whose experience in this wild life for sixteen years, as my principal assistant, gave him great advantages over any one else I could secure for that trust. This party started from Ogden, Utah, surveyed a route to Fort Hall, and there laid in supplies and made the necessary preparations for a pack-train up the unknown region of the Upper Snake Valley. The party was also provided with a chief geologist, topographer, meteorologist, botanist, and other necessary assistants. From Fort Hall this party proceeded up the west side of Snake River. Two weeks were spent in making a careful survey of the previously unknown Teton Basin. The range of the Three Tetons was carefully mapped. Eleven of the party attempted to ascend the highest peak, the Grand Teton. Only two of these succeeded, Messrs. Stevenson and Langford. So far as we can ascertain they are the only white men that ever reached its summit.

In the summer of 1860 the party under the command of Colonel W. F. Raynolds, to which I was attached as geologist, camped for several days at the base of this range. We had with us as guide Mr. James Bridger, who was more familiar with the western country and the events in its history for the past fifty years than any living man. He regarded the ascent of this peak as impossible, and many of the old mountaineers and trappers state that it has been attempted many times without success.

Immense masses of snow and lakes of ice were found on its sides, and abundant signs of modern glacial action. At certain seasons of the year, usually in August and September, the air is filled to a great height with grasshoppers flying in every direction. They sometimes rise to the height of many thousands of feet. As they passed over this Teton Range they became chilled and dropped on the snow and ice in vast numbers and gradually melted the snow, so that the myriads of little holes which they formed gave to the surface a peculiar roughness. It was due to this fact that Messrs. Stevenson and Langford were able to cling to the almost vertical icy sides of the peak, and complete the ascent. They found the elevation to be 13,858 feet above the sea, thus entitling it to rank among the monarch peaks of our continent.

Yet on the summit of this peak there were indications that human beings had made the ascent at some period in the past. On the top of the Grand Teton, and for 300 feet below, are great quantities of granite blocks or slabs of different sizes. These blocks had been placed on end, forming a breastwork about three feet high, inclosing a circular space six or seven feet in diameter, and while on the surrounding rocks there is not a particle of dust or sand, yet the bottom of this inclosure is covered with a bed of minute particles of granite, not larger than the grains of common sand, which must have been worn off by the elements from the vertical blocks until it is nearly a foot in depth. There was every appearance that these granite slabs had been placed in their present position by Indians, as a protection from the wind, many centuries ago.

The scenery of the Teton Range is truly alpine in its character, approaching that type more nearly than any other known in the West.

Leaving the Teton Basin, the party proceeded up Henry's Fork of Snake River, and at its source, surveyed one of the most interesting and important geographical points in the West. At the head of Henry's Fork are four remarkable passes, representing the four points of the compass, with Henry's Lake located in the center. The Targee, or East Pass, is 7,063 feet elevation, and forms one of the gateways to the Madison Valley and to the sources of the Madison and Yellowstone. Henry's, or South Pass, is about 6,250 feet elevation, and opens into the great valley of the Snake River from the Atlantic slope. Red Rock, or West Pass, is 7,271 feet elevation, and connects the great valley of the Jefferson Fork, while the Raynolds or North Pass, 6,911 feet elevation, leads into the valley of the Lower Madison. These remarkable passes, thus linking the Atlantic with the Pacific slope, are so smooth that a carriage could be driven over them at a high rate of speed. In a practical point of view these passes, as well as the Snake River Valley, must soon become of great importance to the West.

The Snake River and Henry's Fork Valleys form by far the most feasible routes for railroads, connecting Montana and the entire Northwest with the interior basin and the Pacific slope. Compared with the present stage-routes to Montana, a road by this valley would be from one hundred to one hundred and fifty miles shorter, and would open up for settlement a vast area of arable and pastoral land. The immense forests of pine timber would be made available, and I am convinced that in a few years, on account of the scarcity of good timber in the interior basin, this will become one of the most important lumber regions in the West. If the railroad which contemplates connecting Corinne, Utah, with Helena, Montana, passes up Henry's Fork, it will render available two thousand five hundred square miles of pine timber. All the wonders of our great National Park can be seen in one day's travel on horseback from this route.

About ten miles northwest of Henry's Lake a new lake was discovered, which from its peculiar character merits some notice here. It is called "Cliff Lake" on the map, from the fact that it seems to be confined to a deep fissure in the basaltic rocks. It is triangular in shape, its length about one and a half miles, and half a mile in its greatest width. Several streams of considerable size flow into it, but no outlet could be discovered. High, nearly vertical walls inclose it on every side.

From Henry's Lake the party crossed the water-shed by way of the Targee Pass into the Madison Valley, and passed up that stream to the Fire Hole Basin, where both of the parties met on the same day, August 14, though starting about two months previously from points several hundred miles apart. The Snake River division remained in this basin several days, until supplies could be obtained from Virginia City for the return trip to Fort Hall.

The party then continued its way up the valley of the Madison to its source, and spent some days exploring the different branches of Snake River and the Madison. There is perhaps no more unknown or more interesting geographical region in America than this great water divide of our continent. The maps which are now in process of construction in the office, and which will be issued to the public in the course of the present year, will almost entirely change the geography of this wonderful region. Within a radius of ten miles, may be found the sources of three of the largest rivers in America. The general elevation is from 7,000 to 8,000 feet above the sea, while the mountains whose eternal snows form the sources of these great rivers, rise to a height of 10,000 to 12,000 feet. Flowing northward are the numerous branches of the Missouri, Yellowstone, and Wind Rivers, which all eventually unite into one mighty stream, the Missouri! To the south are the branches of Green River, which unites with the Colorado and finally empties into the Gulf of California, while south and west flow the branches of Snake River, which, uniting with the Columbia, pour their vast volume of water into the Pacific.

The exploration of this remarkable water divide proves that the Madison Fork has its source in a small lake not hitherto noted on any map, and that the so-called Madison Lake belongs entirely on the Pacific slope. This latter lake was found to be about twelve miles long and eight miles wide. From this body of water flows a stream nearly one hundred feet wide, which, after a distance of about five miles, empties into a second lake which is four miles long and one and a half miles wide. The former of these lakes was named Lake Shoshone, and the latter Lake Lewis, in honor of the great pioneer explorer of the Northwest.

At the upper end of Lake Shoshone a new geyser basin was discovered, with from seventy-five to one hundred springs, many of them geysers of considerable power. The ornamentation about these springs was regarded as more interesting and elaborate than those in Fire Hole Basin. The divide between the Yellowstone Lake and Lake Lewis was found to be about 50 feet above the former, and 200 feet above the latter. This low ridge in the great water divide of the continent has doubtless given rise to the story of the Two-Ocean River, and such a stream has found its way to most of our printed maps.

From the summit of Red Mountain the scope of vision embraced a radius of one hundred and fifty miles, within which four hundred and seventy mountain-peaks worthy of a name could be distinctly observed. The area that could be swept by the eye from this point could not have been less than fifty thousand square miles, embracing every variety of grand and beautiful scenery, of mountain and valley, probably without a parallel on the continent. Ten large lakes and several smaller ones were embraced in the view, and the entire Yellowstone Park was spread out under the eye. To those who are familiar with the remarkable purity of the atmosphere in these high latitudes, these statements need not appear incredible. To the east the Wind River and Big Horn Ranges, with the snow-clad summits of Fremont's, Union, and Cloud Peaks, bounded the view. On the north the Yellowstone Range, with Emigrant Peak and many of the loftiest mountains in Montana, were clearly seen. To the west the numerous ranges comprised in what are called the Salmon River Mountains of Idaho form the horizon of vision in that direction, while the mountains near Fort Hall and the Wahsatch Range completed the mighty amphitheater. This remarkable view embraced a large portion of Wyoming, Montana, Idaho, and Utah Territories.

About forty small streams, which unite and form the upper portion of Snake River, were carefully examined. The party then proceeded down the valley of Snake River, through its remarkable cañons, examined Jackson's Lake and the numerous streams that empty into the main river on either side. About the middle of October the party arrived at Fort Hall, where it was soon after disbanded.

It will be seen from this report, and the more elaborate final reports which will follow in due time, that the scientific as well as the practical results of these explorations are of great importance to the material interests of the West. They have already enlisted the interest and sympathy of all classes of intelligent people of our country from Maine to Florida, as the numerous letters and applications for the reports afford ample testimony.

The two principal field parties were organized as follows:

The first division—Adolf Burck, chief topographer; Henry Gannett, astronomer; A. E. Brown, assistant topographer; E. B. Wakefield, meteorologist; Dr. A. C. Peale, mineralogist; W. H. Holmes, artist; Walter B. Platt, naturalist; W. B. Logan, secretary; A. E. Bingham, Joseph Savage, and T. O. C. Sloane, general assistants.

Second, or Snake River division—James Stevenson, director; Professor Frank H. Bradley, chief geologist; W. R. Taggart, assistant geologist; Gustavus R. Bechler, chief topographer; Rudolph Hering and Thomas W. Jaycox, assistant topographers; William Nicholson, meteorologist; John M. Coulter, botanist; Dr. Josiah Curtis, surgeon and microscopist; C. Hart Merriam, ornithologist; Campbell Carrington, naturalist; William H. Jackson, photographer; Charles R. Campbell, assistant; Robert Adams, P. J. Beveridge, J. S. Negley, W. A. West, S. F. Hamp, T. B. Brown, and S. C. Jones, general assistants; Hon. N. P. Langford, C. S. Spencer, and Dr. Reagles accompanied the Snake River division from Fort Hall as guests. Mr. William Blackmore of London, England, accompanied my party from Fort Ellis to the Geyser Basin for several weeks as guest, for the purpose of examining the National Park.

Although most of the members of both parties labored with great zeal to advance the objects of the survey, yet the burden of executive duty was so great in managing the affairs of so large an organization that a large part of my time and force has been abstracted from the purely scientific labors, and for this reason my personal report will be much less elaborate and important than heretofore. I trust, however, that the report as a whole will not be surpassed in interest and value by any of the preceding ones.

My first assistant, Mr. James Stevenson, performed his duties with his usual zeal and fidelity. In his management of the Snake River party, he exhibited executive abilities of the highest order. Professor Bradley made some important discoveries in geology. The discovery of an upper member of the Potsdam group will prove an important addition to our knowledge of western geology. Among the fossils brought back by Professor Bradley, Mr. Meek has identified the equivalent of the Spergen Hill beds of Indiana, (Saint Louis limestone of the western carboniferous series.) The report of Dr. A. C. Peale will show his great industry and care. I regard it as one of much importance. W. H. Holmes, as artist, rendered most important services in all departments of the survey. His sections and sketches have proved useful not only for the geological reports, but have been of great value to the topographers in preparing their maps. Mr. William H. Jackson, the photographer, was more successful than in any preceding year. In testimony of the importance of his labors, I quote from a notice of his photographs from the January number of the American Journal of Sciences, by Professor J. D. Dana:

Next to a personal visit to this land of geysers, hot springs, fountains of boiling mud, watorfalls, lakes, and majestic mountains, is a morning spent over these photographs. They would do credit to the best photographic laboratory, and, considering the difficulties inherent in a long and arduous journey, they are really admirable. The Yellowstone series well illustrates the advantage of photography over any hand-drawings in bringing out details of structure, especially where the artist is guided by the geologist in selecting the best points of view. Among the novelties which are a positive addition to our knowledge of orography we mention particularly the views of the Three Tetons. Among the geyser views there are two of "Old Faithful" in full action which are exceedingly effective; others of basins and cones in which the varied tracery of the surface may be studied with much of the satisfaction to be had from actual examination; others, of long cascade slopes which have been gracefully terraced by the mineral depositions of the waters, and whose basins, brimful to their delicate edges with the petrifying waters, reflect mirror-like the surrounding objects; others showing large areas of the geyser region with the geysers in action. Such views give an opportunity for the geologist to compare beds of chemical deposition with our ordinary limestones.

Mr. C. Hart Merriam's report will show his zeal in his special department. Mr. John M. Coulter acted as botanist, and his report exhits an unusual number of species of plants for a single season's labor. Mr. Walter B. Platt made interesting collections about the sources of the Yellowstone and Missouri Rivers. The plants were added to those of Mr. Coulter, and the birds and mammals to those of Mr. Merriam. The new species of plants have been described by the eminent botanist, Professor Thomas C. Porter, of Easton, Pennsylvania. Of flowering plants there were one new genus and six new species, besides several varieties. They number about nine hundred species. Of grasses there were about sixty species; mosses, fifty-three; lichens, with probably one new species and two new to this continent, sixty-seven; other cryptogamia, with two new species of fungi, seventy. There will probably be one thousand two hundred species in all. The report of Dr. Curtis, on the microscopic forms of that region, and especially about the hot springs, must prove of interest to microscopists.

It is believed that the results of the survey as a whole will be found to be worthy of the liberal appropriation made by Congress for the purpose.

The results of the labors of the topographical corps will be visible in the series of maps, which will be published as soon as possible. Some of the smaller ones, prepared by Mr. Bechler, accompany this report. Mr. Bechler labored with the utmost zeal and fidelity, and his maps of the Snake River Valley and its tributaries cannot but prove a most important addition to the geography of one of the least known portions of our continent. The observations for latitude and longitude were taken by Mr. Rudolph Hering, who also superintended the meteorological observations. He was assisted in the field by Mr. Jaycox. Mr. William Nicholson remained at Fort Hall and made a most valuable series of meteorological observations. Mr. Adolph Burck, assisted by Messrs. Gannett and Brown, secured the materials for a map of the Yellowstone, Madison, and Gallatin Rivers, with their branches, comprising an area of about nine thousand square miles. The sudden death of Mr. Burck before the completion of his map, threw additional labor upon Mr. Gannett. Mr. Gannett has performed his duties both in the field and in the office with the highest credit to himself and to the survey.

Besides the two main parties, several smaller parties have been operating under the auspices of the survey in different portions of the West. It is a part of the policy of the survey to invite distinguished specialists to examine some of the more obscure and difficult problems in the geology of the West. There has been for a long time some differences of opinion in regard to the exact age of some portions of the Cretaceous and Tertiary groups of the West. I desired to gather all the evidence that could be secured for the solution of the question the present season. Professor Joseph Leidy and Professor E. D. Cope spent a large part of the summer in studying the ancient lake-basins in the interior of the continent, which have now become celebrated all over the world for the richness and variety of their vertebrate fossils. These eminent gentlemen were most successful and obtained a vast quantity of valuable material, which will be embodied in a series of memoirs illustrated with plates, which will form volume I of the quarto series of final reports.

Part I, volume I, by Professor Leidy, containing thirty-six plates, is now passing through the press. Part II, by Professor Cope, with fifty to sixty plates, will be ready for publication during the year.

Professor Leo Lesquereux, our great authority in fossil botany, made a careful study of the coal regions of the West, with one assistant, and procured a mass of valuable information and many new species of fossil plants. He has been engaged for some time past on an exhaustive memoir on the ancient flora of the Cretaceous and Tertiary formations west of the Mississippi in the service of the survey. This will form Part II, volume II. Part I, by Dr. J. S. Newberry, containing about sixty plates, is nearly ready for publication.

Volume III, by the eminent paleontologist, Mr. F. B. Meek, will contain the invertebrate fossils of the survey, with about eighty plates. About forty of the plates have been engraved. Mr. Meek, assisted by Mr. H. M. Bannister, spent about two months during the past summer along the line of the Union Pacific Railroad and procured much evidence from the fossil invertebrata. All these gentlemen have prepared essays of great value for the present annual report.

Volume IV will contain the profiles, sections, and other illustrations with descriptive text by the chief geologist. Part I will contain about one hundred illustrations, printed by the Albertype process from photographic negatives taken by Mr. Jackson. The views will embrace some of the most remarkable scenery of the West. Part II will contain the profiles and sections, with suitable descriptive text.

Volume V will embrace memoirs on the recent zoology and botany of the survey. The first memoir of this volume, "Synopsis of Acrididæ of North America," by Professor Cyrus Thomas, is now passing through the press. Special memoirs by the most eminent authorities are in preparation on the new species of mammals, birds, fishes, reptiles, insects, indeed all the new forms of life, animal or vegetable, collected by the survey.

It will be seen that the survey contemplates two classes of publications: the annual reports and miscellaneous memoirs in octavo, containing an account of the preliminary work, catalogues and such matter as may be regarded of popular interest, and are, therefore, printed in large editions and distributed to the people generally, and a series of quarto volumes which will contain the new and more technical results of the survey. The quarto volumes may be regarded as containing positive additions to knowledge, and are intended more especially for distribution to libraries and men of science.

The collections of the survey, which are very great in all departments, are deposited in the Smithsonian Institution, in accordance with a law of Congress. The first and most complete series will be selected for the National Museum, and the duplicates divided into sets and distributed to the museums and institutions of learning in our country.

I have again the pleasure of acknowledging important favors from the military authorities. Hon. W. W. Belknap, Secretary of War, issued the same order on the military posts of the West as last year. His personal interest in the success of the survey has been of great material value. There is not space to mention the names of all the officers who exhibited a kindly interest in our success. From General Ord, commander of Department of the Platte, at Omaha, our party received the most prompt and generous aid in every way in his power. He has always manifested the greatest interest in the exploration and development of the West by all parties, civil or military.

By Colonel C. A. Reynolds, of Fort D. A. Russell, Captain Putnam, Lieutenants King and Nelson of Fort Hall, and Major Forsyth and Lieutenant McAdams, of Fort Ellis, special favors were granted, for which I beg them to accept my cordial thanks. By the citizens of the western Territories everywhere we were always received with great good will and aided in our work. To his excellency Governor Potts, J. L. Corbett, A. B. Knight, and Raymond Brothers, of Virginia City; to Willson and Rich and Nelson Story, of Bozeman, Warren, Hussey & Co., Salt Lake City, and Nat Stein, of Corinne, and many others, we are under many obligations for favors of great importance.

To the officers of the Union Pacific Railroad, Hon. Horace F. Clark, president, and General T. E. Sickles, general superintendent, the survey is under the most important material obligations for free transportation for nearly all the members of the party. From the Central Pacific, Kansas Pacific, Denver Pacific, Chicago, Burlington and Quincy, and the Denver and Rio Grande roads we received a liberal number of passes. I wish to extend my cordial thanks to the officers and employés of all the railroads of the West for uniform courtesy and marked sympathy in all our operations.

I would again express my sincere thanks to the press in all parts of our country for their uniform interest and encouragement in our work. Since the commencement of our surveys in the West, there has not been an unkind expression from the press, secular or scientific, in this country or in Europe.

To the editors of the Illustrated Christian Weekly I am indebted for some most valuable electrotypes which have been used in this report. Thanks are also due to Professors Henry and Baird, of the Smithsonian Institution, for many favors of great value.

The success which has attended the operations of the survey for the past six years; the publication of six annual reports which have been received with great favor not only by the people of our own country, but in all parts of the world, would appear to entitle it to the continued confidence of Congress. Its organization is becoming more efficient and more perfect every year, and it is believed that it occupies a position under the General Government not filled by any other body devoted to kindred pursuits. From the great interest which the people of our country have continually manifested in its success, it would appear to supply an existing want, and it is capable of expansion to meet the necessities of the Government so far as its duties are concerned. I therefore venture to ask that additional power be given it to increase its efficiency, that it may continue to command the respect not only of men of science, but of the intelligent world generally.

To render the organization more perfect, so far as the topographical portion is concerned, Mr. J. T. Gardner, so long favorably known as the chief topographer of the geological survey of the fortieth parallel, under the direction of Mr. Clarence King, has become associated with me as chief of the topographical staff. Mr. Gardner brings with him to this duty the ripe experience of ten years of topographical work, extending over an area from the Pacific coast to the east base of the Rocky Mountains. Mr. Gardner thus expresses his conception of a true topographical map for geological purposes:

> For making maps suited to geological purposes it is necessary to carry over the country a systematic trigonometric and topographical survey, checked by astronomical observations. The maps must represent the features of the country accurately, and in bold relief; or, in other words, they must be a picture of the earth's surfaee as one would see it looking down from above.

The work of the survey as contemplated by the present organization demands the very highest order of talent. To command this, it is necessary that the young men who may embark in this enterprise should feel a confidence in the permanency of the work, instead of regarding it as a stepping-stone to more lucrative positions. Each professional assistant is worth to the Government from 50 to 100 per cent. more, every succeeding year. To make thorough astronomical, topographical, meteorological, geological, and botanical researches, and to develop the mining and agricultural resources properly, trained experts in all the different departments are absolutely essential. Such men to identify themselves permanently with the survey must be paid in proportion to their abilities.

In conclusion, I would again extend my cordial thanks to the honorable Secretary of the Interior, and to Hon. B. R. Cowen, Assistant Secretary, for their prompt action and sympathy in every movement that tended to promote the best interests of the survey. The broad discretion and freedom of action which has at all times been given to the Chief Geologist under the Department of the Interior have contributed very greatly to its success.

Very respectfully, your obedient servant,

F. V. HAYDEN,

United States Geologist

Hon. C. DELANO,

Secretary of the Interior.

PART I.

REPORT OF F. V. HAYDEN.

GEOLOGICAL SURVEY OF THE TERRITORIES.

CHAPTER I.

INTRODUCTORY.

I had intended in this report to present a careful *résumé* of the geology of the Northwest, so far as my explorations have extended; but the unusual pressure of executive duties, in connection with so large a party, has prevented me. I shall, therefore, in this chapter pass hastily in review some of the more important points that occur along our route, from Cheyenne to the Yellowstone region.

I will first notice briefly the lignitic formations as they appear along our route. Inasmuch as there has been some diversity of opinion among geologists in regard to the precise position in the geological scale of the great coal or lignitic group of the West, I desired to secure all the evidence possible bearing on that point. For this purpose Professor Leo Lesquereux, our great authority on fossil botany, was directed to spend a few months in exploring the coal-beds of the West. He passed along the Kansas Pacific Railway to Denver, Colorado, examining the Cretaceous coal-beds on the route. From Denver he proceeded along the base of the mountains to Santa Fé, and returning, made a careful study of the coal-groups as shown in the vicinity of Denver. He then visited the principal points of interest along the Union Pacific Railroad to Salt Lake City. The reader is referred to his valuable reports in this volume for the results of his examinations.

Besides the lignitic group, there is a series of extensive lake-basins in the interior of our continent which have already yielded an astonishing number of remarkable vertebrate remains. Inasmuch as greater weight is attached by some geologists to the testimony of the higher order of organic remains, Professor Joseph Leidy and Professor E. D. Cope, both of whom are justly regarded as the most eminent comparative anatomists of our country, made a careful exploration of the lignitic and more modern lake groups, under the auspices of the survey. Their reports, appended to this volume, will throw great light on the age of these formations.

Mr. F. B. Meek, paleontologist of the survey, assisted by Mr. H. M. Bannister, made a careful study of the lignitic group from the invertebrate side, and their reports contain most valuable results. The time has been so short for the preparation of this report that I have not been able to examine the results of the studies of these eminent gentlemen, and therefore cannot present their conclusions in regard to the age of these deposits with certainty. I am of the impression, however, that Professor Lesquereux concludes, from his study of the fossil plants, that the lignitic strata are mostly Eocene. Mr. Meek believes them to be upper Cretaceous, passing up through a series of transition beds to Eocene; while Professor Cope regards them as of Cretaceous age. All these gentlemen must be regarded as individually responsible for the opinions expressed in their reports.

I will just here state briefly the history of the growth of the evidence in regard to the age of the lignitic group as expressed in my previous reports. As far back as 1854 and 1855, the writer was exploring the Tertiary formations along the Missouri River, and made large collections of shells and plants, most of which were new to science. These explorations were continued each year up to the autumn of 1860, in various parts of the Northwest, and annually large additions were made to the collections both of vegetable and animal remains. The shells were all of extinct species, of brackish or fresh-water origin, and, while they did not appear to be positively characteristic of any age, were regarded by Mr. Meek as more nearly resembling Tertiary types than any other. The fossil plants were mostly of extinct species; and in his most valuable chapters contributed to the "Report of the Exploration of the Yellowstone and Missouri Rivers," during the years 1859–'60, Dr. Newberry expressly states that they are of Tertiary age, and most probably Miocene. Now, these lignitic strata occupy a vast area in the Upper Missouri Valley, extending far southward, with very little interruption, to New Mexico, and westward into the interior of the continent. I have many times, in my previous reports, expressed the opinion that the lignitic formations of the West were all portions of one great group, interrupted here and there by mountain-chains, or concealed by more modern deposits. Having, therefore, fixed the age of these beds on the Upper Missouri, and subsequently tracing them across the country, southward below Santa Fé, and westward nearly to Salt Lake Valley, I ventured to express the opinion, from the identity of the fossil flora, that all the lignitic strata of the West might be of Tertiary age. In the summer of 1868, I made an examination of the lower coal-beds at Bear River City and at Coalville, Utah, and made the statement that the evidence seemed to point to the Cretaceous age of these beds. Since that time the proof of the Cretaceous age of the lower coal-beds in Utah, especially at Bear River and Coalville, appears to be conclusive. But if we admit that the coal-beds of Wyoming and Colorado are all of Cretaceous age, I think we may extend them all over the Northwest and ignore the evidence from the fossil flora entirely. The facts, as we possess them at the present time, seem to point to the conclusion that the deposition of the lignitic strata commenced during the latter portion of the Cretaceous period, and continued on into Tertiary times without any marked physical break, so that many of the Cretaceous types, especially of the vertebrata, may have lingered on through the transition-period, even into the Tertiary epoch. I propose to discuss this very important problem in detail at some future time. Each year's exploration adds immensely to our knowledge of the vast Cretaceous and Tertiary groups of the West, and the time cannot be far distant when the facts accumulated will enable us to reconstruct the physical history of those remarkable periods.

Although the survey began its labors near Ogden in the Great Salt Lake Basin, yet we shall delay only to note a few features which seem important. The geology of this great basin, from the Sierras to the Wahsatch Range, will doubtless be ably discussed in the forthcoming volumes of Mr. Clarence King, in charge of the geological exploration of the fortieth parallel. The results of this survey will prove of the highest importance to Rocky-Mountain geology. The survey under my charge is annually accumulating materials looking toward a more complete discussion of the principal geological features of this interior region, should the much-looked-for period of leisure ever arrive to digest them. A portion of the observations made on several expeditions have been given in the reports of the survey for the years 1870 and 1871.

By examining a good map of Utah, it will be seen that the Wahsatch Range forms the eastern boundary of the great interior basin. In many respects this is the most remarkable range of mountains in the interior of our continent. Mr. King, in Chapter VII, Mining Industry, has briefly but most graphically described its general structure. He remarks that the materials of this range are identical with the numerous great chains of the interior basin, though developed on a scale of grandeur observed nowhere else. The basis rocks are a series of alternating layers of quartzose, mica and hornblendic schists. Above these rests a heavy bed of quartzite, with very regular and marked stratification. Above the quartzite comes a bed of very hard ashen-gray limestones, probably of Silurian age; then a group of shales, clays, quartzites, &c.; and then a great thickness of limestones, the upper portion of which has been shown by the organic remains to be of Carboniferous age. In the Weber Cañon and on the east side of the range from Ogden, there is a large group of quartzites, passing up into siliceous limestones and capped with a bed of red sandstone, which, so far as my own observations are concerned, is of doubtful age, but may be Triassic. Above these comes a thick group of bluish-gray limestones, with characteristic Jurassic fossils. These ranges, which seem to me to run in nearly parallel lines, about north and south, appear to possess a common structure and point to a common origin, and cannot be treated in a comprehensive manner except by a geologist familiar with the entire basin and its surroundings. These ranges rise up in long, sharp ridges, apparently from the plains, while the lowlands are covered with a group of modern deposits, which jut up against the base of the mountain-chains on either side. Since the crumpling, or folding, of the earth's crust, which gave origin to this wonderful series of mountain-chains, the erosion has been immense. It is most probable that at a comparatively modern period the vast area between the Wahsatch Mountains on the east and the Sierra Nevada on the west was one great lake, the mountains rising up as islands in this vast inland sea. The lakes, large and small, which we find scattered over the basin at the present time, are only remnants of this former sea. The modern deposits which cover the lowlands are mostly calcareous and arenaceous beds, and sometimes reach a thickness of 800 to 1,200 feet, and often filled with fresh-water or land shells, indicating a very modern origin, probably not older than the Pliocene period. At any rate, the strata are all horizontal or nearly so, showing that no disturbance of any great importance has occurred since their deposition. These ranges of mountains extend, with greater or less intervals in their continuity, far northward into Idaho and Montana. Certain changes in the details of structure are apparent as we pass northward to Snake River Basin, but there is a remarkable similarity in the rock-materials as far as the great water-divide of the continent, when rather marked changes occur in the mountain-ranges of Montana, where the quartzites give place to great thicknesses of limestones. Indeed, in Montana the quartzites, which are so well shown in Utah, have no existence, though far to the westward in the Salmon River Mountains they continue in full force. We have not the materials as yet for a critical study of these remarkable folds or wrinkles in the earth's crust that are scattered throughout this interior basin, more or less parallel to each other. Sometimes the granitic nucleus is revealed, with the unchanged beds obscurely exposed around the sides or base of the range. Usually the very hard limestones have served as a sort of protection, and are generally seen in full force. In the Wahsatch Range some of the peaks rise to the regions of perpetual snow, and on either side deep and most picturesque cañons are carved out of the solid mass into the valleys below. Little and Big Cottonwood and American Fork Cañons are only examples of hundreds of these wonderful cañons, having, on either side, nearly vertical walls 1,000 to 2,000 feet in height. The Oquirrh Mountains at the south end of Salt Lake form a fine illustration of an oblong quaquaversal, an interrupted fold or puff, with the strata inclining at various angles from all sides. From Lyon Hill the geologist can see the Carboniferous limestones inclining southward from the south end of the range, and as he follows along the base northward the quartzites, shales, or limestones which compose the sedimentary group incline westward, while at the north end near the lake, the strata bend around, and apparently dip under the waters of the lake, while on the east side, these beds incline to the eastward, and apparently pass under the valley. We can see, therefore, that these valleys are really synclinals, which have been excavated more or less by erosion. The islands in Salt Lake are only the crests of these folds, while the waters occupy the synclinal valleys; and this remnant illustrates on a small scale the scenic beauty of the great inland sea when it extended over the entire basin. Ophir Cañon is one of the deep gorges carved out of the west side of the Oquirrh Range, at right angles to the axis of elevation, revealing the strata on either side in a wonderfully clear manner. Regularly-stratified quartzites rest upon a series of granitoid strata, which are exposed only here and there in these deep gorges. The quartzites pass up into micaceous clays or shales, then gradually up into limestones, in which are located some of the richest silver-mines in Utah. It is quite probable that the lower beds of quartzites and limestones are of Silurian age, perhaps as old as the Potsdam group, while we know that at least the greater portion of the second limestone-bed is of Carboniferous age. On Lyon Hill, the silver-mines are located in limestones that are full of characteristic Carboniferous fossils. Another interesting feature which tends to complicate the structure of these ranges is the great number of dikes of every size. In some instances the igneous matter has poured out over a considerable area. Again, it has never reached the surface, as is shown only in the deep water-carved gorges. In Brigham Cañon, on the east side of the Oquirrh Range, are several well-marked dikes; also on Lyon Hill and Ophir Cañon. At the north end of this range the effect of erosion is well shown by the outcropping edges of the beds of limestone that are exposed on the bottom and extend even into the lake. Black-rock appears to be a mass of Carboniferous limestone, a remnant of a bed that once extended over the area occupied by the mountains, but now probably dipping beneath the valley and the lake-basin. Church Island is composed almost entirely of quartzites. Antelope Island has a table-shaped top, which would indicate that the terraces reached as high as its present summit.

As a fine illustration of erosion in connection with these remarkable anticlinal folds and synclinal valleys, we might take the Wahsatch Range from Salt Lake City northward. To the southeast and east of Salt Lake City we can see, with great clearness, the deep water-worn cañons cleaving the mountains from summit to base, while on either side are the sharp angular peaks rising up among the regions of perpetual snow. Twin Peaks are among the loftiest of the range, and may be seen at a great distance on either side. The cañon of the Little Cottonwood is one of the most picturesque in this very picturesque region. At the head of it is located the celebrated Emma Mine. The walls on either side rise to the height of 200 to 300 feet. We have at the base the beautiful gray massive syenite, which is employed in the construction of the Mormon Temple, and resembles our best Quincy granite. Upon this rests a series of feldspathic gneissic strata, and upon these were deposited the lower quartzites unconformably. The dip of the gneiss is south or southeast, while the quartzites incline north or east of north. The order of superposition is most clearly shown by these wonderful gorges. But as examples of erosion they excite wonder.

The evidence of drift or glacial action is everywhere seen on a grand scale. The sides of the cañons are worn and furrowed by the masses of snow and ice that have slidden down for centuries. The waters gathering and freezing in the fissures on the sides and margins of the cañons pry off, as it were, immense masses of rock, which fall down into the valley below. Masses, 50 to 100 feet in diameter, block up the pathway. Near the entrance of the cañon from the valley the amount of drift-material which has been swept down from above is prodigious, showing the results of forces not now in operation. As we pass along the west side of the range, we shall find a vast thickness of the sedimentary rocks, ranging through the Silurian, Carboniferous, Triassic, Jurassic, and Tertiary, inclining from the mountains toward the plains, showing the original anticlinal structure of the entire range.

In City Creek Cañon, just in the rear of Salt Lake City, we find near the head, all the older rocks, up to the Jurassic inclusive, standing nearly vertical, or inclining at a high angle, with the conglomerates of the Wahsatch group, jutting against the Jurassic beds, also inclining at a moderate angle. I have never yet observed any rocks on the west side of the Wahsatch Range filling up the interval between the Jurassic limestone and the Wahsatch conglomerates. We know, however, that south of Utah Lake, the interval is filled up more or less by the coal-group, which seems to be, from the evidence of the fossils, the same as that so well shown at Coalville on the east side of the Wahsatch. We see by this fact that the conglomerates, although not conspicuous at the present time, on the east side of the valley, did, however, extend over the range into the valley, and may, for aught we know at the present time, extend far across the valley, for they are shown with a great thickness on the west side from City Creek Cañon for several miles to the northward.

From among the Tertiary clays and conglomerates north of the city near the Hot Springs and above, the dark steel-gray limestones of the Carboniferous period crop out in numerous places. About ten miles north of Salt Lake City all this immense mass of sedimentary beds, at least 10,000 feet in thickness, has been swept away, leaving the gneissic nucleus bare with the modern drift which underlies the terrace jutting against the sides. From Farmington to Weber Cañon, a distance of about twenty-five miles, the beds of the little streams which flow in great numbers and carve out deep cañons in the sides of the mountains, furnish no trace of any unchanged rocks.

Standing upon some high point and casting the eye northward along the range, the very granitoid nucleus would appear to have been worn away, and the east side of the anticlinal to appear with the upturned edges of the strata cropping out toward the valley near Ogden. This monoclinal condition of the range continues northward beyond Corinne, and in the intervals are some very fine exhibitions of the strata. Here and there the granitic rocks appear from beneath the quartzites, but not continuously. If we take the position that this wonderfully picturesque range of mountains, which we call the Wahsatch Range, was originally a complete anticlinal fold, then it forms a fine illustration of the erosive effects of water in comparatively modern geological times, which for so great a distance has swept away the entire half of the range. We may also suppose that beneath the great thickness of superficial deposits which compose the terraces, the edges of the strata which form the west side of the fold now exist, dipping beneath the valley, but rising again on the side of some other fold in the basin as Antelope Island, &c. If our suppositions are true, the next question that at once arises in the mind would be as to the cause of this tremendous erosion. We have neither space nor time, even if we had all the facts, to discuss this most interesting problem in the present report, but we promise our readers to recur to it again at some future time. We may, however, suppose that the Wahsatch Range formed the eastern shore of the great inland sea which, at a comparatively modern geological period, covered the entire basin. How great a depth it ever attained it is difficult now to determine, but at some period its waters must have reached high upon the sides of the loftiest ranges, so that they appeared scattered here and there as islands projecting above the surrounding waters. It is probable that during the gradual decrease of the waters of this lake the greater portion of the erosion of the cañons was performed. Up the valleys of all the little streams that lead into Salt Lake are the terraces and peculiar lake-deposits, showing that the lake-waters extended far up beyond the wall-like shores. It is altogether probable, from the proofs which are found everywhere in these valleys, that there were continued oscillations in the depth of the lake-waters, a rise and fall, and long periods when the waters would remain at a fixed level. If we take the position that the present results of erosion have all been brought about by the slow destruction of the rock-materials by water, and that this force is produced by the agitation of the waters beating upon the shores, then we may suppose that the winds from the west and southwest prevailed and gave to the waters the force that slowly produced the erosive results that we now see on the east and northeast sides of the valley. Other causes may have united in producing these results, which we hope to present at some other time.

From Salt Lake Valley the Snake River division of the survey proceeded northward, by way of the parallel valley, to the valley of Snake River near Fort Hall. In my report for 1871, I recorded most of our observations on this route, and now refer the reader to the more complete account of Professor Bradley in this report.

As we proceed northward toward the divide between the waters of the basin and Snake River, the quartzites seem to diminish and the calcareous beds to increase, and the conditions seem to have been more favorable for the preservation of organic remains. The Carboniferous limestones seem to be well developed, and charged in some places with characteristic fossils. On the divide between Ross Fork and Lincoln Valley, near Fort Hall, Professor Bradley obtained a stray mass of limestone, in which was crowded together a mass of minute fossils, nearly forty species, many of them identical with species found at Spergen Hill, Indiana. (See Catalogue of Fossils, by Mr. Meek.) This is certainly a most important discovery, extending the existence of this formation very much farther west than it had ever been known before. Previous to this time not a single species of this group had been found west of Iowa or Missouri. It indicates that quite probably, if the great mass of Paleozoic rocks of the West could be examined in detail, they might be separated into numerous subdivisions, as we find them where they have been studied so minutely east of the Mississippi. The evidence, however, so far as I have been able to procure it as yet, is against any well-defined lines of demarkation; that the fossils which have been employed by paleontologists at the East to characterize certain beds pass from one to the other in these western groups, so that no well-defined line can be drawn in most cases.

As far back as 1857, while the writer was connected with the exploring expedition of Lieutenant Warren, United States Topographical Engineers, he obtained, from a series of reddish calcareous sandstones, a group of fossils, which Mr. Meek at once identified as belonging to the horizon of the Potsdam sandstone of New York. The key having been once secured to the age, it was not difficult to extend the area of this group farther west and north and south on a geological map, and one was prepared by me and published in connection with my report for 1869, which indicated the existence of this division all along the margins of the eastern Rocky Mountain ranges. But it was not known until the present season that still higher members of this group existed in the far West. While the Snake River division was passing up the Malade Valley, Professor Bradley discovered masses of limestone filled with fragments of trilobites that indicated the existence of the Quebec group. The proof once made known from some favored locality, it was not difficult to extend the geographical area over the greater part, or perhaps all the area, of the Northwest. At any rate, the party under my direction found this group well developed over the greater portion of Montana. Along the Gallatin River, near the Three Forks, and below, the Silurian beds reach an aggregate thickness of 1,600 to 2,000 feet, and most probably include the entire Potsdam group. Future explorations in localities where the conditions are favorable, may reveal the existence of other subdivisions of the Silurian, Devonian, or Carboniferous. The discovery of the well-known Silurian coral, *Halysites catenipora*, in the summer of 1871, near the sources of Ogden Creek, points to the existence of the Niagara group.

In the spring of 1859, a large expedition was organized under the War Department for the purpose of exploring the sources of the Missouri and Yellowstone Rivers, and placed under the direction of Captain William F. Raynolds, Topographical Engineers. To this expedition the writer was attached as geologist. The party started across the country from Fort Pierre, on the Missouri River, in the spring of 1859, passed along the north side of the Black Hills to the valley of the Yellowstone, and then up that valley to the mouth of the Big Horn River, and then up the valley of the Big Horn to the Big Horn Mountains southward to Deer Creek, a tributary of the North Platte about one hundred miles above Fort Laramie, where they spent the winter. In the spring, the party passed up the North Platte, by way of the Red Buttes, to the valley of Wind River, ascended that stream to its source, and crossed the Wind River Mountains over Union Pass into the valley of Snake River, crossed that stream near Jackson's Hole, passed up the valley northward across the sources of the little streams running into Henry's Fork on the east side, and entered the valley of the Madison through Low or Raynolds's Pass. Captain Raynolds's report, accompanied by an excellent map, was published by Congress in 1868, and the report of the geologist, accompanied by a geological map in colors, was published in 1869. As these reports are now out of print, I take the liberty of making such extracts as will be of interest in this connection. The portion recording my observations of the geology about the Wind River Mountains, Snake River Valley, Tétons, &c., is comprised in the following extracts from Chapter X, commencing at the bottom of page 85. I have quoted the chapter without corrections, that it may be compared with the more careful observations which were made by the party the past season. Only one prominent error occurs, and that is the statement that the central portion of the Téton Range is composed of erupted rocks, whereas Professor Bradley has shown that they are formed mostly of gneissic strata, penetrated here and there by dikes.

"*June* 1.—On the west slope of the Wind River Mountains we met with a thick deposit of drift material, which, as we descended to Gros Ventres Fork, soon expanded into a great thickness of recent strata, evidently quite recent Tertiary. The banks of the Gros Ventres Fork present high bluffs, some 300 to 600 feet high, but I should think that this formation had been deposited after the surface of the country had attained, for the most part, its present configuration. The strata consist of loose fine arenaceous clays, the layers containing more or less arenaceous matter, which does not effervesce, and layers of harder rock, a fine-grained and coarse sandstone, and sometimes an aggregation of grains of quartz with ferruginous matter and particles of mica. The materials are all evidently derived from the vicinity. Some of the masses of rock present a compact fine siliceous structure and effervesce feebly.

"*June* 4.—To-day the Tertiary strata begin to assume a good deal of importance. We have the brick-like materials which result from the burning out of the lignite beds. There were also masses of indurated clay, covered with vegetable remains and impure lignite beds; indeed, all the indications which the lignite Tertiary beds present on the east side of the mountains. The beds are also much disturbed, inclining at various angles. The following section of the lignite beds was taken here, which will serve to show their resemblance to those on the eastern side of the mountains:

9. A yellow fine-grained sandstone and a dark gray limestone, with a parting of clay. The limestone is quite brittle, breaking into thin laminæ, and contains impressions of dicotyledonous leaves and a distinct species of *Unio*. 15 feet; inclination, 28°.
8. Light yellow sandy marl. 15 feet.
7. Impure lignite. 4 feet.
6. A series of marly clays which, when saturated with water, forms a thick paste, variegated in color. Near the summit, just below the lignite, is a thin seam, four to six inches, of hard-shell limestone, with the shells in the most comminuted condition. I recognized *Unios*, *Viviparas*, &c., sufficient to show that the deposit is fresh water. 150 feet.
5. Alternate dark gray and brown-yellow gray, fine sandy and clay layers, with some calcareous matter and a few seams of incoherent sandstone, sometimes assuming a concretionary character. 200 feet.
4. Impure lignite and clay. 8 inches.
3. Yellowish-gray clay. 4 feet.
2. Impure lignite. 6 inches.
1. Yellowish clay, with some calcareous matter.

The general inclination of all these beds was about 20°.

June 5.—We ascended a high ridge, from which we could see to a great distance. Looking to the dividing crest of Wind River Mountains, we find the exposed belt of granite to be not more than four or five miles in width, and gradually lost in the basaltic or eruptive range, which also renders itself conspicuous. The Tertiary beds seem to reach fully up to the crest on the west side, and often passing what appears to be the junction of the Big Horn Range, even to the entire divide of the mountains. We also see, high up on the flanks of the mountains, a full series of the more recent Tertiary beds, with pinkish bands, precisely similar to those in the Wind River Valley. These pass up into yellow sandy marls and sandstones. I have estimated the entire thickness of the Tertiary beds on the west side of the mountains at 1,200 to 1,500 feet. In the lignite beds and vicinity are great quantities of selenite and silicified wood. All over the highest hills near the crest of the mountains, 10,000 feet above the sea, are the recent Tertiary beds. A large portion of the superficial Tertiary strata incline from Wahsatch and Green River Mountains, showing that these deposits were probably disturbed at the same time by the uplift of these ranges. In the distance are the Three Tétons, rugged peaks of erupted rocks, towering high above the rest. These peaks are sharply pointed, piercing the clouds like needles, and it is said that the trappers have never been able to get near them. So far as we have yet seen, at least fifty miles of the dividing crest of the mountains are covered with Tertiary rocks.

"*June* 7.—We passed up a ravine to-day, which runs north and south, and is close to the divide which overlooks Snake River. The lignite strata incline nearly northeast at an angle of 40°, and as we ascend, many of the lower members of the lignite strata are exposed. We also see quite large areas covered with eruptive rocks, and also a sort of basaltic conglomerate composed of large angular masses of rock cemented with the melted material. Mr. Bridger informed me that these same formations continue all along the Wahsatch Mountains to Bear Spring and Henry's Fork, and down Snake River nearly to Blackfoot Creek. It also covers the valley of the Yellowstone to points below the lake. There is simply a band of granite along the divide in the form of a narrow belt.

"Descending the Gros Ventres to its junction with the Snake River, we find the same Tertiary beds prevailing to a great extent, and sometimes assuming a variety of lithological characters, at one locality a thickness of 200 feet of worn pebbles and sand, the whole inclining from 20° to 35°. Gradually the Cretaceous rocks appear along the valley of the stream. A section of these rocks would be as follows:

3. A series of sandstone, arenaceous limestone, and laminated marls. 150 feet; inclination, 20°.
2. A series of thin indurated beds of clay, sandy marl, limestone and sandstone, with six or eight seams of impure lignite, which has ignited in several places, giving to the earth in contact a brick-red color. 80 feet.
1. Gray ash-colored sandy laminated marls, with layers of fine sandstone. Sandy matter predominates. 100 feet.

"In the upper beds were quite abundant fossils, consisting of a huge *Inoceramus*, two species of *Ostrea*, a large *Pinna* four inches long, a *Cardium*, and many small shells. The whole deposit indicates shoal water in a shore-deposit, and there are also fragments of wood. As we descend, the Jurassic is exposed with *Ostrea* and *Belemnites densus*, and there is an enormous development of the red arenaceous beds, making a thickness of 1,000 to 1,200 feet or more. Near the middle of the red bed is a layer of gypsum 4 feet in thickness. There are other seams or layers of gypsum, each with partings of the red marl. The dip is quite variable, at one place 29°, at another 15°, and again 7°.

"The Cretaceous beds differ from those on the east side of the Wind

River Mountains, both lithologically and paleontologically, but the Jurassic and red deposits are, so far as could be observed, precisely alike in their character and contents. I believe, however, that all these formations at one time extended continuously over the entire divide of the Rocky Mountains.

"As we descend into Jackson's Hole, we find the Carboniferous limestones with their usual lithological characters, a very hard brittle yellow rock, with much cherty material, inclining 12° to 15°. There is one thick cherty layer, 15 feet thick, dark bluish color, inclining 12°. We find these limestones along the mountains on both sides of Jackson's Hole, but the central portions of the mountain-ridges are composed of eruptive rock.

"Near Snake River, on the right bank, is a rather low range of hills, which presented the appearance at a distance of being composed of stratified rocks. On examination the rocks appear to be a bluish, very hard cherty limestone, apparently Carboniferous, 160 to 200 feet thick, passing up into a compact siliceous gray rock with a reddish tinge. In the limestone are numerous fossils, mollusca, and corals, but too much broken and obscure to determine. On the left side of Snake River I saw limestones charged with fossils, especially corals. These limestones are scattered promiscuously along the flanks of the lower hills and ridges, and while in many places they are in part or entirely removed by the erosive action of water, the evidence is clear that they were deposited here with a thickness fully equal, and were possessed of a similar character, to those on the eastern slope of the mountains. The valley of Snake River is broad, fertile, and beautiful, and very few traces of the Tertiary beds are seen, and I am now inclined to think that we can see, to a very great extent, the configuration of the main portion of the Snake River Basin as it was prior to the Tertiary period; for the Tertiary beds, being of a loose friable material, were easily eroded away, leaving along the banks large areas covered with it.

"*June* 18.—Crossing over Snake River, we ascend the pass 1,900 feet above the bed of Snake Fork. The mountain-ridge over which we passed could not be less than 1,000 or 1,100 feet higher, so that these mountains are between 9,000 and 10,000 feet above the sea. The highest Téton, was measured with the sextant and made to be about 10,000 feet. All along the margins of the ridges we see a plenty of the blue, cherty Carboniferous limestone; also, the siliceous rocks which lie above, and a great many granitic masses, and also gray micaceous slates. We have seen much of the Carboniferous rock along our road to-day; also red arenaceous beds, with now and then an erupted ridge. The central portions of the mountains are composed entirely of the eruptive material.

"*June* 19.—We traveled nearly due north twenty miles, down Pierre's fork into Pierre's Hole, a beautiful valley, surrounded by mountains, about fifteen miles wide and thirty long. On our right is the Téton Range, composed entirely of eruptive rocks, with a general inclination west or a little north of west. It would seem as though this whole valley had been formed by the drainage accumulating in a fissure of the upheaval, for the mountains all seem to incline in the same direction. The hills are composed in part of a sort of vesicular trachyte, exceedingly porous, some of the cavities being an inch in diameter. The broad, level prairie is composed, to a large extent, of well-worn rocks, basalts, obsidians, granites, &c.

"*June* 20.—We continued our course directly north, and soon began to ascend low ridges, breaking the level of the prairie. These ridges extend down from the mountains on each side, and seem to give shape to the valleys of the multitude of little streams. We have here and there an exposure of the rocks, which are undoubtedly eruptive, and present the appearance of stratified deposits. They are arranged in more or less thin layers, some of which sound under the hammer like clink-stone, and are quite compact. Sometimes the breakage-joints, or cleavage, are vertical in a single layer, but from their external appearance I would suppose the bluffs of vertical rocks were a dark-gray marly limestone, charged with fossils. There is also a good deal of uniformity in its composition, the only difference being that some of it is more compact than others. The eruptive material in this valley assumes a variety of form; some of it has a black, opaque crystalline appearance, like obsidian; then a sort of sandstone, easily decomposing, or, as it were, exfoliating; then a sort of lava, or slag; then a vesicular trachyte. There are also veins of quartz, sometimes ribbon-like, one-fourth of an inch wide. The greater part of these rocks, however, would seem to have been melted or heated under comparatively little pressure. These rocks predominate, and, indeed, comprise almost the only rocks on the western slope, and therefore it may be called a basalt country. Many of these rocks seem to yield very readily to the decomposing agencies of the atmosphere, and furnish entirely the soil of the valley, which is quite black and fertile, sustaining a luxuriant growth of vegetation. The streams that issue from the mountains are very numerous, the water pure as crystal, and the valleys clothed with rank herbage; but the timber, which fringes the little streams here and there, is very scarce. There are also many beautiful springs and lakes.

"*June* 20.—We passed up the valley of the Lake Fork and crossed the dividing crest of the mountains to the Madison Fork of the Missouri. High hills of eruptive rock surround us on every side, with now and then small patches of limestone along their sides, inclining at various angles. There are, also, mica schists, talcose slates, and quartzose limestones often underlying the layers of eruptive material, and conforming to them in inclination, which is from 30° to 60°. Many of the ridges are 2,000 feet or more above us, and are covered with snow. The Low or Raynold's Pass is like a lawn—smooth and covered with grass, with a large superficial deposit composed of the rocks in the vicinity. It is plain that the eroding agency of water has had its effect in smoothing this pass, though it has not formed it. It is undoubtedly due, to a great extent, to a break in the continuity of the elevatory force. The mountains here do not seem to follow any fixed lines of fracture, or in fixed directions, but to be a series of protrusions, forming, in many instances, a continuous line for a great distance; but the irregularity of the outline of the crest is due, to a great extent, to the irregularity of the force along the line of continuity, though a small portion may be due to atmospheric agencies. The facts above stated are true from the fact that the different strata of sedimentary rocks, which must, prior to the upheaval of these ridges, have covered the surface, lie in regular order of sequence outward from the ridges. We have every variety of volcanic rocks and metamorphic conditions. Washed out of the Madison cañon and scattered over the terraces along that stream are every variety of granitoid rocks, mica slates, hornblende, &c. There is every variety of these rocks, depending upon the greater or less predominance of some constituent, and disseminated through the rock are seams of white quartz. None of the red feldspathic rocks which so prevail in the Black Hills are seen in this region. Along the rivers is a series of terraces which are covered with bowlders, slightly worn, exhibiting the rock-character of the mountains from which these streams take their rise. As we descend the Madison we find that the valley seems to pass along a sort of anticlinal axis, and on each side lofty, nearly vertical walls of trachyte, arranged in thick layers. The lower portion appears to yield quite readily to atmospheric agencies, owing to the ferruginous matter contained, which renders it a loosely aggregated mass of crystals of feldspar. As we ascend upward the rocks become more compact, and the upper layers are a cellular trachyte. In some places the upper compact beds assume a columnar structure, breaking into the form of vertical columns; these break in pieces and cover the sides of the hills with masses of rock. Lower down on the Madison we find layers of the red feldspar, which present the appearance of stratified beds like the Azoic rocks, with an inclination in the same direction with the overlying basaltic rocks. There are numerous seams of white quartz, also trap, running across the country in every direction, many of which indicate the presence of gold-bearing rock. The summits, or crests, of the high mountains are ragged, not from erosions since upheaval, but owing to the manner of the upheaval. Each peak assumes, to a certain extent, the form of an independent uplift, with layers of rock inclining around from every side; and yet it is by a series of these peaks connected together, more or less, that a mountain range is formed. Wherever these peaks or groups of peaks are separated a short distance, a low point is made in the range, which gives passage to streams. Very many of these low passes have no streams issuing from them at this time. The Madison forms a cañon by cutting through one of these lofty ridges at the upper portion of the Burnt Hole, and a second one at the lower end of the same valley. Still below the feldspar beds and near the junction of the Three Forks of the Missouri we have beds of exceedingly slaty character, inclining at angles of 31° and passing down into the granitoid rocks below.

"In the valleys of these streams is a series of marls and marly sands and conglomerates, precisely like the upper beds of the White River Tertiary. These marls are mostly of a flesh-color, sometimes assuming the texture of a quartzose sandstone. Its greatest thickness in this region is about 200 feet, and not conforming to the Carboniferous rocks beneath, but inclining in the same direction about 8°.

"The Carboniferous rocks are largely developed in this region, and incline at very large angles from the mountains. The lower part of these limestones have been so affected by heat that the stratification has been very nearly obliterated, and presents a very rough appearance. Above this is a bed which is undoubtedly Carboniferous limestone changed, but which now very much resembles basalt, but contains more arenaceous matter, and appears to have had the stratification but partially changed. From the Three Forks these limestones extend westward or southwestward about twenty to twenty-five miles, and then continued northward toward the gate of the mountains along the Missouri. They also extend to the northwest to a range of mountains, in which is the Blackfoot Pass of Lewis and Clarke.

"*July* 3.—Visited the plateau, mentioned by Lewis and Clarke, between the mouths of the Gallatin and Madison. It is a long flat ridge of limestone, representing the portion of the inclined rocks which form the left side of the cañon below.

"The rocks on that side incline 24°, continuing far on the distant hills. The base of this small ridge is a bluish cherty limestone, sometimes yellowish, very compact or hard, breaking into fragments just like the Carboniferous limestones before seen. Dip, 33°. This bed corresponds with a portion of the right side of the cañon next to the water. There are traces of abundant fossils, as broken crinoidal remains and other mollusca. It weathers so as to expose upon its sides small flinty masses of chert. This bed passes up into a light-gray limestone with drusy cavities, and breaking into irregular fragments in the direction of stratification, a form of fracture common to the Carboniferous rocks. The dip of this bed is 31°. Obscure traces of fossils are seen. These layers continue on up, divided by thin partings; others are solid, from 6 to 20 feet in thickness. Then comes a bed without distinct lines of stratification, often assuming the form of a sort of conglomerate, with masses of limestone on all sides, cemented together with sulphate of lime; dip, 20°. There is then a return to the former condition of a yellow limestone. It is full of dog-tooth spar and seams of crystalline matter. I should estimate the limestone to be about 500 feet in thickness.

"On the right side of the Gallatin, and dipping eastward from the cañon at an angle of 8°, is a bed of yellow-gray sandstone and marl. It does not quite conform to the Carboniferous limestone, though dipping in the same direction. The Gallatin Fork, from its mouth to the point where it issues from the mountains, is about fifty miles, flowing through a beautiful valley well fringed with cottonwood trees, mostly bitter cottonwood. The upper portion of this valley has been most beautifully smoothed by the erosive action of water, leaving a space between the base of the mountain-ridges and the upturned edges of the sedimentary rocks of twenty or thirty miles which is smooth like a lawn. The Carboniferous rocks present a series of monoclinals of the most interesting character. Underneath them is a series of rocks, which seem to represent the Potsdam sandstone. It is the most variable series which I have yet seen. In order of descent we have a reddish, rust-colored rock, mostly fine grained, compact, quartzose, siliceous, almost the appearance of a metamorphic rock. It is sometimes made up of an aggregation of grains of quartz. Beneath is a series of thin strata of dark steel-gray micaceous sandstone, sometimes becoming a fine aggregation of water-worn pebbles and dark-brown clay-slate, gradually passing down into what appears to be a true eruptive rock, with vertical seams of white quartz running through it. I am inclined to think that the eruptive rocks have been thrust in between the partings of rock, so that we have a bed of eruptive rock, and then a layer of the sandstone, and so on alternating.

"From the Gallatin we passed up one of the little forks emptying into that river, over Carboniferous rocks, on to the source of Smith's or Kame's River, which empties into the Missouri below the gate of the mountains. Reaching the vicinity of the mountains, we find that the basaltic or eruptive rocks prevail to a very large extent over all others. On a little branch flowing into Smith's River near its source, we find a dark steel-brown bed, 50 feet in thickness, a fine conglomerate at base, but gradually growing coarse until toward the summit it is composed of large angular blocks of mixed gray basalt, aggregated with a reddish material. The beds dip northeast 45°. The imbedded masses are more or less water-worn. This bed seems to continue a long distance, and is sometimes vertical; sometimes the pebbles are as much worn as those of the little streams; and it seems to me that they have been changed since deposition, for they now partake much of the color and character of the matrix, except that they are much harder. The basaltic rocks along our route are developed to an enormous extent, and present every variety of texture, that which yields readily to atmospheric agencies predominating.

"*July* 6.—Passing along the Smith's River, I saw this series of curious, somber, apparently basaltic rocks, which, except for their structure and color, I would regard as Cretaceous or Tertiary. The whole series is arranged in beds of marl, with more or less compact layers of harder rock, which project out the same as in those formations. In these upper beds I found fragments of wood, and in the uppermost beds were fragments of leaves, which I cannot but regard as of Tertiary age, and that the whole series of beds have been greatly affected by heat so that the lowest beds have been entirely changed. Passing up the mountain we found ourselves in a synclinal basin, with the strata dipping at a low angle, those at the southeast at an angle varying from 30° to 60°, apparently comprising the different formations from Tertiary to Carboniferous. The rocks do not show so many signs of heat as heretofore. Our course has been directly north, and mostly through Carboniferous rocks, dipping about southeast at an angle of 20°. There are, in the cañon that we passed through, at least 1,000 feet of limestone exposed, and as we leave the cañon northward we find 200 to 300 feet of red marly limestones, much like the red deposits we have before met with, only harder. These rocks are peculiar, differing from any before seen. They pass from a red loose slate down into a compact clay-slate, gradually varying from a deep red to black thin slates, becoming more and more compact as we descend, until they appear to be a melted rock, and the joints are so close that they separate the whole mass into small fragments. The rock does not effervesce at all with sulphuric acid, but is of a very compact texture. In regard to the age of these beds I can form no exact idea, no fossils having been detected, though frequent sun-cracks are seen upon the surface of the slates."

The following paragraph, describing one of the four passes near Henry's Lake, is taken from the report of Colonel W. F. Raynolds of his explorations in 1860, page 98:

"The pass is only four miles from, and 200 feet above, the lake, and so level that it is difficult to locate the exact point at which the waters divide. It is about a mile in width, with the sides sloping gently to the center. The barometer stood at 23.65 inches, indicating a height of 6,350 feet above the sea-level, or 1,500 feet lower than the summit of the South Pass. The approaches upon either side are remarkable, being of about a uniform ascent of 50 feet to the mile, and thus affording unequaled facilities for either wagon-road or railroad purposes. I named it Low Pass, and deem it to be one of the most remarkable and important features of the topography of the Rocky Mountains."

This beautiful pass has been so carefully described by Colonel Reynolds that I gladly record its name on an official map as Reynolds's Pass; the name Low Pass, given it by Colonel Reynolds, not being sufficiently distinctive for a geographical name.

CHAPTER II.

GALLATIN VALLEY—YELLOWSTONE VALLEY.

In my annual report for 1871 I gave a brief description of the Gallatin Valley; but inasmuch as one division of the survey took Fort Ellis as its initial point again in 1872, I shall render the present account more clear by presenting a *résumé* of the geology of the valley.

In beauty and fertility the valley of the Gallatin surpasses all others in Montana which have come within the limit of our explorations. The town of Bozeman is located near the upper or south end, and Fort Ellis lies about three miles to the southeast, under the shadow of the mountain-ranges that form the water-shed between the Missouri and the Yellowstone. On the east side of the valley is the Gallatin Range of mountains, which gives origin to numerous branches of the Gallatin River on the west side, and many branches of Shield's River on the east side. On the north side of the valley is a series of broken ranges, which give origin to numbers of branches of the East and West Gallatin Rivers. A ridge or low divide extends down between the Gallatin and Madison Valleys, and entirely disappears before reaching the junction of the Three Forks. This valley is about forty miles in length from north to south, and five to fifteen miles in width. This valley may be regarded as typical of the general character of the surface of Montana, as well as parts of the adjacent Territory which were examined by the survey. Two general divisions might be made of the entire surface, mountain and valley. The valleys and the portions which are open to settlement are, at the present time, occupied to a greater or less extent by thriving farmers, with here and there prosperous villages. They are for the most part old lake-basins, geologically of comparatively modern date. Along nearly all the more important rivers, from their sources to their entrance upon the plains, there is a chain of these valleys, varying in length from a mile to fifty or sixty miles, and connected by a cleft or gorge in the mountains, through which the river has worn its way. In all these valleys there is a greater or less thickness of deposits, very similar in character, of a light-gray or cream color, and composed mostly of clay, lime, and silica in various proportions. Very few fossils have been found in these deposits about the sources of the great rivers, but it is most probable that the deposits are of the same age in Western Idaho, Oregon, and California which have yielded large quantities of vertebrate remains. In the summer of 1871 I discovered in these lake beds species of *Anchitherium* in the head of the Jefferson Fork, and with it were associated fresh-water and land shells. But these beds yield the most beautiful forms of silicified wood that are found in any part of the continent. It is sometimes called opalized wood, and it was doubtless formed in connection with hot springs. It is most probable that during the Pliocene period hot springs prevailed to a greater or less extent all over the western portion of our continent, and their action may serve to account for many problems which now seem obscure. This deposit varies from a few feet in thickness to 1,000 or 1,500 feet, and is usually nearly horizontal, resting unconformably upon the older rocks. Not infrequently these beds incline 5°, indicating slight changes in the general level of the surface since their deposition.

Then we have a vast thickness of what may be called coal-strata in the West, the age of which seems obscure. They contain the great and valuable deposits of coal in the West, and are thus of the utmost importance in an economical point of view. This group varies in thickness from 1,000 to 5,000 feet, and in some parts of the country may reach the thickness of 10,000 feet. The evidence at the present time points to the conclusion that the lower portions of this group are Cretaceous, passing up by gradual transition into the Tertiary, and that the greater portion may be regarded as of the age of the later period. Then follow in descending order the Cretaceous, Jurassic, Carboniferous, and a vast thickness of Subcarboniferous strata, most probably of Silurian age. . The Silurian beds usually repose unconformably on metamorphic strata, composed of gneissic or granitoid rocks of every possible texture. These constitute the nucleus of nearly all the principal mountain-ranges.

From the above brief outline it will be seen that two divisions of the geological scale, Triassic and Devonian, are not represented in Montana, so far as we have the evidence up to the present time. We may state, however, in this connection, that we do not deny the existence of these formations in this portion of the West, only that the rocks have yielded us no such information as yet. When we reflect that, in countries where the geological formations have been studied for nearly a century by the ablest minds under the most favorable circumstances, they are yielding up new and startling facts every year, we cannot hope in a preliminary survey of so vast an area to exhaust the discoveries.

In the great area which comprises what we term the Rocky Mountain region, the groups of strata mentioned above appear and disappear in a strange manner at times, thus rendering their study more difficult and laborious than one might suppose at first sight.

Sometimes the Carboniferous limestones, with their characteristic fossils, appear to rest on the gneissic beds below; then again there will be 1,500 to 2,000 feet of Silurian strata intervening. At one locality a certain group of metamorphic beds will occur, and at another, a series quite distinct in texture. In one locality the red beds will be well developed, reminding one of the possible existence of the Triassic; in another locality, not far distant, no trace of these can be found. The same may be said of all the groups of strata. One peculiarity of the coal-strata consists in their dark somber color, which I have observed nowhere else except in this region.

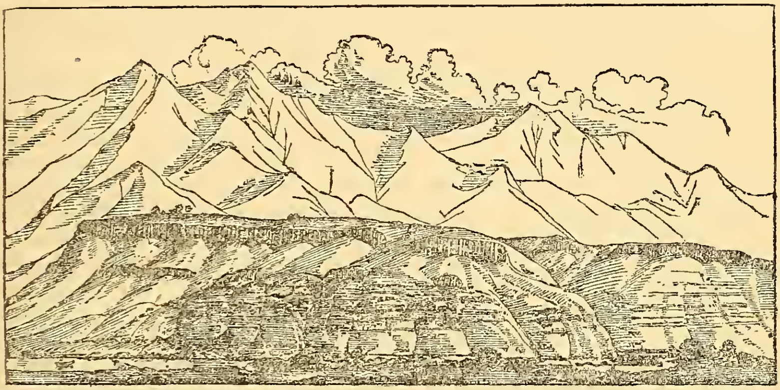
In order that all the details of the local geology may be more clearly set forth, I have continued the same plan in this report which was adopted in the previous ones, of describing the geological features of the country as observed along the routes traveled.

The party under my direction left Fort Ellis for the Yellowstone Valley July 20. Much scientific work had been done previous to that time, but during the present season the deep snows on the mountain-ranges would have prevented successful exploration in Montana before the 10th of July. The previous winter had been one of the severest ever known in the Territory, and the snow remained until late in the summer. During the melting of these winter-snows the streams are so high that traveling becomes very difficult. The season of exploration is comparatively short.

Our entire outfit having been completed at Bozeman and Fort Ellis, we passed up the grassy valley of Spring Creek, by way of Bozeman Pass, to the summit of the divide. Just opposite Fort Ellis, on the east side of the creek, is a ridge of gray and grayish-white marly sands and sandstones, with nearly horizontal strata jutting up against the older rocks. This ridge presents a fine example of the lake-deposits which are so common in the valleys all over the West. It has evidently escaped the erosion which has swept away the greater portion of these deposits, and this ridge may now be regarded as a remnant—a monument left to indicate the approximate thickness of the original beds. The greatest thickness of these beds in this valley was probably about 1,500 feet. The summit of this ridge is 800 feet above the valley, and its greatest thickness could not have been less than 1,000 feet. The evidence is clear that all these valleys were once filled with water, so that only the summits of the loftier portions were exposed; that probably, during what geologists term the Quarternary period, these waters gradually subsided, sweeping downward, to the lowlands near the main

Missouri and the Mississippi, the greater portion of these deposits to form the great Yellow Marl or Loess group. That the origin of these deposits dates back to the Pliocene period at least, we believe from the evidence given by the organic remains; and there is other evidence that points to the conclusion that these lakes continued up nearly or quite to our present period. The surface is usually covered to a greater or less extent with the usual drift deposit of the country, and not unfrequently the groups of rounded bowlders are so arranged as to indicate that no important changes have taken place since the waters subsided. In the Yellowstone Valley, about two miles above Boteler's ranch, the river has exposed a section of the Pliocene beds, (Fig. 1,) which reveals

Fig. 1.



MODERN LAKE DEPOSITS CAPPED WITH BASALT. TWO MILES ABOVE BOTELER'S RANCH, VALLEY OF THE YELLOWSTONE.

about 200 feet of light-gray marly sands and sandstone, passing up into about 100 feet of pebbly drift, the whole capped with a bed of basalt that must have overflowed since the lakes existed in full force. A little distance back of the river, extending to the base of the mountains, there is evidence in the superficial deposits that this lake continued a long time after the overflow of the igneous matter.

I shall pass rapidly over the geology of the region about the source of the Gallatin, referring the reader to the excellent report of Dr. Peale, who made a minute examination of Spring Cañon, Mystic Lake, and the district about Mount Blackmore.

In general terms, the Gallatin Range is composed of gneissic and quartzitic beds as a base, with a great thickness, 1,700 to 1,800 feet, of Lower Silurian strata resting unconformably upon them. Above these, and apparently conforming, is a thickness of 1,000 to 2,000 feet of well-marked Carboniferous rocks, mostly limestones, more or less pure; then running eastward from the Gallatin Valley and inclining at various angles in the same general direction are the Jurassic, Cretaceous and Coal groups, with an aggregate thickness of 10,000 to 15,000 feet. This entire group of strata, which compose the Gallatin Range and its foot hills, extends nearly to Shields's River, a distance of twenty miles in a straight line. The Carboniferous limestones, which are very hard and yield less readily to atmospheric influences, form, with their upturned edges, the very summit of the Gallatin Range, including Bridger's Peak, Union Peak, &c. On the west side of the Gallatin Range the foot-hills are very abrupt, rising at once to a height of 800 to 1,200 feet, while the peaks and the sharp ridges are 2,000 to 2,500 feet above the valley below. On the east side the hills, composed of the more modern groups, descend gradually to the immediate valley of Shields's River.

We thus see that this range constitutes the east portion of an anticlinal, and, so far as we know, a huge monoclinal. We may hereafter discover fragments of the west portion. So far as the line of uplift is concerned, the Gallatin continued southeastward, crossing the Yellowstone River, forming what we have located on the map as the Lower Cañon. The mountains about the sources of the branches of the East Gallatin, and those between the East and West Gallatin Rivers, are largely composed of the limestones thrown up in great confusion apparently; but really all having an inclination in the same general direction.

In my report of last year, I stated that there seemed to be a true anticlinal extending over to the Yellowstone, and that Trail Creek might flow in the valley between the two portions, but the more careful explorations of the past season have shown that all the uplifts belong to one side of the anticlinal, however chaotic the strata may appear. This great monoclinal is very remarkable. It commences down below the Three Forks, with a trend east by south, indicating greater irregularity in form. Sometimes the beds are inverted, and the whole series exposed down to the granitic, then again all are concealed except the coal strata. From Bridger Cañon to Spring Cañon, a distance of four miles, there is a complete break in the range, forming several passes, which are easily traversed with wagon-roads, in which no rocks older than the Coal group are seen. Then in Spring Cañon the older rocks are again brought to the surface in full force.

The investigations of the present season have shown that what appeared to be fragments of the western portion of an anticlinal are only fragments of the one great mass which have been broken off in the uplift and now lie scattered around in the valleys, on the foot-hills and mountain-sides, in apparent confusion. As I have before remarked, the main range of sedimentary beds continues east by south, forming the high divide between the waters of the Gallatin on one side and those of Shields's River and the Yellowstone on the other, but crosses the Yellowstone, forming the Lower Cañon, and inclining from the east side of the great range of mountains in which the Bowlder, Rosebud, and Clark's Fork, with their numerous branches, take their rise. In the intermediate space, sometimes low down in the valley of Trail Creek, and sometimes on the mountain-sides, are beds of coal, the strata above and below being vertical or horizontal, as the case may be. This region has been very carefully prospected for coal. The artificial excavations that were made threw great light on the position of those fragments, which seem to have been broken off and fallen down in the general uplift. At the present time it is only by most carefully following the channels of the streams as they cut down into the sides of the mountains, or by studying the artificial excavations, that we can gain any of the details of structure. With the exception of the main ridges of upheaval, the strata are mostly concealed by modern superficial deposits, which are covered with a thick growth of grass. Occasionally, also, these fragments crop out from beneath the mountains of trachyte, and volcanic breccia, which are so remarkable in this region. As previously stated, the limestone seems to have yielded less readily to atmospheric agencies, and consequently projects high up above the surrounding hills, and forms the leading topographical feature. In tracing it across the country, we may call it a limestone ridge, as it loses the name of Gallatin

Range east of the source of the Gallatin River, although the ridge continues on eastward, or south by east, to an unknown distance.

The Carboniferous limestones are always well defined, not only by their texture, but from the fact that they always contain fossils characteristic of that age in greater or less quantities. In some localities strata of considerable thickness are made up of an aggregate of fossils in a fine state of preservation. The almost universal distribution of these fossils would point to a uniform moderate depth for the waters of the Old Carboniferous ocean.

The Lower Cañon is about three miles in length, and the Yellowstone has cut its way through the ridge at right angles, so that as complete a section of the strata is shown on either side as one could desire. It was this limestone ridge that checked the waters above which formed the lake-basin, extending from the Lower Cañon to the Second Cañon, a distance of about thirty miles, and it was undoubtedly the slow wearing-out of the channel or cañon through the ridge that gradually drained the lake-basins above. After leaving the Gallatin Range, the older group of beds, which we have called Lower Silurian, ceases to be as conspicuous. The limestones of this group have a much older look, are more compact and contain a greater per cent. of silica, are full of cavities lined with crystals of quartz, and weather into much more rugged forms. The lower portions, instead of being composed of clays, shales, sandstone, &c., are quartzites or quartzose sandstones, entirely destitute of any traces of organic forms. They seem gradually to change their character and thin out very much in their eastern extension, so that not more than 100 or 200 feet in thickness rest upon the gneissic rocks in the Yellowstone Range east of the Lower Cañon. In the West Gallatin Cañon the same change in the Silurian group is observed.

Above the cañon the Yellowstone Valley expands out to an average width of ten miles, and was undoubtedly one of the old lake-basins peculiar to the West. From any of the peaks of the Yellowstone Range on the east side, one may obtain a complete view of the eastern valley, and the landscape thus presented to the eye is one of great beauty. The sides of the valley slope like a dish, so that the immediate base may be 800 to 1,200 feet above the bed of the river. These slopes are grassed over, and to the eye at a distance they appear as smooth as a lawn, gradually descending to the river-bottom. They are, however, oftentimes very much cut up by the little mountain-streams that wear deep channels through them. These channels afford excellent sections of these modern deposits.

On the east side of the Yellowstone River, commencing near the Lower Cañon, is one of the most symmetrical and beautiful ranges of mountains in Montana. In order that I might obtain a more definite knowledge of the structure of this range, I ascended one of the highest peaks that overlook the broad plains along the Yellowstone to the northeast. Last year I had supposed, from an examination of Emigrant Peak and its vicinity, that these mountains were mostly of igneous origin, but found, on a more careful examination of the northern portion, that the rocks are principally granitic and of the kind characteristic of the mountain-ranges generally. Our camp was located on the river-bottom about three miles above the Lower Cañon, and the peak which we ascended is situated a little south of east of the cañon. For a distance of four miles we ascended the grassy slope, covered here and there very thickly with rounded bowlders, which greatly impeded traveling scattered here and there are isolated hills of limestone, remnants left after the erosion of the valley. The sides of these mountains are everywhere almost vertical, and difficult of ascent, so that we were obliged to follow up the rocky bed of a stream for a long distance. Hugh masses of gneissic granite blocked our way at every step. In some of the cañons a few bowlders of igneous origin were observed. The study of the different kinds of rocks along the course of any of these mountain-streams usually gives one a pretty clear idea of the structure of the mountain in which they have their origin. The first ridge, which is about 3,000 feet above the river-bottom, is composed mostly of the metamorphic quartzites. The second ridge, which is about 500 feet higher, is composed largely of mica-schists and granitoid gneiss. The limit of the vegetation is about 9,000 feet, where the small scraggy spruces lie prostrate, and are not more than four feet in length. Above these no more tree-vegetation is seen. From the summit of this peak, a broad area is compassed in the field of vision. Far east and southeast, along the head-waters of the Stillwater, Big Rosebud, and Rock Creek, the gneissic rocks extend, with their sharp ridgelike peaks standing up like pinnacles among the perpetual snows. For fifty miles in every direction there is a chaos of mountain-peaks, varying in form according to the rock-materials of which they are composed. For grand rugged scenery I know of no portion of the West that surpasses this range. The little streams have cut innumerable gorges deep down through the very heart of the mountains, 2,500 to 3,000 feet in depth, and the exceedingly close texture of the granites and quartzites, of which the rocks are mostly composed, has prevented the atmospheric forces from wearing off the angularities, so that they appear as sharp and angular as if but recently brought to the surface. The examples of ribbed or banded gneiss are quite remarkable for their perfection and regularity. The junction of the unchanged beds with the metamorphic is remarkably well shown in the gorges on the north side of the range. The general inclination of the limestone is about 30° to 50° northwest. From this high point the ridge of limestone, with 1,200 to 1,500 feet of outcropping strata, may be most clearly seen for a distance of twenty or thirty miles east and west, forming a remarkable natural section. Extending far to the eastward and opening out into the plains, are the gradually descending ridges of the Jurassic, Cretaceous, and Tertiary beds, presenting an irregular rugged surface depending upon the nature of the rock-materials of which they are composed. The Yellowstone River really emerges into the plains below the junction of Shields's River, and thence to the junction of the Yellowstone with the Missouri the Cretaceous and Tertiary formations prevail. On either side of the Yellowstone, at a distance, may be seen isolated small ranges of mountains until we pass below the mouth of Tongue River.

It is most interesting as well as instructive to explore with care among the deep gorges which the watery agents have worn down through these lofty mountain-ranges. The amount of *débris* or broken rocks which one encounters excites surprise. Water and frost are ever at work, and have been busy for ages in breaking down the sides of the gorge and extending it farther back in the range. We discover here the sources of the myriads of perpetual streams, which we find in the lowlands, and which we see meandering through the plains like the veins in the human body. Each one of these little streams, toward its source, branches out into numbers of small tributaries like the capillary vessels, and each one of these little capillary streams has eaten out its deep gorge or cañon, which adds to the ruggedness of the mountain-scenery. There is in this Yellowstone Range an unlimited field for the artist; photographic views of the most startling kind could be obtained without number. I am convinced that this range of mountains, and the valley at its base, will at no distant period be visited by multitudes of tourists, and afford many a subject for correspondence for the secular press.

Glancing at the map, it will be seen that numerous little streams flow down from the base of the mountains and empty their waters into the Yellowstone. Each one of these streams in the mountains spreads out into a great number of branches five to twenty miles in length. It is to these little streams that we are indebted for the inner history of these grand mountains. We may say in general terms that the nucleus of the Yellowstone Range is composed of granitic rocks, and that the greater portion is made up of these, while far to the south and southeast the summits are covered to a greater or less extent with volcanic rocks. The greater portion of Emigrant Peak is made up of volcanic material. There is no doubt that at some prior period the volcanic rocks and breccia or conglomerate extended over a much larger area and with a greater thickness than at the present time. Many of the high, bald, rounded granite mountains bear all over them the marks of terrific erosion.

In the report for 1871, I described somewhat briefly the interesting lake-basin which now forms the valley of the Yellowstone between the First and Second Cañons. At the risk of some repetition, I may be permitted to take this as the type of these lake-basins, and describe it somewhat in detail, although each one has some features not common to the rest. It seems to me, however, that they must all have one common origin, whatever that may be. Many of the basins have been formed by erosion, but not altogether so. Although the lake-basin which we are now describing is largely due to the action of the erosive forces, yet I am of the opinion that its outline was marked out in the process of upheaval. On the east side is the remarkable range of mountains which I have called the Yellowstone, constituting the nucleus or central portion of a distinct anticlinal; while on the opposite or west side there is a chaotic mass of volcanic peaks and ridges, which have no necessary connection with the Yellowstone Range. At the lower end of the valley, however, are a number of isolated hills of limestone, with strata inclining in the same direction with the main ridge, which forms the cañon below, and these can easily be traced across the valley as remnants of what were once high ridges extending directly across. Other remnants may be observed farther up the valley, which seem to convey a pretty clear conception of the immensity of the erosive action in the past. In noticing this lake-basin as typical of a series or system of lakes in the West, I do not refer to those great lake-basins of the earlier Tertiary period, in which were entombed such vast numbers of animal remains in Wyoming, Nebraska, &c. Those which I am now describing belong to a type of more modern date, which probably commenced in the Pliocene period, and extended up very nearly to our present era.

We shall not go back beyond the time of the existence of this lake-basin and endeavor to indicate the condition of the surface or the climate at that time, but simply remark that we believe that all these valleys were the reservoirs for the accumulated waters from the drainage of the mountains in the vicinity. When they were full, so as to overflow the barriers which were raised in the uplifting of the mountain-ranges, the waters, following the law of gravitation, gradually wore a channel through these barriers, as, for example, at the Lower Cañon, where they have carved out a channel 800 to 1,000 feet deep, directly through the massive limestone, at right angles to the direction of uplift.

The process of wearing out this channel for three miles in length through such a thickness of hard limestone must have required ages, sufficient for the waters of the lake to have deposited 1,000 to 1,500 feet of sediment, and, as the channel was cut down and the basin drained, a portion of the sediment would be swept down the river. We have now the evidence that the waters of the lake must have reached high up on the sides of the mountains, entering far up the open side-valleys, in some cases nearly up to the divide or water-shed. The line of demarcation between the modern deposits as they jut up against the mountain-sides, and the natural *débris* of the mountains themselves, is quite distinct, and is even shown by the vegetation. When we reflect that the productiveness, as well as the possible settlement of these mountain-regions, is due to the former existence of these lakes, we shall at once understand their importance, and their history will become invested with a greater interest. It is only in these valleys that farming-lands can be found. The sediments which were accumulated in the bottoms of the lakes were derived from the destruction of a great variety of rocks, so that the mixture is most remarkable for its fertility. The metamorphic and igneous rocks, and the limestones of the Silurian and Carboniferous epochs have all contributed to them. As the lakes were drained slowly away, the bottoms were worn out and smoothed as we see them now. Here and there we find that these superficial deposits have been stripped off, so as to expose remnants of the old formations which constituted the original skeleton. Patches of limestone are observed here and there, enough to indicate something in regard to the former history of this surface, or skeleton, as it might be called.

Although this valley was originally largely due to erosion no doubt, yet it was not altogether so. It was not a chasm or a fissure in which the waters gained a foothold for their operations, as was the case with many of the valleys. The main feature of the mountain-range, as we see it now on the east side of the Yellowstone River, never crossed to the west side, but formed the east shore of the lake. That the valley was greatly enlarged by the wearing away of the sides of the mountains by the waters of the lake, there is little room to doubt. On the west side of the valley the mountains rise up 9,000 and 10,000 feet above the sea-level, but are mostly volcanic and most probably conceal a vast thickness of sedimentary beds. The igneous rocks seem to have issued from numerous fissures, and to have spread over the surface to an enormous thickness. But the rocks which prevail over all the rest are those which have been formed out of fragments, dust, ashes, &c., which must have been thrown out of the numberless volcanic craters into the surrounding waters, and been afterward deposited as sedimentary beds. The massive basalts or trachytes may be considered the exception, while we find 2,000 to 4,000 feet in thickness, of volcanic breccia or conglomerate, reaching to the very summits of the highest mountains, and presenting a well-marked horizontal stratification. Materials of almost every variety of color, with a peculiar somber hue, are found. Immense masses have fallen down into the valley from the mountain-sides, composed of fragments of trachyte of every possible texture and color. Sometimes these fragments are very coarse, several feet in diameter, and again they are small, like pudding-stones. Sometimes they are angular as if they had not been subject to erosion in water, and again they are much rounded. The cement is also more or less fine volcanic material, partly, perhaps, the dust and ashes thrown out of the volcanic fissures, and partly the eroded materials from the rounded fragments. In the stratified beds there is also a great variety of materials. The conglomerates prevail, but there will be found interstratified seams or local beds of several feet in thickness, of a fine white-yellow or brick-red volcanic dust and ashes, so that when these beds are eroded the surface around presents the appearance of the ground about an old furnace. I know of no district where there is a better opportunity to study the great varieties of volcanic action in past geological times than in the range of mountains which separates the Gallatin Valley from the Yellowstone. On the west side of the valley, from the Lower Cañon to the Second Cañon, a distance of at least thirty miles, the indications of ancient volcanic action are most remarkable and varied in their character. The erosive forces have cut deep cañons into the sides of these mountains, 2,500 to 3,000 feet through the conglomerates, and have worn the portions remaining into the most wonderful architectural forms. Domes, pyramids, pinnacles, palaces, indeed almost any form which one could conceive, can be seen here. One gorge was called the Palace Cañon on account of the symmetrical palace-like forms which could be seen everywhere. The sides of these gorges are vertical walls, inaccessible, except in a few localities, to man or beast. One can stand in the bed of a little stream and look up the vertical walls on either side 2,500 or 3,000 feet. Such gorges as these, extending from five to twenty miles oftentimes, are very numerous. Literally hundreds of them may be found in these ranges extending up to the very crest or water-divide, carved out of the solid mass of conglomerate or trachyte. There is certainly no limit to the remarkable scenery which the artist could select in this prolific field.

Cropping out here and there in the bottom of these deep gorges may be seen the older sedimentary strata, as the Carboniferous limestones, and even those of later date, as the Jurassic, Cretaceous, or Tertiary. The general dip of the unchanged strata is about northeast, and in the valley of Trail Creek the sandstones and clays of the Brown-Coal period may be seen passing beneath the huge mountains of volcanic conglomerate. Farther south and west the limestones appear, and the metamorphic rocks are not seen to any extent until we enter the West Gallatin Cañon. We are thus enabled to gain a pretty clear idea of the original shape of this valley, that it was really marked out in the process of upheaval. I will remark here that I shall attempt to show hereafter that the streams, in coming out of their channels, did not follow any preformed chasms or fissures, but quite the reverse. Most of the cañons were formed by the streams cutting their way directly through the ridges, at right angles to the axis of upheaval.

As I have previously remarked, the granitic rocks are mostly confined to the main ridge of mountains on the east side of the valley, but in the valleys of the smaller streams that flow into the Yellowstone from the west side just below the Second Cañon, as Rock Creek and Cañon Creek, the metamorphic rocks are largely exposed. The Second Cañon is composed of metamorphic rocks entirely. Scattered over the surface of the valley below are many huge bowlders of granite, which could not have been transported to their present position by any forces now in operation. It is quite evident that all the forces, whatever they may have been, operated from above down the valley. Upon the foot-hills, and in one instance on the top of the basaltic floor, several hundred feet above the present bed of the river, are huge rounded bowlders, 25 to 50 feet in diameter, which must have been transported either from the cañons of those little streams above mentioned or from the Second Cañon, a distance of ten to fifteen miles. I know of no power except the combined action of water and ice that could have brought about these results. A very large portion of the foot-hills and terraces, as well as the immediate bottom of the river, is literally paved with rounded bowlders, so much so as to render almost worthless, except for grazing, much land which would otherwise be excellent for farming. Along the bottoms also are old river-beds 50 to 100 feet above the present bed. These old channels are covered thickly with the rounded bowlders, and walls of them are piled up on either side. These are results of very modern date. They must represent the latest period of the draining of the lake-basins. We believe that the temperature was much lower than at present; that the surrounding mountains that form the drainage into these lakes were covered with vast masses of snow and ice which, at certain seasons of the year, became detached and floated down in the form of huge icebergs. All these forces may have been in action from the sources of the Yellowstone and Missouri down to the plains below, and thus the huge icebergs, loaded with immense quantities of bowlders, floated over the valleys, dropping their contents here and there, as we find them at the present time. Most of the bowlders in this valley could have been moved along by the action of swift torrents of water alone, but not even the strongest mountain-torrent of which we have any knowledge now could have moved great numbers of the huge granitic rocks which we find high up on the foot-hills or terraces, at least ten or fifteen miles from their original position. No forces now in operation, even if we were to suppose that the melting of the spring-snows would raise the river so as to overflow all the lowlands, could have transported these bowlders. As it is, they cover an area several miles in width, quite above the reach of the river-waters at their highest stage.

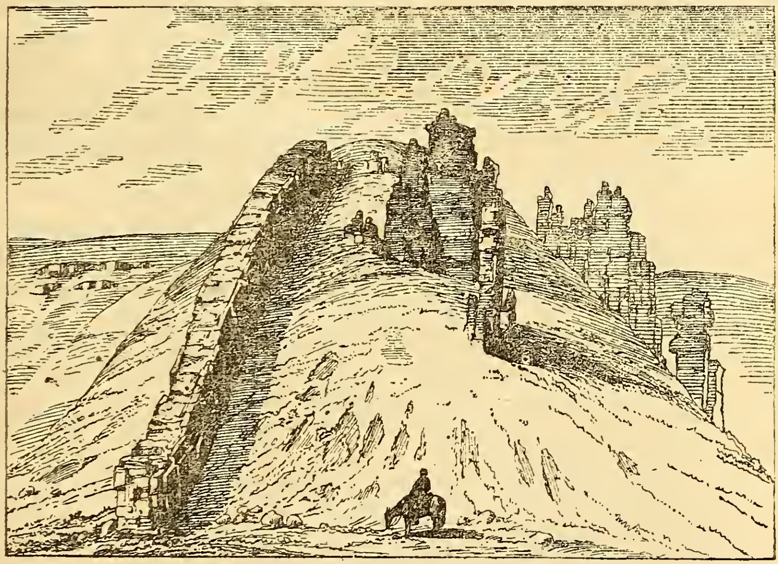
Another point I may allude to here again in this connection, and that is the more modern outflow of basalt which is seen in several localities in the valley. It is probable that the basalt spread all over the valley at one time in the form of a cap, and that it has been swept away in the process of erosion. On the west side, about two miles below Boteler's ranch, there is an extensive remnant of this basalt cap, which has been so smoothed by the passage of ice over it that the surface is glazed. There are also numerous small grooves or scratches. The surface is covered thickly with rounded granite bowlders, but one of them was worthy of special note from its size, which measured 12 feet in height and 20 feet in diameter. It is perfectly massive, composed of a coarse aggregate of quartz, feldspar, with small bits of mica. The basalt has a tendency to break into imperfect pentagonal columns. Underneath it are 100 to 200 feet of what I have called Pliocene deposits, but they are composed very largely of rounded pebbles and bowlders, with light-gray marly clay. On the east side of the Yellowstone, about two miles above the ranch, the river has cut a vertical section through the marly clays and sandstones 100 feet or more, with 50 to 80 feet of loose drift bowlders and pebbles, the whole capped with 20 to 30 feet of basalt. This outflow of igneous matter was among the latest events. Nearly all the lake-basins have this basaltic cap to a greater or less extent, and the evidence indicates that the outflow was synchronous. In the Snake River Basin this cap covers an area of fifty to eighty miles in width and several hundred miles in length, and quite large streams sink beneath it and flow into Snake River. The geological relations of this cap or bed of basalt are about the same wherever it occurs, pointing to a common cause as well as time.

I believe that it occurred before the waters subsided, so that we may trace a portion of its history at least. The lake-deposits are certainly of very moderate date, at least as late, and perhaps later, than Pliocene.

Upon this rests a huge bed of drift, which was deposited still later, and then comes the outflow of basalt before the waters subsided, as is shown by the texture of the rocks, as well as the superficial deposits over it; then the waters were drained slowly away, sweeping with them most of the basalt, with the exception of here and there a remnant, and also most of the deposits beneath, thus giving shape to the valley. All these events must have taken place subsequent to the completion of the general outline of the country by the upheaval of the mountains. It is probable, also, that during this period, and probably throughout the greater portion of the Tertiary period, hot springs were very abundant everywhere, and it is doubtless due to these that the organic remains found in these deposits have been preserved in such a high state of perfection and beauty. The silicified or opalized wood, we believe, indicates the presence of these springs. There are a few warm or moderately hot springs in this valley at the present time.

As an illustration of the volcanic action in this valley, the reader is referred to Fig. 2, which was sketched by Mr. Holmes, about two miles

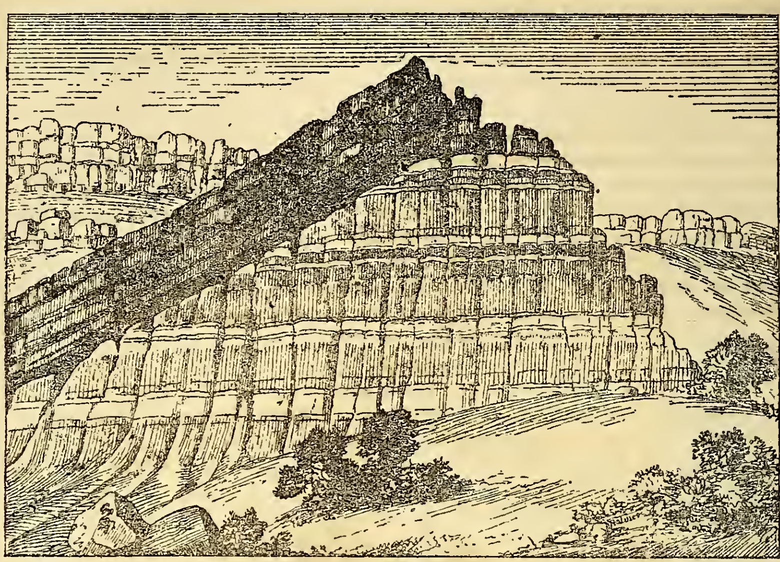
Fig. 2.



TRACHYTE DIKE AND COLUMNS OF BRECCIA, YELLOWSTONE VALLEY.

above Boteler's ranch on the west side of the Yellowstone Valley. The long, wall-like mass that extends down from the side of the hill is a dike of trachyte, while on either side are the tufas and breccias, which have been weathered into columns of varied forms. This may also represent one of the numerous fissures or oblong craters from which much of the volcanic material was ejected. Fig. 3 shows quite clearly the stratified character of the tufas and breccias. This illustration was taken about a mile above Fig. 2, on the same side of the Yellowstone. The entire mass is most curiously variegated in color, from an ashen-cream color to deep purple. This series of gray volcanic ashes alternates with more or less coarse strata of breccias, the fragments cemented with the tufas. In Fig. 3 we see a curious instance of a sort of unconformability, showing, probably, the periods of deposition. The under-

Fig. 3.

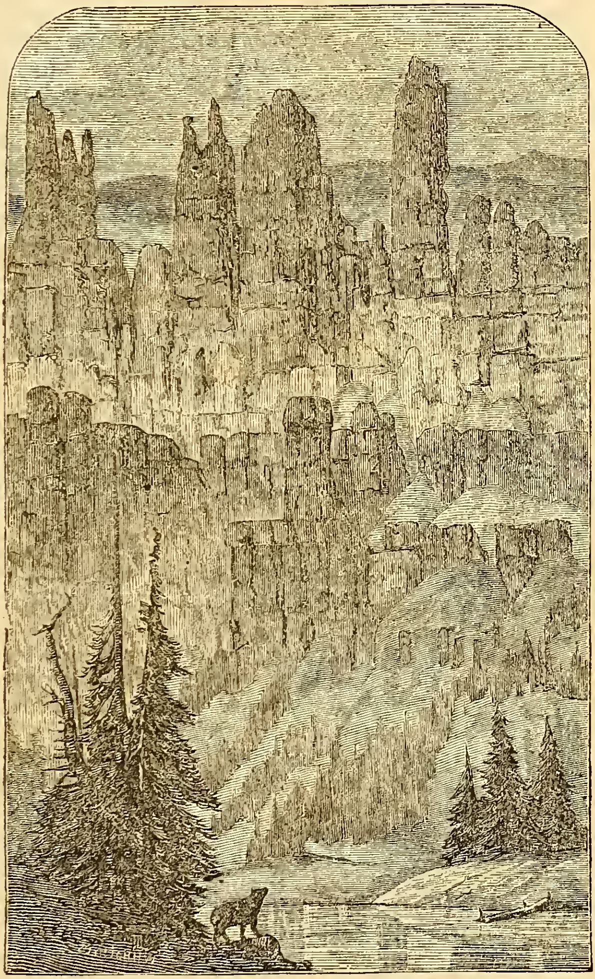


VOLCANIC TUFFS AND BRECCIA, YELLOWSTONE VALLEY.

lying portion had been worn into a conical shape by the waters of the lake prior to the deposition of the slanting mass. In the back-ground there is a lofty range of volcanic breccia or conglomerates, rising 3,000 feet above the valley.

We will now take our leave of this beautiful valley and proceed up the river through the Second Cañon. We may hastily notice the character of the rocks on either side. The divide between the Yellowstone and the Gallatin is quite sharp and narrow, the numerous little streams cutting deep channels down from the crest to the river. The divide itself is formed entirely of the volcanic conglomerate, weathered into the most singular architectural forms. West of the cañon, at the head of Cañon and Rock Creeks, this conglomerate is at least 1,000 feet thick, horizontally stratified, and worn into hundreds of pinnacles or Gothic columns. (See Fig. 4.) These conglomerates extend down the ridges between the little streams for several miles, while the gorges are cleft deep down to the metamorphic rocks. The cañon itself, on either side, is composed entirely of gneissic strata. Silicified wood is found in these conglomerates in great quantities, and sometimes huge logs and stumps are exposed in a vertical position in the walls. Near the head of Cañon Creek, I saw the stump of a tree which must have been at least thirteen or fourteen feet in diameter originally. It was firmly inclosed in the breccia. The question arises in the mind, Whence originated this vast deposit of breccia or conglomerate, and what were the physical conditions under which the materials were deposited? As to their origin, we must conclude that they were thrown out by volcanoes into the surrounding waters much as similar materials are ejected from modern volcanoes at the present time. We find, however, that these breccias are of immense thickness, sometimes 4,000 to 5,000 feet, as at the sources of the East Fork and in the mountains at the head of the Upper Yellowstone above the lake. Some of the highest mountains in the Northwest are capped with these volcanic breccias arranged in horizontal strata, and showing most clearly that the agent was water. In almost all cases these stratified breccias are perfectly horizontal from base to summit, thereby indicating the probability that there has been no important movement of the earth's crust since their deposition. We

Fig. 4.



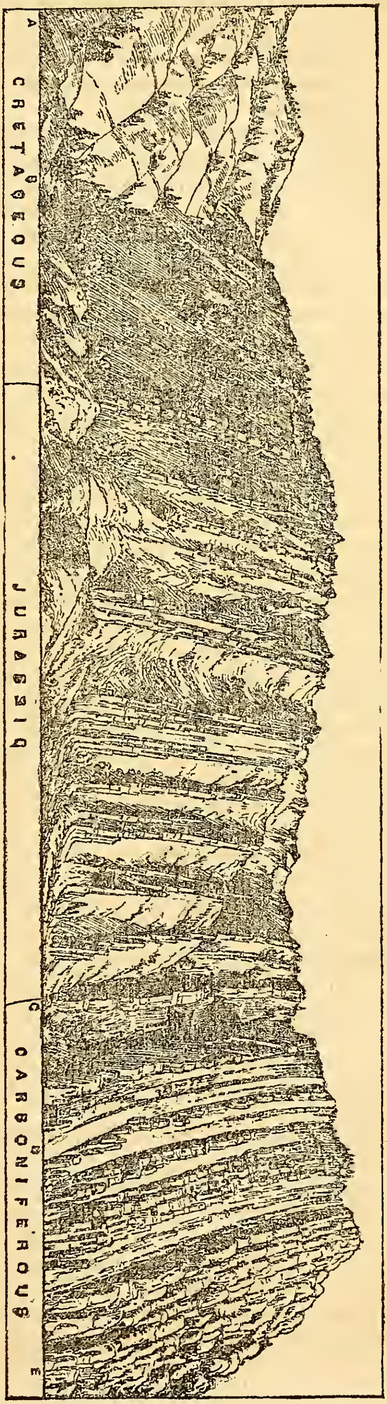
VOLCANIC BRECCIA AT THE HEAD OF CANON AND ROCK CREEKS.

must conclude, then, that at a comparatively modern date the waters so covered these mountain-ranges of the Northwest that not even the summits of the loftiest peaks were above the surface. It is barely possible that we might make an exception in the case of the Grand Tétons. We may suppose that the materials were supplied from the numberless volcanic fissures in unlimited quantities in a comparatively brief space of time; but the period which would be required for the waters to arrange this matter in the remarkably uniform and compact series of strata which we find at the present time must have been great. The results have been carried on upon such a stupendous scale that the mind finds with difficulty the courage to grapple with them or attempt to explain them. And then, subsequent to the deposition of these enormous beds of conglomerates, has been the wearing-out of cañons and valleys 2,000 to 4,000 feet in depth, the sculpturing of some of the most marvelously grand and unique scenery on the continent. In passing up the valley of the Upper Yellowstone, which is about three miles wide and has been carved out of this hard breccia, one could easily imagine himself in some enchanted land, where, on every side, were castles and palaces without number.

We may, therefore, conclude that all the surface-phenomena we find here at the present time are only the insignificant remnants of the past; that the lakes, streams, hot springs, &c., are only the dim departing evidences of a series of events which once were performed here on a scale that almost baffles human conception. The Second Cañon is formed by the passage of the Yellowstone River between lofty walls of gneiss. On the east side is Dome Mountain, a vast rounded mass of granite rising 2,500 feet above the river flowing at its base. On the west side are two or three rounded, naked, granite peaks, 1,500 to 2,000 feet above the river, but less conspicuous. The summits and sides of these granitic mountains show most distinctly the effects of glacial action. The surfaces in many places are smooth as glass, and glazed as it were, and lying about loose are great numbers of rounded bowlders. The forces that stripped off the thick covering of volcanic conglomerates left their traces on the harder rocks below. To the westward the gneissic rocks soon pass out of sight beneath the volcanic conglomerates. I shall attempt to show in a subsequent chapter of this report that the gneissic rocks of this cañon are only a portion of the nucleus of the great range which extends across the country toward the northwest to an unknown distance. The mountains on either side may be said, in the main to be composed of granitoid rocks as nuclei, with almost numberless outflows of igneous matter. Although this statement would indicate that the geological features were remarkably simple, yet the rounded forms which these igneous rocks assume, and the chaotic condition of the surrounding rocks produced by these volcanic movements, renders the unraveling of the structure quite difficult in its details. In the present report I cannot do more than present a general view of the geology of the Yellowstone Valley, referring the reader to the report of 1871 for more detailed information.

The next point of importance is the Cinnabar Mountain and the so-called Devil's Slide. We were enabled the past season to make a more careful examination of this interesting locality, and the sketch taken on the spot by Mr. Holmes is very expressive and accurate. (Fig. 5.) Cinnabar Mountain comprises a group of nearly vertical beds, rising at one point 2,000 feet above the Yellowstone. The ridge, or mountain, as it may be called, is about one mile in length, and in this distance are exposed probably 10,000 feet of strata from the metamorphic quartzites to the coal strata inclusive. The hard rocky strata stand up on the sides of the mountain like high walls, while the intervening softer beds have been washed away; the direction of inclination southwest trends about northwest and southeast. The following section is given somewhat in detail. It commences with the well-marked Cretaceous shaly clays, which are probably Middle or Lower Cretaceous.

1. Dark-brown shaly clay, with thin layers of brown sandstone. With geodes of calc-spar. The whole gradually passing to a slaty shale. 500 feet.
2. A bed of broken sandstone, fine-grained, frequently rising above the surface. 4 feet.
3. Dark slaty shale. 30 feet.
4. A somber brown quartzose sandstone projecting up on the side of the mountain like a wall. 50 to 80 feet.
5. Dark-brown shale, with three layers of sandstone, 4 to 10 feet thick. Toward the summit of the hill or mountain, which is 700 to 1,200 feet above the base, the sandstones project up with very rugged, irregular edges. The rock is very compact, chalky, fracturing easily. 300 feet.
6. A rusty-brown mud-quartzite. Inclination, 75°. 100 feet.
7. Interval of softer brown mud-shale. 500 feet.
8. Brown sandstone, rising up in a high wall 100 feet. Below it are some thin beds of sandstone, one of which, 2 feet thick, is made up of small pebbles, cemented with sand. 30 feet; dip, 80°.
9. Interval of brown, arenaceous, shaly, laminated sandstone.
10. High wall of brown sandstone, with huge, concretions, irregular bedding, with fine illustrations of wave-markings. 20 feet.
11. Low interval of soft material, black shale or slate. 300 feet.
12. High wall of rusty-brown quartzite, so hard and brittle and broken by jointage as to appear metamorphic. 20 feet; dip, 70°.
13. Three or four thin beds of quartzite, ragged edges standing up 5 to 30 feet above the surface, with softer clays intervening. 100 feet.
14. Grassy interval, probably slaty clay. 75 feet.



SECTION OF VERTICAL STRATA AT CINNABAR MOUNTAIN AND DEVIL'S SLIDE.

Fig 5

15. High wall of quartzite, rising at one point 150 feet, with intervals of red banded shale. 100 feet.
16. Three beds of quartzite, with slaty intervals. 200 feet.
17. Bluish-green shale, full of Jurassic fossils. 150 feet.
18. Dike of trachyte 50 feet wide. Inclines 70°. Shown in Fig. at *c*.
19. Black slate, metamorphosed when it is in contact with the dike-material. 200 feet.
20. A huge wall of brown arenaceous limestone. 80 feet.
21. Yellow and red banded arenaceous clay, giving name to the mountain by its bright-red color. 75 feet.
22. Several beds of arenaceous limestone, with partings of clay, very thin; some of it with a reddish tinge; carboniferous fossils. 500 feet.
23. Massive limestone, extending down to the metamorphic quartzites, on which it rests unconformably. 1,500 to 2,000 feet.

The fossils from bed 17 are enumerated in the catalogue by Mr. Meek.

The lower portion of the limestone of bed No. 23 is full of geode cavities, lined with crystals of calc-spar. The rock is very hard, compact, brittle, easily fracturing into small angular fragments, the whole mass resisting the atmosphere quite successfully. The greater portion of this limestone is, most probably, of Carboniferous age; but I have no doubt that the lowest part is Lower Silurian, though it differs much in texture and general appearance from the Silurian strata in the Gallatin Valley. The exact line of separation between the Silurian and Carboniferous is difficult to determine. The partial metamorphosis of the lower limestones has rendered this more obscure. The dike, as shown in the Fig. at *c*, is the most remarkable feature in this section. It may be regarded as the line of separation between the Carboniferous and Jurassic strata. The dark Carboniferous shales have been changed into slates on either side of the dike, and portions of the slate are attached to the mass which now rises above the side of the mountain. At the lower part of the mountain the igneous matter seems to have been thrust up between the strata and to have filled the cavities like a mold, but toward the top it has apparently cut across the layers slightly, producing some singular faults.

Continuing eastward beyond the Cretaceous clays as noted in the section, we find a vast series of arenaceous clays, sandstones, quartzites, arenaceous limestones, with beds of lignitic clay, and good coal 6 or 8 feet thick. I estimated the thickness of this Coal group at 2,000 to 3,000 feet, and this estimate may be too low. There is much confusion in the position of the beds, some of them inclining 45° to 50° for a little distance, and then suddenly becoming almost horizontal, inclining 5° to 10°. Yet there seemed to be no want of conformity. There is a kind of irregular synclinal here, by which the Coal group has been crushed together in such a way as to produce chaos, so far as position is concerned.

From the Cinnabar Mountain the beds seem to incline almost southwest, while from the high mountains between the Gallatin and Yellowstone the internal forces seem to have operated in an opposite direction. Thus, within the space of six or eight miles, extending from the summit of Electric Peak to the Yellowstone River, we have the full series of sedimentary rocks from the Silurian to the limits of the Coal strata inclusive, forming a synclinal. The Cretaceous beds, which are noted as the black shales in the section, may be seen high up on the sides of the mountain, dipping about northeast at an angle of

25°, while the limestones form the entire upper portion of a peak which rises to a height of over 10,000 feet above tide-water. It is probable that a portion of this Coal group is of Cretaceous age, but I also believe that the beds pass up into the Tertiary period, as we find them in other portions of the West. Ammonites and baculites and other Cretaceous shells were found below the coal in a fine state of preservation, but no plants or other fossils were found above. On the east side of the Yellowstone the more modern beds, probably Tertiary, are largely shown, inclining in such a way as to indicate that the Yellowstone had made its way, for a few miles here, through an anticlinal fissure. Opposite the Hot Springs on Gardiner's River, there is a vertical wall of Cretaceous and Tertiary strata, exposing 1,500 feet or more in thickness. Coal-beds occur here also. All the way to Tower Falls, or the foot of the Grand Cañon, fragments of the sedimentary group occur of greater or less extent. They crop out from under mountains of volcanic conglomerate and basalt. The evidence becomes stronger every year of exploration that the erosive forces have acted on a more stupendous scale than I have ever conceived or expressed in any of my former reports; that the entire series of sedimentary strata, from the lowest Silurian to the highest Tertiary known in the West, has extended in an unbroken mass all over the Northwest; and we find here and there by the exposure of the entire series, as at Cinnabar Mountain, and in many other localities, the most satisfactory proof of the statement which I have so often made. This single statement implies that from 10,000 to 15,000 feet in thickness of unchanged rocks have been removed from this mountain-region, except what might be called remnants left behind, occupying restricted areas. Of course, the older the group the larger the area over which it has escaped erosion. The hard and compact limestones of the Carboniferous and Silurian ages are found to a greater or less extent all over the Northwest. They yield much less readily than the more modern beds, and are consequently found on the summits of some of the highest mountains, 10,000 and 12,000 feet above the sea. Indeed, these isolated patches of all the formations which occur here and there render it necessary to explore the country with much detail, in order to prepare a geological map in colors with any degree of accuracy. These isolated fragments are liable to be met with in the most unexpected places—on the tops of mountains, or cropping out of the sides of cañons or ravines. Around the sources of Gardiner's River and Tower Creek, the mountains and hills appear to be entirely of volcanic origin at a distance, and many of them are; but underneath the vast volcanic mass, is a series of the grayish-brown beds of the Coal group, so that many of the lower hills from which the volcanic material has been denuded are covered with an indurated calcareous clay, filled with deciduous leaves in an excellent state of preservation. Farther down these streams, toward their junction with the Yellowstone, outcroppings of the true Cretaceous, Jurassic, and Carboniferous occur here and there. To what extent these trachytes and volcanic conglomerates covered the surface at one time, it is hardly possible to determine, but there is evidence that they must have extended in an unbroken mass over a very large area.

The question continually arises in the mind, At what time in geological history did this period of intense volcanic activity occur? Evidences of greater or less igneous action are found in rocks of all ages, from the lowest metamorphic up to the present time, but there seems to have been, as it were, a culmination of the volcanic forces some time during the later Tertiary period. It may be that the accumulated forces, which had been since the Cretaceous era gathering in the interior of the earth, and had gradually elevated the western portion of the continent to its present position, obtained vent at this time, and exhausted themselves, leaving behind them stupendous monuments of their power. I am now inclined to believe that when our western country is more thoroughly explored by competent geologists, it will be found that the area covered with volcanic rocks is far greater than we have hitherto suspected. Like the more modern Tertiary beds, the basalts and conglomerates of volcanic origin have been subjected to terrific erosion, and only a portion of their wonderful magnitude is left behind.

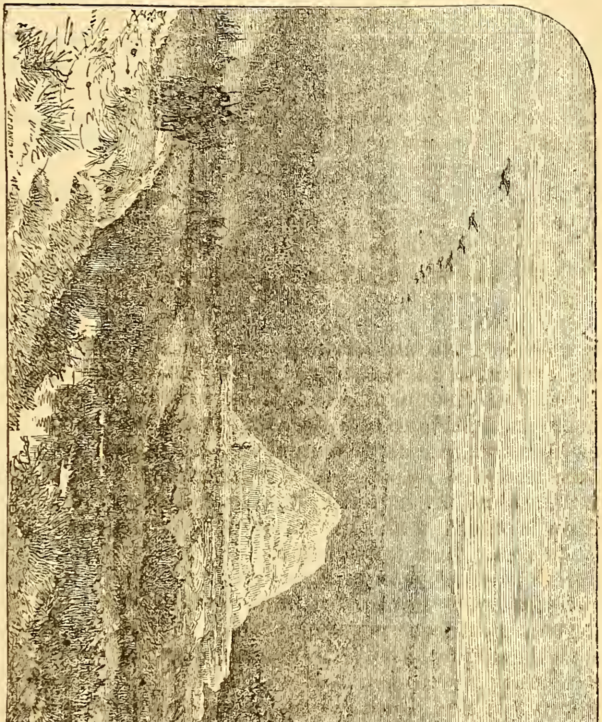
So far as my own explorations have extended, the main portion of the volcanic material of the West has been thrown out at a comparatively modern date. Among the Cretaceous and coal-bearing groups are irregular interstratified beds of basalt, but the great mass of trachyte, basalt, and volcanic conglomerates seems to have been erupted since the surface attained pretty nearly its present configuration. The conglomerates, although in some instances reaching a thickness of 3,000 feet at least, do not seem to have been disturbed to any great extent since their deposition. The position of the trachytes, which have overflowed the mountain ranges, indicates that they could not have been very ancient, perhaps not older than later Miocene or early Pliocene, while the true basalts are extremely modern, approaching closely to our present era. In the report of last year I described the modern basaltic outflows on both sides of the Yellowstone, above and below the junction of the East Fork. On the sides of the granitic mountains, at different elevations, the black igneous outflows can be seen, looking like hot spring-deposits, were it not for their dark color. The liquid material seems to have oozed out from fissures in the metamorphic rocks in numerous places. These basalts fracture readily into small fragments, and the *débris* resemble a pile of dull anthracite coal. These very modern basalts seem also to have oozed up through the fissures in the Cretaceous and Tertiary beds, as shown on the east side of the Yellowstone opposite the mouth of Gardiner's River. Here the outcropping edges of several hundred feet of strata are shown for some miles, spotted with the patches of the black *débris*, from the breaking in pieces of the basalt that had flowed out at different points. We may, therefore, conclude that this period of intense volcanic activity probably commenced somewhere during the later Miocene or early Pliocene epoch, reached its greatest power, and then slowly declined, the hot springs and geysers of the present time being the faint departing remnants of these once terrific forces.

CHAPTER III.

FROM EAST FORK TO THE MINING DISTRICT ON CLARK'S FORK AND RETURN—YELLOWSTONE VALLEY AND HOT SPRINGS—GEYSER BASINS AND MADISON RIVER.

On the 1st day of August I started from the forks of the East Fork for the Clark's Fork mines, in company with Mr. William Blackmore, and Mr. Holmes, artist of the survey. The camp was stationed down below the bridge in a sheltered valley, where the animals would be secure from danger and get a good supply of food. This trip was to take us over new ground that had been omitted in our explorations of last year. Our course was up the valley of the middle branch, past Soda

Butte, which was described last year. (Fig. 6.) I will, however, call to mind here the remark in the preceding chapter in regard to the outcropping of limestones of Carboniferous age in most unexpected places. On the east side of the East Fork the granite rocks seem to have prevailed. On the summits were some trachytes or conglomerates, but before reaching the forks of the East Fork, the high mountains are composed mostly of the conglomerate, while at the very base, the limestones crop out 50 to 100 feet thick. Soda Butte is located about the middle of the valley, and is an extinct geyser. (Fig. 7.) The materials of the mound are mostly calcareous, and show clearly that these limestones run under the valley, and that the waters of the geysers arose to the surface through them, dissolving more or less lime in the passage upward.



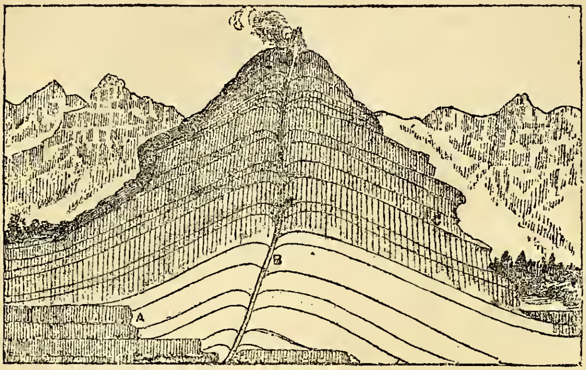
EXTINCT GEYSER, EAST FORK OF THE YELLOWSTONE.

Fig. 6.

As we ascend this valley, we soon find ourselves hemmed in on either side by walls of volcanic breccia 2,000 to 3,000 feet in height. The upper portions have been weathered into the most remarkable and attractive pyramidal and castellated forms. Indeed, all these volcanic conglomerates have a tendency to waste away into very artistic architectural forms. On the east side of the valley there is an irregular terrace-area covered mostly with quaking-aspens and pines, formed by land-slides. On this terrace, which is elevated about 250 feet above the river, there are a number of small lakes, fed by the melting of the snows from the mountain-sides. One of them is about one-fourth of a mile long, and is full of trout varying in length from 10 to 15 inches. We might here ask the question how these little lakes, so far above the main streams, became so stocked with trout. One thing is certain, there is no communication for the fish with the main stream.

Fig. 7 is intended to represent an ideal section of Soda Butte, showing the pipe or orifice and the manner of the deposition of the layers, or the growth of the mound.

Fig. 7.



CARB. LIMESTONE SECTION OF SODA BUTTE.

The limestone that cropped out for a little distance below the forks disappeared again for about ten miles up the middle branch, when it reappeared on both sides of the valley, and continued up to the Clark's Fork divide. The snows are quite deep on the sides of the mountains in the gorges even at this time, and it is probable that they remain all the year. The width of the valley will average about one-fourth of a mile, and is thickly wooded with several kinds of coniferous trees, with here and there groups of the aspen-poplar. About five miles above the forks, fragments of limestone began to appear on the surface, and soon the regular strata commence to rise above the bed of the stream, and about ten miles above, the limestones were exposed in vertical walls on either side of the cañon from beneath the conglomerates 500 to 1,200 feet. The upper surface is quite irregular, indicating a great amount of denudation prior to the deposition of the conglomerate. The limestones are yellow, brown, and in many localities brick-red. The mass is alternately depressed or elevated; that is, sometimes a very high vertical wall is exposed with the strata inclining at various angles, again it is depressed nearly to the bed of the stream. There is one locality near the source of the Middle Fork, where the limestones rise up 1,000 to 1,200 feet. So far as texture aided to determine, these limestones seem to be of Carboniferous age. Numerous fossils were found, which were all of that age, and I saw no locality where the Silurian limestones appeared to crop out. One curious fact could be observed here, which shows the vastness of the eroding forces. The rocky walls on either side of this cañon are alike, and reveal the fact that the entire valley has been carved out of the massive rocks which must have been far more extensive than we see them at present. From the source of this branch to the entrance into the main valley, a distance of fifteen miles, a mass of rock-materials has been worn out one-fourth of a mile in width, almost fifteen miles in length, and of a thickness at least equal to the summits of the highest peaks, some of which are 3,000 feet above the valley below. We cannot now estimate how much of the surface may have been wasted away, but the evidence is clear that no inconsiderable portion has been removed. When the limestones are exposed underneath the conglomerates on one side of the cañon, the corresponding strata are seen on the opposite side. The conglomerates are very nearly or quite horizontal, the lower portion adapting itself to the irregular surface of the limestone like any other sedimentary deposits. This valley or cañon is only an illustration of many others. I have no doubt that the Carbon-


N
VOLCANIC MOUNTAINS
Hell Roaring Cr.
Buffalo Cr.
Slough Cr.
Red Trout L.
7936 El.
Rose Bud Cr.
El. 9536
Copper Leads
Mining Region
Clarks Fork
Index Peak
Pilot Peak
Miners Camp 7856
Clark
Soda Butte Cr.
Hot Spring Cone
Bridge
5986 El.
East Fork
6286 El.
Falls
River
Amethyst Mt.
SKETCH OF A RECONNOISSANCE
TO THE
MINING REGIONS
OF
CLARKS FORK OF THE YELLOW STONE.
1
5
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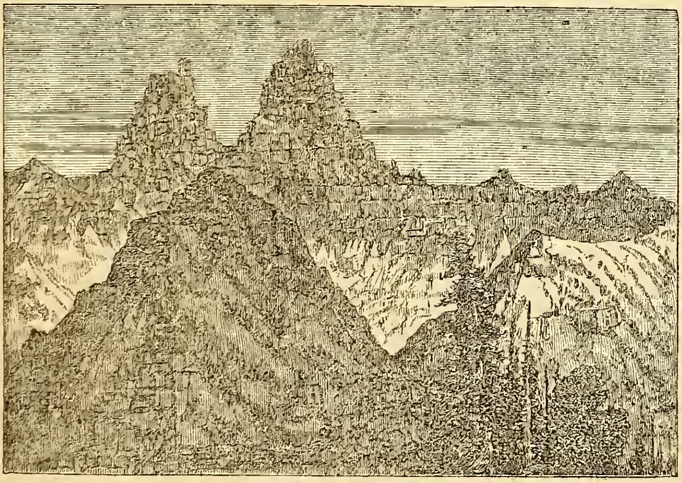
Jewett & Chandler, Buffalo.

iferous limestones underlie the greater portion of the country east of the Grand Cañon and the lake, extending over to the sources of Clark's Fork, Stinkingwater, and other streams. This enormous thickness of conglomerate once extended all over it in one unbroken mass, but since the subsidence of the waters the volcanic mass has been cleft down into the underlying beds of limestone in every direction, forming some as remarkable scenery as there exists on our continent. Mr. Holmes, the artist of the expedition, has sketched many natural sections showing most clearly the relations of the conglomerates with the limestones below, and presenting in detail the singularly unique forms which are produced abundantly by the meteoric forces. Mingled with the conglomerates are vast irregular masses of trachyte, the result of repeated overflows from the craters and fissures. In many cases the nucleus of the cones or peaks are massive trachyte. There are also alternate beds of trachyte and conglomerate.

About the sources of the Middle Fork and Clark's Fork are some very interesting silver-mines. They are all located in the limestones, from 6,000 to 7,000 feet above sea-level. These limestones rest upon granites near Clark's Pass, and one poor mine has been found in those rocks. The "croppings" are of a rusty yellow color, a sort of rusty limestone or quartzite, which can be traced for miles. The mines have not yet been developed to any extent, but the ore, which is galena, looks well. I think the ore is located in regular fissure-veins, extending downward about at right angles with the strata, (which are nearly horizontal,) and probably reach down into the metamorphic rocks beneath. There is the greatest abundance of water and wood in this region to work these ores should they prove of any value; but the mines are at present so difficult of access, so far from market, and the seasons are so short, that their value is nominal at this time. Still, the rapidity with which this western country develops under the stimulus of rich mines and railroads is so great that these far-away ores may become valuable

Fig. 8.



INDEX AND PILOT PEAKS.

sooner than we could anticipate. A regular mining-district has been formed here and numerous lodes staked out. (See map of East Fork.)

Passing the divide, we ascended the mountains which give origin to one of the main branches of Clark's Fork. This divide or pass was found to be 8,500 feet. The view from the mountain-summit was grand in the extreme. Extending far to the south is a chaotic mass of volcanic peaks, varying from 9,500 to 11,000 feet. Pilot and Finger Peaks are located near together, on the divide between the East Fork of Yellowstone and Clark's Fork. (Fig. 8.) One of them derives its name from its shape, like a closed hand with the index-finger extending upward, while the other is visible for so great a distance from every side that it forms an excellent landmark for the wandering miner, and thus its appropriate name of Pilot Peak. The metamorphic rocks underlie the limestones everywhere, and in the valley of Clark's Fork they are exposed over quite large areas. At least one hundred small tributaries pour into the river and its main branches from the lofty snowy mountains. Each one seems to rise in a small lake, and as we pass our eyes along the rounded low granite mountains on either side of Clark's Fork, they rest upon numbers of these reservoirs, glistening like gems in the sunlight. On the east side of Clark's Fork is a remarkably rugged granite range, covered with perpetual snows. On the west side, low down in the valley, the massive walls of limestone-strata may be seen most distinctly. The beds of limestone do not seem to incline at very great angles, but to have been elevated to different heights. Sometimes a group of strata will be found in the bed of the valley, and then again lifted up in a nearly horizontal position on the mountain-sides 1,000 or 1,500 feet above the bed of the river. Although the scenery is so rugged and grand, yet an air of desolation reigns over the whole. Perpetual snow is seen everywhere, and the somber nakedness of the volcanic peaks adds to the gloom; but toward evening the setting sun envelops them with such a delicate golden haze that one seems wafted into the land of enchantment. The delicious colors are blended with a delicacy and a richness that no artist has yet fixed on canvas. Toward the north and stretching off to the Yellowstone are a great number of sugar-loaf peaks, giving origin to Stillwater, Rock Creek, and Bowlder Creek, with their numerous branches on one side, and Slough Creek, with many other creeks that flow into the Yellowstone or East Fork, on the opposite side. Slough Creek rises in a little lake about 7,300 feet above the sea. This little lake is about three-fourths of a mile long and half a mile wide, and so full of trout that they cannot find sufficient food for their subsistence. At any rate, Mr. Blackmore caught over one hundred trout in a few hours, which averaged from 12 to 15 inches in length. Every one of them was poor and thin. Rock Creek also rises in the same ravine, but the waters are turned in an opposite direction from those flowing into the lake at the source of Slough Creek. Rock Creek flows down the mountain-side with a northeasterly course, carving its channel deep through the limestones into the metamorphic-rocks, and forming some of the most interesting scenery in this region. Nothing could exceed the beauty of the waterfalls on Rock Creek, where the water dashes over the rocks 1,500 feet in a distance of two miles. The photographer could here find subjects for his art without number. The tops of the mountains on the immediate divide are mostly limestone, and on every side the conical or pyramidal peaks have been cut down so as to expose the metamorphic rocks to a greater or less extent. In the valleys where the massive feldspathic granites are revealed, they have been so worn by glacial action that a smooth surface like enamel has been formed.

We followed down the somewhat difficult valley or cañon of Slough Creek on our return. The distance was about eighteen miles. A number of quite important branches, which also have cut deep cañons for ten or twelve miles back to the divide, flow into Slough Creek on either side. The sides of the valley are everywhere from 2,500 to 3,000 feet in height, and are much more irregular than in the cañon of Middle Fork. In the granites are seams of feldspar and quartz two feet in width. So abundant in some localities are these seams that they become a noticeable feature.

The valley for the first twelve miles from its source is from one-fourth to half a mile in width. The upper portion of the valley is volcanic, but seems to have cut down to the granites, so that in the bottom we travel for the most part over huge granite-bowlders.

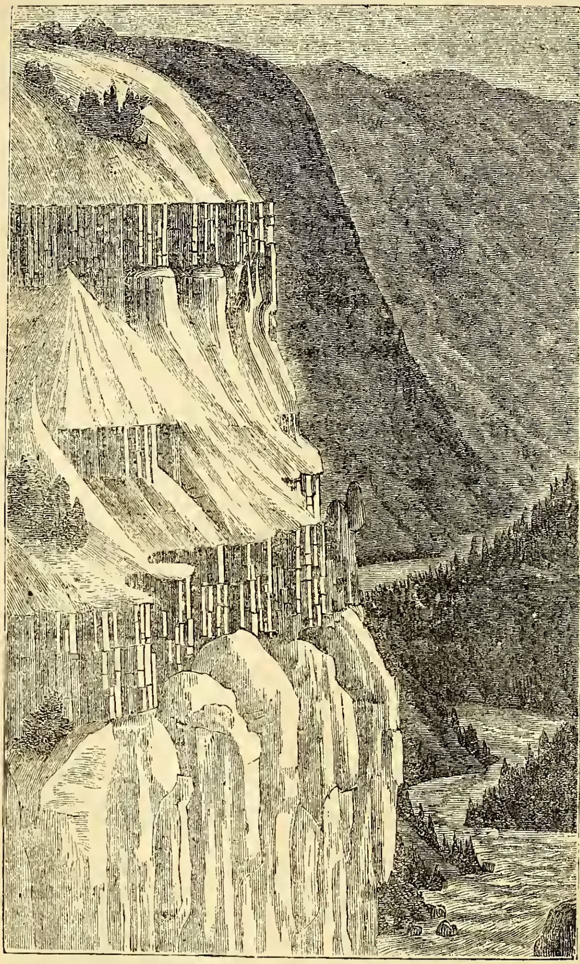
About twelve miles down the stream we came to an open bottom three-fourths of a mile wide, covered thickly with sage. This continued about three miles, then the valley closed up again within granite walls, and the waters of the stream formed a beautiful cascade. Again the valley expanded out and limestones were revealed on either side in regular strata, from 100 to 300 feet in thickness. Again the valley closed up in a granite cañon, and soon opened out into the valley of East Fork. It is plain that the valley of Slough Creek is purely one of erosion. Through the volcanic rocks and the limestones the waters have carved a clean smooth channel, but immense masses of granite have been left in the lower portion of the valley. The surface of the metamorphic or granitoid rocks seems to have been very irregular, and when the limestones have been stripped off by denudation, the valley would be obstructed by masses 50 to 150 feet high, over which the waters seem to have rolled for ages without making much impression. At any rate, the evidence is clear that the volcanic rocks and the limestones yield far more readily to meteoric agencies than the granites.

We may say, in conclusion, in regard to the rocks of this district, that we find a series of limestones probably of Silurian, and containing some of Carboniferous age, resting upon an irregular surface of metamorphic gneiss, and upon the irregular surface of these limestones reposes a greater or less thickness of volcanic trachyte and conglomerate. We may judge of the different elevations at which we find the granite where the peaks capped with limestone are 1,000 to 1,500 feet higher than the valleys with the rocks holding the same relations. We thus see that while depression of some portions of the surface may come in as an element, yet elevation has really been the most prominent direction of the force.

We left this most interesting region with regret. I do not believe that there is, at the present time, a more novel or interesting portion of our continent for exploration than that about the sources of the various branches of the Yellowstone, from the Lower Cañon to the mouth of the Big Horn River. The numerous large streams like the Bowlder, Rosebud, Rock Creek, Clark's Fork, Pryor's Fork, &c., cut deep and most picturesque gorges down the sides of the mountains until they flow out into the plains. We have probably expressed the geology of this region in general terms in the present report, but the amount of interesting detail which must yet be wrought out before the formations can be colored properly on a map must be very great.

We returned to our camp below the mouth of East Fork, and the following day pursued our way up the main valley of the Yellowstone. For a detailed description of this valley, its falls, cañons, hot springs, &c., the reader is referred to the Report of the United States Geological Survey for 1871. The exploration of the present season developed but little that was new in this region. More careful instrumental observations were made by different members of the party, and some additional facts were obtained by Dr. Peale. These will all appear in subsequent portions of this report. We will, therefore, pass by the wonderful basaltic columns, which are so finely shown in Fig. 9. Tower Falls, Grand Cañon, Upper and Lower Falls of the Yellowstone, as well as the numerous groups of hot springs, which are abundant, can only be alluded to in general terms. Some new groups of springs were added to the list, but none that threw any additional light on their history. There are, no doubt, many small groups of springs yet undiscovered. Glowing accounts were given to us of a very interesting group at the very source of the West Branch of Gardiner's River. When the National Park has been rendered more easily accessible for travelers, many curious discoveries will, no doubt, be made which will increase the public interest in this wonderful region. The origin of the remarkable lake-basin, in which the greater part of the wonders is located, is most interesting in a geological point of view. I am convinced that it is not altogether one of erosion, but in part of elevation. It seems probable, however, that the intense volcanic action, of which we see everywhere such unmistakable indications, occurred at a very modern geological period, not further back than the Pliocene period, and perhaps even not later than what we usually denominate the Quaternary or Drift. At any rate, it is probable that the waters surrounded and perhaps covered the highest mountain-peaks, inasmuch as we not only find drift-bowlders upon most of the loftiest ranges, but the volcanic conglomerates, tuffs, &c., are arranged in a stratified and, for the most part, horizontal position as high as the most elevated peaks in the Yellowstone Basin. On the west side of the lake some of the highest peaks, as Pomeroy, Langford, Stevenson, Doane, and others, are seemingly huge volcanic cones, com-

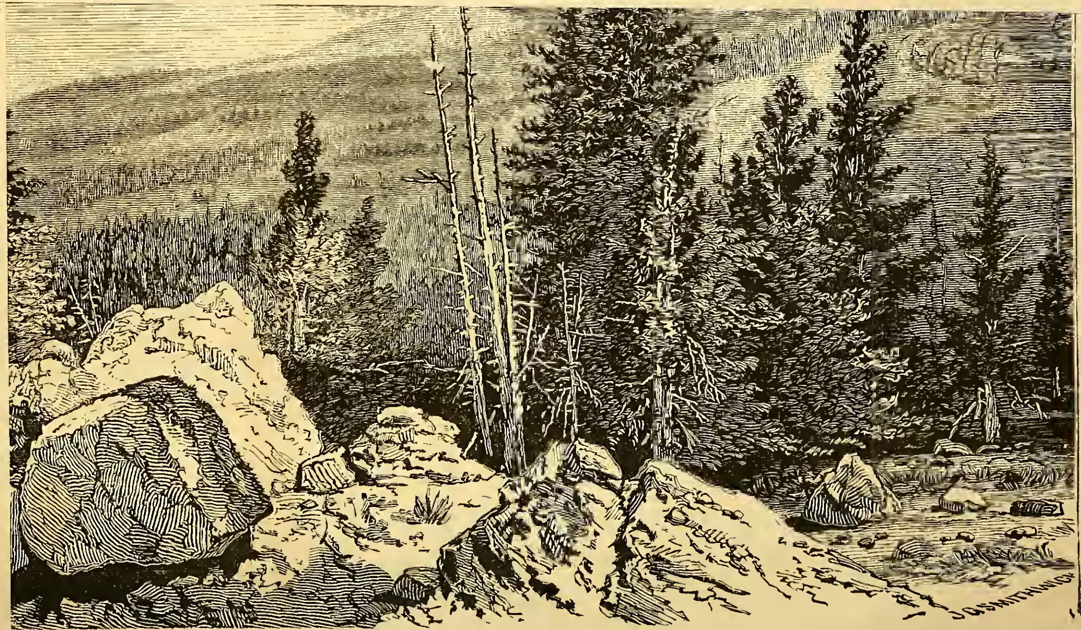
Fig. 9.



BASALTIC COLUMNS, YELLOWSTONE, NEAR MOUTH TOWER CREEK.

Fig. 10.

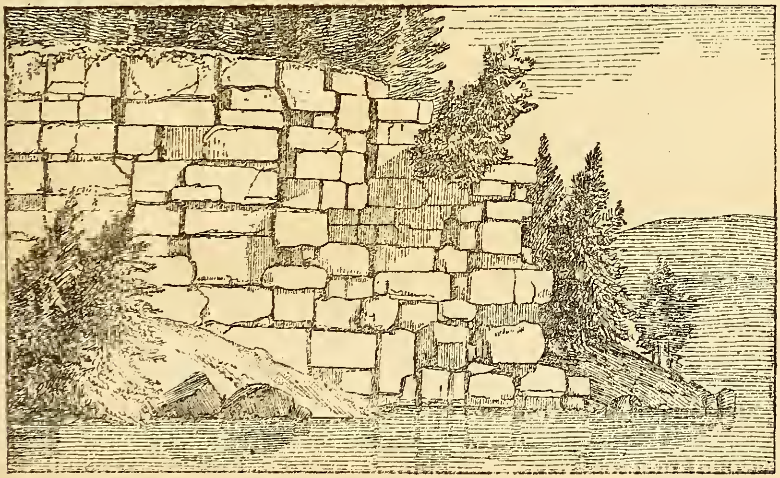
YELLOWSTONE LAKE. (EAST SIDE.)



YELLOWSTONE LAKE. (EAST SIDE.)

posed of compact trachyte, but surrounded with stratified breccia or conglomerate, jutting up against the sides and reaching nearly or quite to the summits. Indeed, some of the highest peaks are apparently made up of the conglomerate. We may conclude, not only that the carving out of the channel of the Grand Cañon was a very modern event, but that the deposition of the entire material which forms the cañon is, in a geological sense, quite a modern occurrence. The drainage of the country commenced long before the excavation of the present water-courses, but it is difficult to answer the question how this great drainage was brought about, unless we account for it by a general elevation of the entire country, gradually sending this immense body of water, which must have prevailed all over the Northwest at least, perhaps all over the Rocky Mountain region, westward into the Pacific and eastward into the Atlantic. As the waters slowly subsided they were separated into lakes of greater or less size, and then came the excavation of the Grand Cañon, which slowly drained the great lake-basin above the falls, so that now we have only the comparatively small remnant, the Yellowstone Lake. (Fig. 10.) Other small fragments are scattered about in the vicinity, which now form reservoirs for the local drainage. Undoubtedly the same series of remarkable physical events occurred in Oregon and in California and in Idaho and Washington Territories, and, perhaps, far southward into Mexico, judging from the published reports. The Hot Springs, which are now slowly dying out, are, of course, the last of this series of events. The evidence seems clear that all over the West during this great period of volcanic activity the hot springs and perhaps even geysers were very numerous. We everywhere find the remains or deposits in all the States and Territories west of the Mississippi, and now and then a warm or hot spring remains to indicate the story of their former power.

Fig. 11.

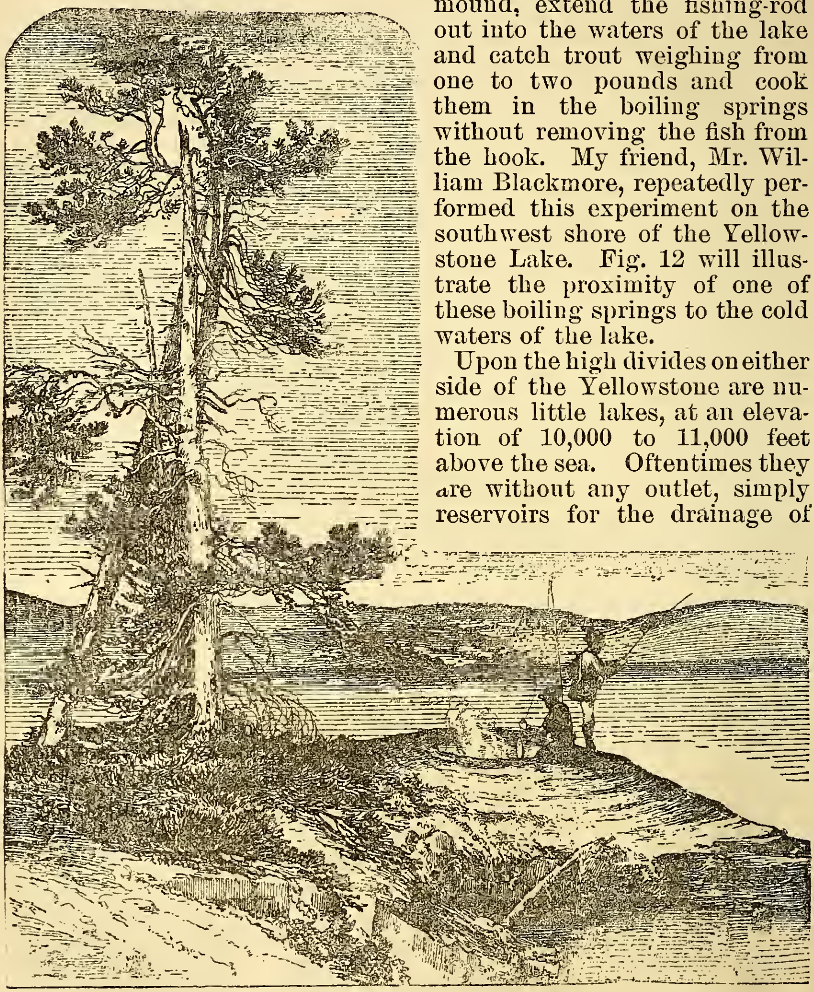


WALL OF BASALT, YELLOWSTONE RIVER, AT MUD SPRINGS

Fig. 11 is intended to illustrate the probable avenues through which the meteoric waters pass down through the rocks to the heated portions. At Mud Springs, about six miles below the Yellowstone Lake, there is a vertical wall of basalt, about 50 feet high. This wall is only a remnant of a vast mass which extended all along the river, but which has now been dissolved into clay of varied colors by the hot springs. The joints are very regular.

In my report of 1871, page 100, I described the Hot Spring mounds that extended into the lake from the shore, and stated that a person might stand upon the siliceous mound, extend the fishing-rod out into the waters of the lake and catch trout weighing from one to two pounds and cook them in the boiling springs without removing the fish from the hook. My friend, Mr. William Blackmore, repeatedly performed this experiment on the southwest shore of the Yellowstone Lake. Fig. 12 will illustrate the proximity of one of these boiling springs to the cold waters of the lake.

Fig. 12.



HOT SPRING, SOUTHWEST OF YELLOWSTONE LAKE.

Upon the high divides on either side of the Yellowstone are numerous little lakes, at an elevation of 10,000 to 11,000 feet above the sea. Oftentimes they are without any outlet, simply reservoirs for the drainage of the high plateau. Fig. 13 represents one of these elevated bodies of water which will always be invested with a charming interest on account of their romantic picturesqueness. Fig. 13 shows our camp at night after the party had made a long, tedious march from the Yellowstone Lake on the way to the source of the East Fork. Fig. 14 represents the party on horseback as it left the camp the following morning. The cuts were engraved from photographs taken by Mr. Jackson. The photographs show the whole party reflected in a remarkable manner in the clear waters of the lake.

Fig. 14.

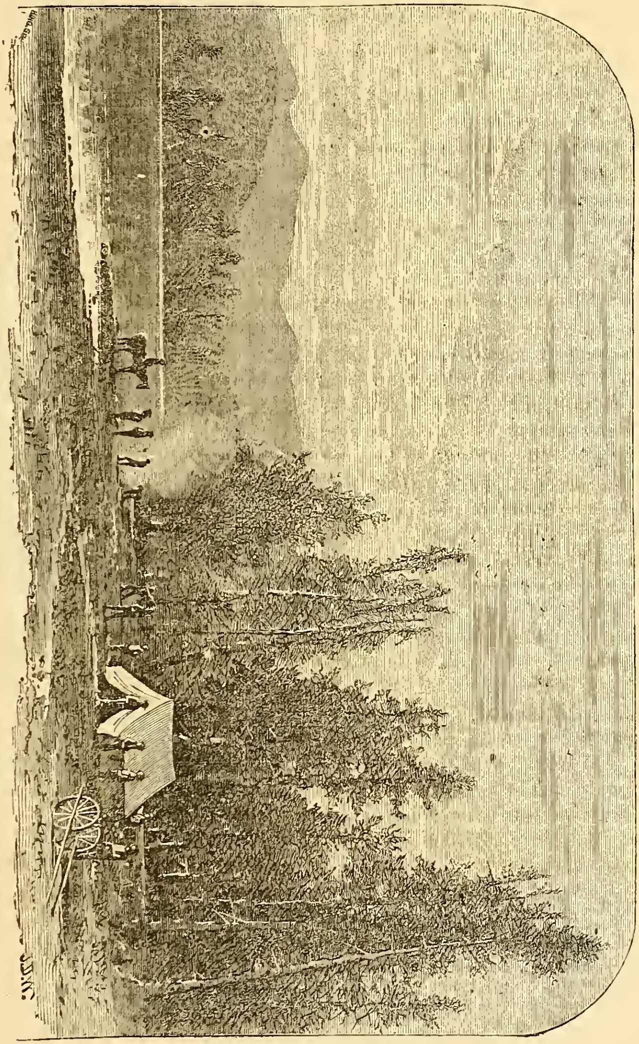
U. S. GEOLOGICAL SURVEY EN ROUTE.

Fig. 14.

U. S. GEOLOGICAL SURVEY EN ROUTE.

The hot springs and geysers of the Yellowstone and Madison were so fully described last year, and are, with considerable detail, noticed in the present report by Dr. Peale and Professor Bradley, that I have given them but little attention. I will refer, however, for a moment, to a few illustrations, and among them the fine one which I am permitted to use in this report by the courtesy of the editors of the Illustrated Christian

Fig. 13.



CAMP OF UNITED STATES GEOLOGICAL SURVEY, ON SHORE OF LAKE.

Weekly. The cuts were engraved from photographs taken by Mr. Jackson, of the survey, during the summer of 1871. The "Hot Spring Cone" we called the "Fish-Pot," from the fact that it extended out into the lake several feet, so that one could stand on the siliceous mound and hook the trout from the coldwaters of the lake, and, without moving, boil them in the steaming-hot water of the spring. There seemed to be no connection between the orifice of the Hot Spring and the cold water around. In the upper right-hand corner is the Castle Geyser, and the most beautiful spring in the Upper Geyser Basin of the Madison. The Grotto and Giant Geysers are first-class spouters, throwing a column of water up from 100 to 200 feet and continuing the operation from one to two hours. The "Boiling Spring," at Sulphur Mountain, is located in the valley of the Yellowstone, about ten miles below the lake, at a locality known as the "Seven Hills." It is indicated on the chart in the report of 1871, page 88, and described on page 89. This spring is known as the Sulphur Spring, and the open portion is about 15 feet in diameter. The ornamentation about this spring is beautiful in the extreme. At the lower right-hand corner is a small sketch of the Calcareous Springs on Gardner's River, with the curious terraces and bathing-pools which were described in detail last season.

So far as we could ascertain in our explorations, all the rocks about the sources of the Yellowstone and the Madison are of volcanic origin. It is true that in the valleys, the very modern lake-deposits reach a thickness of several hundred feet, but they are seldom taken into account as distinct geological formations. Still, they are found everywhere in the valleys. The foot-hills that border the Yellowstone Valley between the falls and the lake are entirely made up of them, and must have an aggregate thickness of 600 to 800 feet at least. Between the Yellowstone Valley and the head-waters of Madison and Snake Rivers, these modern deposits are seen everywhere, filling up the inequalities of the surface of the underlying volcanic rocks, and giving a rounded smoothness to the present surface. They form the soil upon which the existing vegetation grows. These deposits are all plainly local in their origin; that is, they are derived from the rocks in the immediate vicinity, or within the limits of the drainage in which the specific beds are found. For example, the modern lake-deposits of the Yellowstone Basin were all derived, so far as I could observe, from the rocks within the limits of the drainage of the Yellowstone River above the falls. The local origin of the modern drift-deposits seems everywhere apparent. The same deposits are found to a less extent in the Geyser Basins of the Madison. On the west side of the Madison, above and below the junction of East Fork, the bluff bank is 400 to 500 feet high, composed of trachyte. In the basin are a number of long, low ridges or hills, composed of porphyritic obsidian and trachyte, which, I think, are only the remnants of the great continuous mass out of which the entire valley has been carved. The Twin Buttes are also partially-disconnected portions nearer the high trachyte ranges that border the basin. Much of the rock is made up of rounded masses with a radiate structure, as if the igneous rocks were partially crystalline; other masses are composed of concentric coats, with cavities filled with feldspar, which, decomposing readily, give to the extensive surface a rough appearance. From the junction of East Fork down six miles, the Madison flows very majestically and most beautifully. The banks are low, and fringed with vegetation of the most vivid green, while visible through the water, the patches of vegetation give a most pleasing variety to the current. The warmth of the water seems to have given a kind of tropical luxuriance to the vegetation, stimulating to an unnatural growth. There comes a series of rapids of great beauty, with walls on the west side 600 to 800 feet, rising nearly vertically, and composed of layers of trachyte. Much of it is made up of rounded masses from the size of a pea to several inches in diameter, either with a semi-crystalline radiate structure, or filled inside with feldspar. The east side of the Madison recedes in step-like hills or ridges, until a certain elevation is reached, when, as far as the eye can reach, nothing can be seen but a dense forest of pines. We

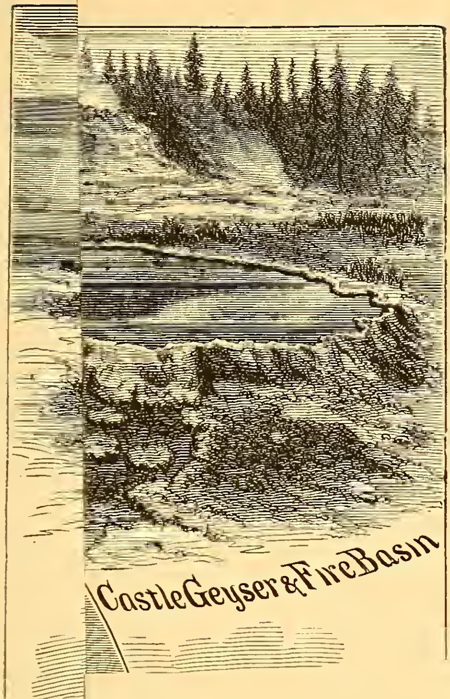

Castle Geyser & Fire Basin

Fig 5

YELLOWSTONE GEYSERS.

camped the night of August 21 in a very romantic place, at the junction of Gibbon's Fork with the Madison. Gibbon's Fork is a beautiful stream that flows into the Madison on the east side, about 100 feet wide, quite unknown on any of our maps. We have named this stream in honor of General John Gibbon, United States Army, who has been in military command of Montana for some years, and has, on many occasions, rendered the survey most important services.

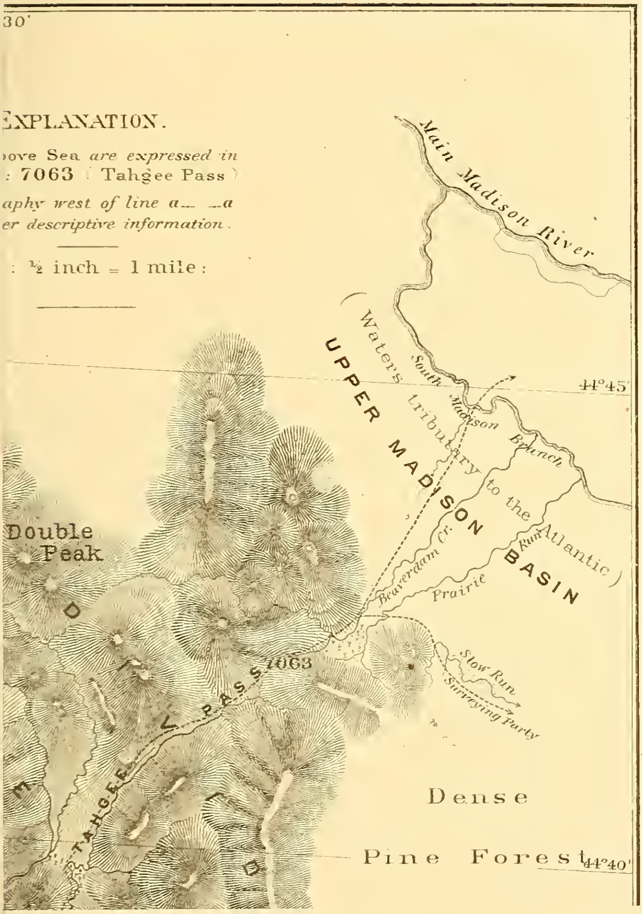
About half a mile up Gibbon's Fork on the west side are some very interesting hot springs. They are located near the immediate base of the hills that inclose the valley, elevated about 100 feet above the bed of the stream, and cover several acres with their peculiar deposit. The varied colors of the jelly-like substance were fine, and other vegetable forms are abundant. Several quite large streams flow away from the springs in winding channels, with beautifully-scalloped edges. One large spring forms a reservoir about 200 feet long, and on an average 50 feet wide. At one end of this reservoir are two orifices, one quite large in mass, two feet or more, boiling constantly. There is also a small side-orifice. From the sides of the hill several small hot springs flow into the reservoir along most elegantly-ornamented channels. If it were not for the greater and more important group of springs above, this small group would attract much attention at some future period. The old deposit has now become dry, but it was formed into quite large terraces, somewhat like those made by the calcareous springs, with larger reservoirs or pools, instead of the more delicate ones in the Geyser Basin. In the reservoirs and along the channels of the living springs are most beautiful masses or locks of vivid green confervoid vegetation, floating in the water like locks of wool. There are several other fine springs, but mostly of low temperature, with the inner surface of the basins covered over with a thick, deep, rusty-yellow, leathery substance, which gives them the look of a tan vat. The rocks on either side of the Madison are trachyte, but apparently arranged in vertical layers, so that the river seems to have worn its channel through them. The rocks appear as if they had originally been formed in horizontal layers, but had been tilted up subsequently into a nearly vertical position; but it is probable that this slaty fracture is due to some process of cooling. In the cañon where the walls rise on either side to a vertical height of 800 to 1,400 feet, there is no evidence of any tilting of the rocks of modern date. The valley through the cañon is about 300 yards wide, covered thickly with small pines. About five miles down the cañon on the right side, there are rather imperfect basaltic columns. In one instance a most picturesque arch is formed. On the summit of the cañon there is a bed of somber-brown rock that looks like basalt. The lower portions, which we have usually called trachyte, probably cooled under considerable pressure and is older, while the basalt is the result of a second outflow under far less pressure, is less compact and yields readily to meteoric agencies.

After passing through the cañon, which is about eight miles in length, we came out into a vast basin with a remarkable system of terraces on both sides of the Madison. The river is beautiful in its quiet flow. The water is shallow, clear, and at the bottom the bright vegetation may be seen like little green islands. As we come out of the cañon we have the bold basaltic peaks about the sources of Gardiner's River, extending down between the Yellowstone and the Madison; on the south is the long, low wooded divide between the waters of the Madison and Snake Rivers, very seldom rising above 7,000 or 8,000 feet; on the west side of the basin is the grand range, which extends on both sides of the Madison, through which the river has carved the Middle Cañon. The modern deposits in this basin are quite extensive, reaching an aggregate thickness of 400 to 800 feet, but they are composed mostly of volcanic sand and gravel or coarse drift-material, much worn, with only a small proportion of the light-gray marls, which we find so abundant in the valley of the Three Forks. Vast quantities of rounded bowlders are scattered over the surface, all of which, so far as I could ascertain, are of volcanic origin. This basin is mostly covered with a thick growth of pines, with here and there open meadow-like spaces or parks.

From this basin we made a short side-trip to Henry's Lake, which forms the source of one of the main branches of Snake River. After traveling several miles across the bottoms through dense pine-woods, we came out near a good-sized stream, which flows into the Madison from the west. Crossing this we have a broad open meadow for several miles until we reach the Tahgee Pass, which leads over to the valley of Henry's Fork. The scenery was very attractive in every direction. This branch, which has never yet been laid down on any of our maps, is about 100 feet wide, and on an average one foot deep, and winds most sinuously through the low, boggy bottom. We followed the old Tahgee trail to the East or Tahgee Pass, named years ago after the head-chief of the Bannacks. This is a low level pass over which a coach and four might travel on a gallop. It is underlaid mostly with limestones, but as we approach Henry's Lake, the quartzite and gneissic rocks appear beneath the limestones. The lower portion of these unchanged rocks are pebbly arenaceous limestones and sandstones. The pebbles are much worn, and are either quartz or micaceous gneiss, showing that the sediments were derived directly from the metamorphic rocks.

In this pass there is a group of huge hemlocks that will at once arrest the traveler's attention. They seem to belong to another age. There are ten of them, and several others have perished. They are four to six feet in diameter, and rise to a height of 100 to 150 feet. This group of trees is the more conspicuous from the fact that they are larger than any others in this region, and have a very ancient appearance.

There is one peculiarity of the tree-vegetation all over this portion of the West, that it has a fresh, young look. The pines are seldom more than two feet in diameter, sending up a straight stem 100 to 150 feet high, and a large aged pine, or tree of any kind, is a landmark as well as a curiosity. We ascended the mountains on the north side of Henry's Lake, and from this point obtained a fine view of the country in every direction. The view down Henry's Fork was remarkably fine. The air was clear and pure, and the valley to the junction with Snake River was spread out like a picture, while the magnificent range of the Tétons, full fifty miles distant, seemed not half that distance. The metamorphic rocks are best shown on the west side of this range. Henry's Lake was at our feet, shallow and full of little islands, only a remnant of its former self. To the west there is a beautiful grassy valley, with a small stream that flows into Henry's Lake. This valley leads up to the divide from which the west fork of the Madison takes its rise. South of this valley there is a belt of metamorphic rocks extending off far to the west, rising 800 to 1,200 feet above the lake. On the south side, and extending to the southwest toward Red Rock Lake, is another valley, which forms a beautiful pass. The low belt of mountains between these two passes is grassed over or thinly-wooded with pines. While the range on the south side of the lake, which extends off in a southwest direction from Henry's Fork Valley, is very heavily timbered. This is a fine range, and is at this time covered with large patches of snow. The


30'
EXPLANATION.
ove Sea are expressed in
: 7063 (Tahgee Pass)
aphy west of line a— —a
er descriptive information.
: ½ inch = 1 mile :
Main Madison River
(Waters tributary to the Atlantic)
UPPER MADISON BASIN
South Madison Branch
Beaverdam Cr.
Prairie Run
Slow Run
Surveying Party
44°45'
Double Peak
7063
TAHGEE PASS
Dense
Pine Forest
44°40'

FOLDOUT

first peak to the east is about 10,000 feet, the second peak 10,500, and the third peak in the range 10,000 feet. This will afford some idea of the general elevation of these mountains. On the east side the mountains gradually bend down to the valley, but are covered with a dense growth of pines. Far southward extends the valley of Henry's Fork—a marvel of beauty and freshness. The upper portion, for an extent of twenty to twenty-five miles in length and five to ten miles in breadth, is like a meadow, covered with a luxuriant growth of grass; while flowing from the lake and winding through the middle of the valley, receiving on either side numerous branches, is Henry's Fork. Still farther southward is a dense black mass of pines, and just on the dim horizon, more than one hundred miles distant, is the range of mountains that forms one side of the rim of the Snake River Basin near Fort Hall. North of this is the wonderful Téton Basin, which is also like a meadow. To the southeast the shark-teeth summits of the Grand Tétons are most conspicuous and clearly defined, rising so high above all other mountain-peaks that they stand isolated, monarchs of all. To the northeast of the Tétons there is a broad extent of table-land, with a general elevation of 8,000 to 8,500 feet, covered with a dense growth of pines. This plateau is probably covered with volcanic rocks. On the east or northeast is the Tahgee Pass, and Bannack Trail, which cuts through a range of mountains, the highest peaks of which are 9,000 feet, down the eastward slope, to the pine table-lands about the sources of the Madison and Yellowstone. Nearly all the rocks on the southeast side of the Tahgee Pass are volcanic. Yet on the sides of the pass are a few outcroppings of limestone. We know that the limestones are underneath the trachytes. The area occupied by the different kinds of rocks can only be shown by colors on the geological map, which will be prepared in due time. On the north side of Henry's Lake is the range of mountains which forms the divide between the Snake and Madison Rivers, and through which the Madison cuts its way in forming its Middle Cañon. Henry's Lake is a fine illustration of a remnant, dating back probably to Pliocene times, when all these valleys were filled with water, perhaps connecting the drainage of the Missouri with that of the Columbia, and as the waters subsided, formed the vast chain of lake-basins along all the important streams on both the Atlantic and Pacific slopes, of which our present lakes are only insignificant remnants.

I have no doubt that the lowest strata of unchanged rocks about Henry's Lake are Silurian, probably of the Potsdam group, but I looked in vain for any traces of organic remains. The Carboniferous limestones higher up were filled with characteristic fossils. I regard this as one of the most interesting geographical points in the West. Within a circle of about fifteen miles in diameter there are four most important passes in the Rocky Mountain divide, which may represent the four points of the compass. The East or Tahgee Pass connects the Yellowstone National Park, the sources of the Madison, and the Yellowstone, with the Pacific coast. It has an elevation of 7,063 feet. The second may be called the North or Raynolds Pass, and leads from the Snake Valley, by way of Henry's Lake, over a smooth, grassy lawn, into the Lower Madison Valley. The third is the Red Rock or West Pass, which opens into the valley of the Jefferson by way of Red Rock Lake, and is as smooth and as easily traveled as the Madison Pass. The South or Henry's Pass completes the circle, and is lower than either of the other three. The ease with which railroads or wagon-roads can be constructed across these great divides is almost incredible to one that has not made them a subject of study, and the great area of valuable territory which may be opened to settlement through them may entitle them to the appellation of the Great Gateways of the West.

On the night of August 24 we camped at the upper end of the Middle Cañon of the Madison, and here remained a day or two in the midst of most instructive illustrations of mountain-scenery. The relations of the limestones to the metamorphic rocks below are most clearly shown. The strata have been lifted up in mass at various elevations, and the outcropping edges have been smoothly worn off, so that the line of separation is unmistakable. There is always a want of conformity. The limestones sometimes cap mountain-peaks that are full 10,000 feet high. Terrific chasms have been cut deep down through the limestones into the metamorphic rocks in every direction from 1,500 to 2,500 feet deep. The geology is as easily read as in the pages of an open book. The admirable sketches of Mr. Holmes cannot fail to make the relations of the strata clear to the general reader as well as the professional geologist.

The valley of the Madison above the Middle Cañon is a marvel of picturesque beauty. The descent must be slight, for the river, with the branches which come in on either side, meanders through the grassy meadow with the most remarkably sinuous course I have ever seen. The skillful landscape-gardener could gather some useful hints in his art from this region. The channel appears as though it had been cut out by the hand of art, and the little islands in the channel are of every conceivable form and of great beauty. Although only a portion of this basin comes within the limits of the park, yet this lower portion, with such a marvellously beautiful landscape, will ever remain one of the wonders of this region in a purely esthetic point of view. As a study for the artist I have nowhere seen any view of the kind that could compare with it, and I now call attention to it as one of the attractive points for visitors at some period in the future. In the lower half of the basin there is but little pine-timber, and high up, on both the east and west branches, which enter the Madison near together at this point, the surface is covered with a luxuriant growth of grass. I estimated that the grass-land in the lower portion of this basin exceeded one hundred and fifty square miles. The slopes from the base of the mountains on either side down to the river are most admirable illustrations of lawns on a grand scale. The bottom ascends to the foot of the mountains with a very gentle slope, and the latter rise abruptly with almost inaccessible sides. The East Fork rises near Mount Gallatin and receives a portion of its waters, and winds its sinuous course through the basin for a distance of twenty to twenty-five miles. This fork seems to drain the entire range west of the sources of the Gallatin, about twenty or thirty miles in length, and a stream about 150 feet wide and 1 foot in depth, on an average, is the result. The four branches, which we find entering the Madison below the Lower Geyser Basin, are very handsome streams and about the same size. For several miles, before reaching the immediate entrance to the Middle Cañon, the valley slowly closes up, and on either side some very interesting facts may be read. On the east side of the Madison the limestones are remarkably well exposed, but incline at all angles. I found it difficult to obtain any local dip that would apply over large areas. There is, however, a system in the aggregate, and I think the general inclination is south and southwest. The lower beds of limestones are very cherty, brittle, and entirely destitute of fossils. My entire party searched diligently for a day or two and no trace of life could be found, but in the upper limestones great quantities of mollusca, corals, &c., characteristic of the Carboniferous period, were obtained. Thick beds of limestone were entirely composed of an aggregate of these fossils. Most of them were in an excellent state of preservation. The lower beds doubtless belong to the Potsdam epoch. It is barely possible that some other divisions of the Silurian occur between the Potsdam group and the Carboniferous, but as yet we have no evidence, and until it is discovered we will take it for granted that the Carboniferous limestones and the Silurian beds are in apposition, and that they all rest on the metamorphic rocks. The limestones seem to dip beneath the basin on the south side of the range, and as we ascend the high and almost vertical sides of the mountain, we pass ridge after ridge of limestone, each inclining at a greater angle, until, on the summit, they are vertical and stand up in lofty massive walls. Thus exposed for ages to the elements, they have been weathered into the greatest variety of columns and other picturesque forms. Between these ridges are beautiful grassy valleys, 2,000 and 3,000 feet above the river, to which the mountain sheep seem to delight to descend from the rocky pinnacles to graze.

Near the head of the Gallatin there is a very prominent cone-shaped mountain, to which Captain Raynolds gave the name of Mount Gallatin twelve years ago. It is visible from a great distance on either side, probably for a radius of fifty miles. On each side of this peak, and in close proximity, are two smaller peaks of nearly the same height. Mount Gallatin is about 10,000 feet high, while the smaller peaks are about 9,000 and 9,500 feet. These peaks are composed mostly of limestones, and the intermediate space to the cañon of the Madison, a distance of thirty miles, is occupied to a great extent with these rocks. I have no doubt that in the divide between the Gallatin and the East Fork some of the more modern beds occur. Dr. Peale found the Jurassic beds at one locality on the East Fork rising up from beneath the limestones. It is probable that here there has been an inversion of the strata, as we find to occur, in a marked manner, only a few miles below. Basaltic rocks are found to a greater or less extent everywhere among the limestones, sometimes at the base of the mountains, and again at the summits or high up on the sides. The igneous material seems to have issued forth from fissures whenever a favorable opportunity presented itself. The gorges are quite remarkable. In some places the waters seem to have gouged out, as it were, a semicircular mass, with a vertical descent of 1,200 to 1,500 feet, and on the sides the massive strata of limestone are worn into columns or pinnacles, so unsteady in their position that the loose rocks may be pushed over into the gorge below. The bottom of the cañon is full of *débris*, and doubtless ice had much to do in wearing these very curious and immense gorges into the mountain-side. What may be called the secondary series of hills or ridges are 2,000 to 2,500 feet above the Madison, while the higher peaks rise 3,000 to 3,500 feet, and here and there a peak sends its sharp summit 4,000 feet or more. The proofs of erosion are everywhere on the most gigantic scale. The cañon has been worn out in the same manner as those on the Yellowstone, but in the mean time the narrow channel doubtless became gorged from time to time. The basin which we have attempted to describe, which is about thirty miles in length and ten to fifteen in breadth, was once a fresh-water lake, but the water slowly wrought its way through this high range of mountains. Near the immediate entrance of the cañon, on the east side of the river, there is a short, high, terrace-like ridge, about one-fourth of a mile long, 250 feet high above the bed of the river, paved on the surface with rounded bowlders, and, I have no doubt, made up of a local drift. The upper end is quite abrupt, steep, and at this point in the side of the mountain there is a small cañon, from which a considerable amount of water must flow at certain seasons of the year, and the materials from this cañon may have assisted in building up the ridge. I have no doubt, however, that the upper portion of the cañon has been at some period filled up with loose bowlders and drift transported from above, and when the gorge broke away, most of it was carried down the river, but that this portion was in some way protected. The entire valley between the mountains is literally paved with rounded bowlders, and there is no doubt that this same coarse material extends beneath to a great depth. In the cañon itself there is a still more prominent ridge, and the loose rocks on every side are much larger and more abundant. A fine stream comes into the river from the mountains on the east side. This little stream has cut a narrow gorge for fifteen miles, with walls on either side 2,500 to 3,000 feet high. There is an abrupt bend in the river just above this ridge of bowlder-drift, which may account in part for its accumulation at this particular spot. The central portions of this range are mostly micaceous gneiss, some parts very compact, fine-grained, steel-black in color. The variations in texture and color are very great, as is usual among the metamorphic rocks. From the summit of the high ridge on the east side of the river, at a height of about 9,500 feet, we were able to take in a large scope of country, and study out the character of these rugged mountain-peaks. In this range, which is a limited one, there are a dozen peaks which will reach 9,800 to 10,250 feet, while two of them are about 10,500 feet. The rocks are all metamorphic or gneissic, and remarkably hard and compact, so effectually resisting the meteoric forces that the rocks to the summits of the highest peaks are as sharp and angular as if only fractured within the present season. These unworn angles give a peculiar sharp ruggedness to the view, as the eye passes across the summits of the many peaks or descends into the innumerable gorges on every side. To the east, toward the valley of the Gallatin, the strata of limestone may be most clearly seen where they have been cut down in the gorges, yet holding a great variety of positions. Sometimes they dip down suddenly in the valley and pass out of sight, then again they are elevated bodily to the summit of a high peak, resting on the metamorphic rocks. On the west side of the Madison there are three or four peaks which are at least 10,000 feet high. Among these mountain-gorges we see the sources of the myriad small branches which, in the aggregate, form the large river. Nestled among the craggy cliffs are here and there little ponds of clear water, derived from the melting of the snows, seldom ever seen except by the birds and the game that visit them to quench their thirst. The tendency of all these gorges is to work their way inward toward the divide. Great masses of snow and ice accumulate in them during the winter, and the water, flowing down among the fractured masses, freezes, and expands with a force that year by year tears down a portion, that falls into the depths below and is swept down by the torrent. The aggregate of the forces which have continued in operation through a series of ages, which no man can determine now, and which we agree to denominate meteoric or atmospheric, are the combined action of water, air, and ice. These forces have undoubtedly been far more effective in ages past than at present. In one of the gorges which lead down to the river in the cañon, we discovered a complete inversion of the strata, and this condition of things was found afterward to prevail to a large extent in these mountain-ranges. I would refer the reader to Dr. Peale's report, and also to the descrip-


SKETCH OF A
RECONNOISSANCE
OF
CLIFF LAKE
Eight miles N. W. of Lake Henry
and five miles S. E. from Junction of
Madison River with its West Fork
BY
GUSTAVUS R. BECHLER
Chief Topographer
SNAKE RIVER DIVISION
DEP'T. OF THE INTERIOR
U. S. GEOLOGICAL SURVEYS
OF THE
TERRITORIES.
PROF. F. V. HAYDEN
IN CHARGE.
Note.
No visible outlet known
to this Lake.
111° 44'
111° 42'
44° 50'
44° 48'
44° 46'
Steep high Bluffs
High Table Land broken and Terraced
Rapidly descending Bluffs
Vertical Cliffs
Cliffs
General descent toward
Madison Valley; terraced and
intervened with Ravines
and depressions.
Gradual descent →
Pyramid I.
Narrow Cañon
Spring
Steep Bluffs
Steep high Bluffs
Inlet
Inlet
Country broken and Terraced
with ascent toward western Range
Scale
0 ¼ ½ ¾ 1 Mile.

tion of the Gallatin range in a subsequent chapter, where other examples of inversion of strata will be noticed.

About ten miles northwest of Lake Henry, below the Middle Cañon, a small stream, which has its origin in the Raynold's Pass, flows into Cliff or Wade's Lake. The little stream has cut a singular gorge through the trachyte-rocks, with vertical walls 400 to 600 feet high, runs southwest about two miles, turns abruptly south around a point of trachyte 600 feet high, and continues nearly west. This lake, which has not been noticed on any of the existing maps, is said to have no outlet. It seems to be formed in a huge fissure in the volcanic rocks, and is surrounded by lofty nearly vertical walls.

This lake was carefully explored by Mr. Bechler, and the beautiful map of it, accompanying this report, was prepared by him. He says that it has three small streams flowing into it, but has no visible outlet, but the surplus water probably passes under the basaltic cap. The sides of the lake are so steep and high that it is not possible to travel near the shore, but Mr. Bechler ascended the high cliffs overhanging the lake and obtained a beautiful view of the surrounding scenery. The high basaltic cliffs that inclose it suggested the name of Cliff Lake. Near the middle of the lake, there is a small, conical island, about 150 feet in diameter, but rising 100 feet or more, covered with tall, straight pines. There were several smaller lakes in the vicinity, all of them apparently formed in these basaltic fissures, and without any visible outlet.

The valley below the Middle Cañon gradually expands until it becomes six to ten miles in width. At the upper end of the valley the terraces do not show as well as below, but in no other portion of the West have I seen so uniform and so beautiful a series of terraces as in this basin. I point this out here to the reader, who may ever chance to visit the country, as one of the wonders of this remarkable region. At the upper end of the basin the terraces are quite well defined and show a most extensive deposit of loose material at the bottom of the lake. The surface of the entire valley is covered with bowlders of greater or less size, many of them huge massive granite. On both sides of the river are caps of basalt covering and protecting from erosion the underlying lake deposits. From these basalt-capped hills or terraces I infer that the modern lake-deposits must have originally been from 500 to 800 feet thick, perhaps much more. The river has cut its way through this deposit, forming in some instances a narrow gorge with the basaltic cap on either side like a high terrace, while the foot of the mountains on both sides is distant from half a mile to one mile. We can thus understand pretty clearly what must have been the thickness of these lake-deposits immediately after the outflow of the igneous matter. As we pass down the river all this basaltic floor has remained, and the entire surface of the valley, from side to side, smoothed like a lawn. Whether there was one period or several of outflow of basalt I cannot state positively. In the vertical sides of the river-channel the basalt may be seen at different elevations, but no continuous layers, and, therefore, it may have fallen down from the summit; yet I suspect there were several periods of outflow. In many localities the basalt is exposed in the form of a high vertical wall with a partial columnar appearance. It also varies, in color as well as in texture, from a very dark-brown to a purplish-drab. All the lake-deposits, as well as the igneous rocks, lie in horizontal position, and, so far as can be observed, have not been affected by any subsequent movements. We may, therefore, infer that the forces which raised the surrounding mountains to their present position, and tilted the strata, operated prior to the existence of these fresh-water lakes.

There may have been periods of elevation and subsidence since the existence of the lakes; if so, the disturbance has never been great. In some cases, where the river either in ancient or modern times, has washed the foot of the mountains, the old trachytes have been removed, exposing the granites at the base.

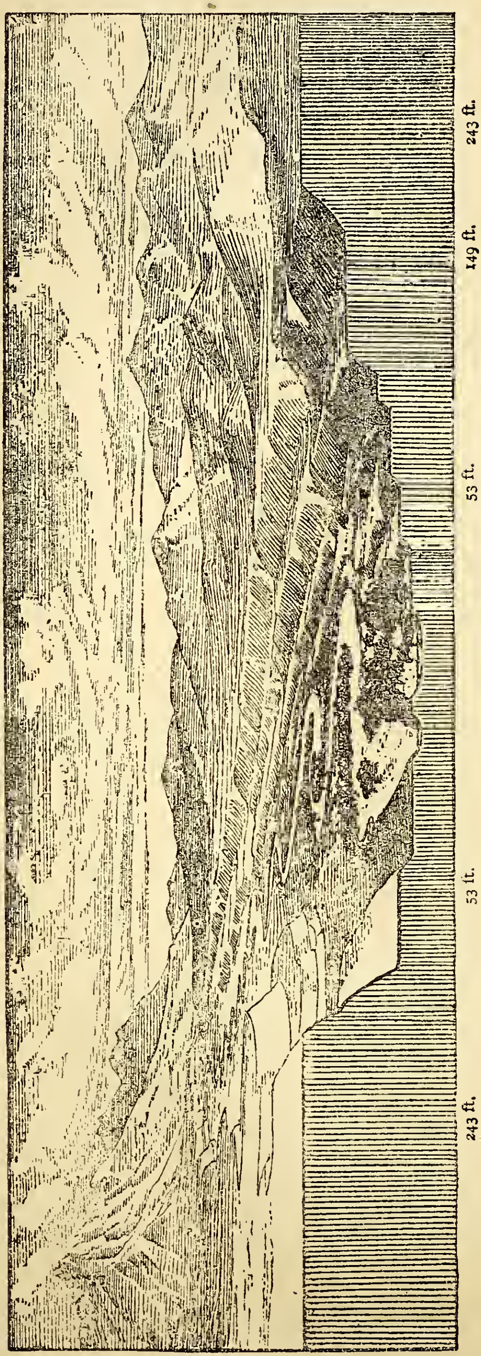


Fig. 16.

TERRACES, VALLEY OF THE MADISON. (Elevations are given above water level of the river.)

This basin is about fifty miles in length, with an average of five miles in width. The lower thirty miles present the most remarkable system of terraces that I have ever seen. There are usually three of the terraces on either side of the Madison, and locally they may be increased to six or eight. The great feature in regard to them is their persistency and uniformity, each terrace being at the same elevation as the corresponding one on both sides. This is quite unusual. Generally, the terraces will be well displayed on one side of a stream and scarcely seen on the opposite side; and, if they are shown on both sides, there is not necessarily the same elevation to corresponding terraces. The lake must have been drained through the Lower Cañon very slowly. The general elevation of these terraces may be estimated, above the bed of the river, about as follows: First terrace, 10 feet; second terrace, 30 feet; third terrace, 100 feet. Messrs. Gannett and Brown made quite an extensive series of observations with the barometer, and the results will be given in a subsequent portion of this report. These terraces are well shown in Fig. 16.

An interesting feature may be observed in this basin in the character of the bowlder-deposits. At the upper end of the basin the entire surface is paved with rounded masses of granite and basalt, some of great size; but as we descend they become smaller in size and less abundant, so that the lower portion of the basin reveals a considerable thickness of the light-gray marls and sands, which give evidence of having been deposited in comparatively quiet waters. So thick are the bowlders over the upper half of the basin that it can never be used except for grazing-purposes, while the lower half is already occupied with fine farms. The rush of the waters through the Middle Cañon must always have been very great, but their force almost entirely subsided before reaching the Lower Cañon.

Between the Madison Valley and that of Passamari Creek there is a long somewhat irregular range of mountains, the geology of which I can present in this report only in general terms. Although the structure is comparatively simple, it would require long and faithful labor to work out all the details. The general elevation is not great, 7,000 to 8,000 feet, and only two or three peaks rise up so as to be prominent, Pyroxene Peak and Old Baldy. As usual, the nucleus is composed of the various kinds of metamorphic strata, with effusions of igneous rocks, while the unchanged sedimentary strata, mostly the Paleozoic, are observed at all elevations resting on the granites. The evidences of erosion are more striking in this range than in the mountains between the Madison and the Gallatin, probably because their general elevation is at least 1,500 to 2,000 feet lower, and they were much longer exposed to the wasting influences of the aqueous forces. Deep cañons are worn into the mountains on either side, and the numbers of old dry ravines or gorges are almost countless. Prior to the effusion of the igneous rocks the greater part of the erosion took place, though comparatively little had been done to produce the present configuration. The skeleton or framework was formed of the metamorphic rocks with the remnants of the Silurian and Carboniferous strata that were left after the vast work of erosion, which occurred prior to the outflow of the igneous rocks. In subsequent erosions the latter have protected the sedimentary beds over a great area, so that they are exposed in little patches everywhere, sometimes on the summits of the mountains or at all elevations in the ravines or cañons. Sometimes the igneous rocks have been worn away from the surface for a considerable area, leaving a greater or less thickness of the limestones. In some localities they present a great vertical thickness and then again thin out or disappear entirely. There is an interesting but obscure feature which is shown in the mountains on both sides of the Madison. There is, in restricted localities, an enormous development of a very hard gray quartzitic sandstone, apparently partially metamorphosed. It evidently forms the underlying rocks of the sedimentary strata, resting on the strictly metamorphic gneiss. The various members of the survey have examined it most carefully, but have never been able to find any trace of organic life, yet it undoubtedly belongs to the oldest Silurian. It makes its appearance quite abruptly, with a thickness of 1,000 to 2,000 feet, and as abruptly disappears or thins out. It is well shown in the Middle Cañon of the Madison and in the lower part of the cañon of the Gallatin, and is thinly represented in several other localities. We may say of all these different groups of strata that they appear at times in grand proportions, and are soon lost or are only thinly shown. Along the east side of the Gallatin River, above the Three Forks, at least 1,600 feet of shales, clays, sandstones, &c., which belong undoubtedly to the Potsdam group of the Lower

Silurian, are clearly shown, and yet, at a distance of thirty miles to the northward, this entire group seems to be wanting.

In the report of the survey of last season I described the country about Virginia City in brief terms, and but little more can be added from the examinations of the present season. Alder Gulch is well known to the mining world as one of the richest placers in the West. It is estimated that about thirty millions of gold have been taken out of it. The bowlder-drift is a marked feature in the gulch. Upon the sides of the hills patches of black basalt may be seen in considerable numbers, indicating the very latest period of eruption. The older trachytes also occur on both sides of the gulch, which have been erupted at different periods and have overflowed the gneissic rocks. None of the igneous rocks observed by me, however, were old in a geological sense; none that date back further than the Pliocene epoch. A more careful scrutiny of the rocks might have resulted in detecting igneous rocks of different geological ages, but very few seem to date back beyond the Pliocene. It is not uncommon to find the basalts interstratified with Cretaceous and Tertiary beds, but I do not think it follows that the eruption took place during these periods. In the high bluff opposite the Mammoth Hot Springs, on Gardiner's River, thick beds of basalt are exposed in the upper portion of the bluff of irregular extent. On the summit is a very thick bed lying across the upturned edges of the strata, and the line of contact is quite red, showing the influence of the melted lava on the sedimentary strata immediately beneath. I am disposed to believe these short intercalated beds of basalt may have been of very modern origin.

At the head of Alder Gulch there is a high wall of limestone of which Old Baldy is the highest point. The aggregate dip seems to be about southeast 30° to 45°. The exposure is a fine one, with 1,200 to 1,500 feet of vertical strata. The lower portions of the sedimentary beds are quartzose, sometimes pebbly, very hard, compact, gradually passing up into limestones, which are also very hard and splintery, destitute of fossils. But in the upper portion of both sides of Old Baldy the characteristic Carboniferous fossils are very abundant. Thick beds of limestones are a simple aggregate of well-preserved fossils, and among these some very interesting crinoids. For a list of the fossils from this locality the reader is referred to the catalogue of Mr. Meek. The high ridge or mountain-range of limestones, of which Old Baldy forms a part, trends off to the southwest, across the head of the Passamari, Black-Tail Deer, and Red Rock Creeks, to an unknown distance. These huge ridges, which extend in such long lines across the Northwest, are undoubtedly portions of grand anticlinals. It will prove a great source of pleasure at some future time to trace these great axes of elevation across the country and aggregate them into a symmetrical group. Until this is done it will hardly be possible for us to comprehend the correct topography or geology of this region.

We will return to the Madison Valley. That the period of the eruption of the igneous rocks began before the mountain-ranges had reached their present height and form is shown by the position of some of the ridges of trachyte that extend down the sides of the mountains into the valley on the west side of the Madison. The ridges of trachyte have been so eroded that the bluff-sides present a stratified appearance and the inclination is 5° to 10°, the beds passing from near the summit of the divide down beneath the superficial or lake deposits of the basin. As we descend the Madison the range of mountains on the west side is more purely metamorphic, few of the igneous rocks being observed, and no sedimentary at all. This continues nearly to the Jefferson Fork, where the South Bowlder Range is cut off by a narrow synclinal which forms the valley of the Jefferson. The limestones incline away from the north end of the South Bowlder Range, but the greater portion, including all the lofty peaks, is composed of granitic rocks.

The divide which separates the basin which we have just described from the lower basin about the Three Forks is composed almost entirely of metamorphic strata. Here and there we observe an outflow of igneous matter, but very seldom. In the ravines and depressions, as it were filling up the inequalities of the surface of the metamorphic rocks, are the lake-deposits, which show so clearly that at a modern period the Madison Basin was connected by water with the entire valley of the Three Forks, even far below their junction. As the waters subsided so as to expose this granite-divide, they gravitated toward that portion of the basin where they now flow through the granite-cañon. What caused the waters to wear out the present channel is not obvious at this time. The ridge or divide may have been lower at that point or there may have been a slight fissure which determined its choice.

In following up the channels of some of the little streams that flow out of the mountains on the east side of the Madison, Dr. Peale and Mr. Holmes found that the strata were inverted. In the cañon of Jackass Creek all the beds, from the lowest Silurian to the Tertiary inclusive, were inverted so that the youngest Tertiary beds were at the bottom in order of superposition. For a more complete account of the geology of this region, as well as the Cherry Creek mines, the reader is referred to the report of Dr. Peale.

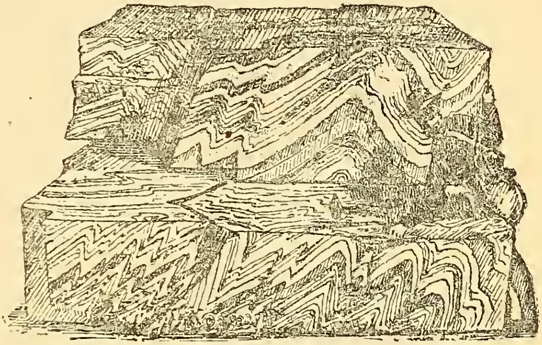
CHAPTER IV.

MADISON VALLEY—THREE FORKS—GALLATIN VALLEY AND CAÑON TO SOURCE OF RIVER—FROM THREE FORKS TO HELENA.

Just below the mouth of Elk Creek, the Madison Valley expands into an open basin with high, rather rounded hills of the lake-deposits on the east side about ten miles distant from the rim, while on the west side are bluff-lands, cut by the river, exposing the strata clearly and showing their horizontal position. In none of the upper basins are the lake-deposits as well exposed, and the character of the sediments shows that they were deposited in comparatively quiet waters. The long point or tongue which extends down to the junction of the Forks, between the Madison and the Gallatin, is composed of these deposits, and in the ravines, which in some places cut deep into the ridge, large masses of very beautiful silicified wood are found. I have no doubt that bones might be found by diligent search; for in the Jefferson Valley, in the same kind of deposits, I discovered the teeth and jaws of an Anchitherium, and a species of Helix. Of course these basins were all connected at one time far up the valley of the Jefferson as well as the Gallatin, but during the gradual period of subsidence became disconnected and ended in quite distinct lake-basins. The South Bowlder Range formed a shore-line on the west side. The waters must have reached so high up on the sides that little more than the summits of the peaks were above the surface and therefore most of the ranges were then represented only by small islands. The Madison and the Gallatin Ranges on the east were also shore-lines, but became more conspicuous as the waters diminished; and while thin patches of the peculiar lake-deposits are found high up on the mountain-sides, showing that at a very modern date the valleys of most of the streams must have been connected through the low passes, yet the principal sediments are in the lower basins. Indeed, I could imagine that the entire Northwest (and how much more of the country I cannot now positively determine) presented much the appearance of the basin of Great Salt Lake, with the numerous mountain-ranges rising above the waters. Now, if we can imagine the entire area of the great basin between the Wahsatch Mountains and the Sierra Nevada covered with water to a height which it must have reached at a comparatively modern geological period, the vast number of mountain-ranges of greater or less size which now exist within these limits would represent so many rocky islands in this vast inland sea. Here and there in the valleys of the Madison, as well as the Gallatin, the older rocks are exposed beneath the lake-deposits, even where the latter prevail. We can trace out with more detail the skeleton of the surface prior to the laying down of the lake-deposits. In the lower valleys it is quite rare to find rocks more modern than the Carboniferous, but the limestones and granites crop out oftentimes in the most unexpected places. The stripping away of the lake-deposits from the metamorphic rocks in the range through which the Lower Cañon is formed has exposed a moderately rich mining district. There are a number of mines which are wrought with success at this time, and on the whole the mining prospects of all this region are becoming better every year. The excellent reports of Mr. R. W. Raymond, Commissioner of Mining Statistics, are so full in regard to the mines of Montana that I shall at present touch this subject very briefly.

It is my intention to study all the mining districts of Montana at some future period with special reference to their geological relations, carefully mapping the lodes, and endeavoring to study out if possible their natural history. I believe, that Montana is rich in valuable mines, and that, when railroad communication has been established between it and the world at large, an impulse will be given to the mining interests of the Territory that will satisfy the most sanguine. It behooves the enterprising citizens not to let the subject of railroad-communication rest from this time until it becomes an accomplished fact. The world will then begin to appreciate the resources of the Territory, which, so far as I have examined it, surpasses any of the others in the West. The Cherry Creek Mines occur in what has been called the Madison range. The reader is referred to the report of Dr. Peale for such information as he has been able to secure in a brief visit to them. This mining-belt passes across the Madison by way of the Lower Cañon, and extends to the South Bowlder Mountains. Hundreds of lodes have been opened, many of them worthless; but many others would doubtless prove valuable if transportation and labor were not so costly and difficult to obtain in the country. The lodes are all found in the metamorphic strata, the age of which it would be difficult to decide. We only know that they form a vast thickness of stratified rocks with varied texture and composition. They seem here to have been subjected to considerable erosion after the limestones were washed away. These metamorphic strata underlie the entire country and appear everywhere where the unchanged beds have been worn away or when not concealed by the outflow of igneous matter. The work of reducing these metamorphic strata to a system, and connecting them over extended areas, has not yet been attempted, and it seems to me an almost hopeless as well as fruitless task. It will be enough for the present generation, perhaps, if we are enabled to work out pretty clearly the story of the sedimentary formations of the West. Along the valley of the Madison below the mouth of Cherry Creek, there is a remarkable exhibition of the gneissic beds. For several miles the strata are exposed so that the succession is perfectly clear for thousands of feet in thickness. All the varieties of composition and the flexures in the bedding peculiar to mining-rocks are seen in perfection. Veins of feldspar and quartz extend across the bedding a foot or more in thickness, evidently segregated in fissures like the mineral matter in a lode. Masses of a very compact black hornblendic gneiss, 4 to 6 feet thick, and 8 to 10 feet long, lie between the strata as if they were old intrusions of trap. I have never seen a better opportunity for a detailed study of the gneissic rocks, for they are shown here in high vertical walls for six miles, inclining in the same direction 30° to 50°. The beautiful examples of banded gneiss, as shown in Fig. 17, are not uncommon, and excite much attention. I have used the term gneiss in its broadest sense, to signify granitic rock composed of quartz, feldspar, and mica, arranged in well-defined strata, usually thin, but sometimes reaching a thickness of several feet. All the different forms which the metamorphic rocks assume are noted in the catalogue of Dr. Peale, appended to his report of this and last year. In my report of last year I described quite minutely the basin of the Three Forks. I then stated that the immediate valleys of the streams near the junction had been carved out of the lake-deposits, and on either side of the Madison Valley, on the east side of the Jefferson, and the west side of the Gallatin, the bluffs exposed fine sections of these modern beds. From the courses of these great streams the source of the waters during the lake-period might be read from the character of the sediments. We find that they must have rushed with great force along the valleys from the sources, after the impetus was gained through the Upper Cañon, then through the Middle Cañon, and beginning to lose a portion of this force and moving along more quietly just before entering the Lower Cañon, and when reaching the basin of the Three Forks, the water must have been as quiet as in ordinary fresh-water lakes of the present day. The indications of swift currents are not seen about the immediate sources of these streams, so that the sediments of the geyser-basins are comparatively fine, indicating moderately quiet waters. All the other rivers tell pretty much the same story. These sediments, made up as they are of the different kinds of rocks in the vicinity, are much mixed in their character. They are a mixture of clay, sand, and marl, in varied proportion. Sometimes thin indurated layers of clay will include several feet, then sand will predominate or sandstones in thin beds, or sort of indurated yellow or cream-colored marl, and then, perhaps, a bed of loose gravel or pudding-stone. There is a remarkable uniformity in the color and character of these sediments all over the West, from our north line to

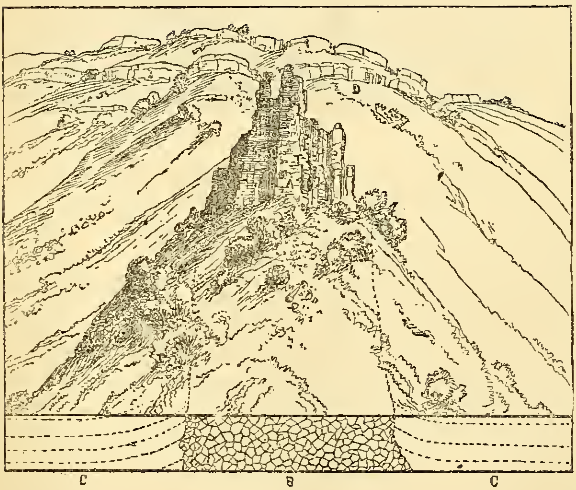
Fig. 17



BANDED GNEISS

Mexico. I have estimated the aggregate thickness of these deposits in this lower basin at the present time at about 1,200 feet. Occupying the area that they do, we can thus see that they possess an importance which demands the notice of the geologist. Between the junction of the Madison with the Jefferson and the mouth of the Gallatin, a distance of about half a mile, there is on the south side a remnant of a limestone-ridge cut off by the Gallatin from the main mass below, 50 to 100 feet high, and trending about northeast and southwest. This is a somewhat peculiar remnant, but it aids much in reconstructing the former surface of the country prior to the great erosion. The Missouri River, immediately below the entrance of the Gallatin, passes through a sort of rift in the upturned ridge, the strata on either side inclining in the same direction. How, in the changing of the channel of the river, this remnant was left, is not clear at this time. There are a number of other remnants of the limestone scattered through the basin, which shows that it was originally scooped out of the series of ridges which probably sent their sharp summits up a thousand feet or more above the general level. All the limestones immediately about the junction of the Three Forks are of Carboniferous age, as the fossils testify. But above and below, the Silurian strata are remarkably well exposed. Below the Three Forks the structure, though simple in general terms as above, is very much complicated by the chaotic condition in which the strata have been left after upheaval. There are a number of local synclinals as well as anticlinals, but to work them out in as great detail as I desired would require more time than we had at our disposal. The Missouri River, below the junction of the Three Forks, flows along a sort of rift in the ridges of limestone, though on the west side these ridges are worn across, so that the waters followed the intervening valley but a short distance.

Fig. 18.



DIKE ON THE MISSOURI.

A, Dike of basalt; B, Supposed continuation of dike-matter below the surface; C, Underlying sedimentary beds, probably Pliocene; D, Pliocene beds somewhat disturbed by the protrusion of basalt.

On the east side the waters run close up by high limestone-walls for about one-fourth of a mile, and then the valley expands a few hundred yards in width for about three miles and then closes again for a short distance, a mile or so, and then again expands to a width of three to five miles. These valleys are evidently worn out of the group of uplifted ridges, as is shown by the remnants here and there in the valley and in the bed of the river. On the east side, immediately below the entrance of the Gallatin, the river has worn a well-defined terrace in the limestone for a half a mile below, forming a sort of continuation of the isolated low ridge in the bottom just above the Gallatin. In the second expansion of the valley there is a broad bottom about two miles wide. On the east side of the valley are quite thick deposits of the Lake period cut up into ridges, which are weathered into architectural forms like what we have usually termed in the West, "bad lands." The lower portion of these deposits is a kind of calcareous shale, passing by degrees into an indurated sandstone capped by a large thickness of conglomerate. This is made up to a great extent of rounded masses of limestone loosely held together by a sand cement or with a whitish marly paste. In many localities in these deposits there are dikes of basalt which seem to have been formed during the existence of the lake, and that the basalt had been exposed by the wearing out of the ravines which have been cut into these modern deposits at a very modern date. (Fig. 18.) For miles along the high mountains that border the river, hundreds of deep cañons or gullies, from three to six miles long, are carved deep into the sides. The modern beds are nearly or quite horizontal, with no evidence of disturbance since their deposition, and they lap on to the much-tilted strata of the older rocks. There are here, as near as I can estimate, about 2,000 feet of more or less metamorphosed slates, clays, and quartzites of all textures and colors, but mostly thinly laminated. Much of it is very slaty. Here and there a dike is seen which shows an effusion of melted matter at some period subsequent to the upheaval. No fossils could be found, but I have no doubt that they belong to the Potsdam group, so well shown on the Gallatin, and, indeed, the same beds are much more changed. As we ascend the mountain the compact gray limestones, which are also of the Silurian age, are well developed and, above these limestones, full of well-defined carboniferous fossils. (Fig. 19.) How far to the northward these

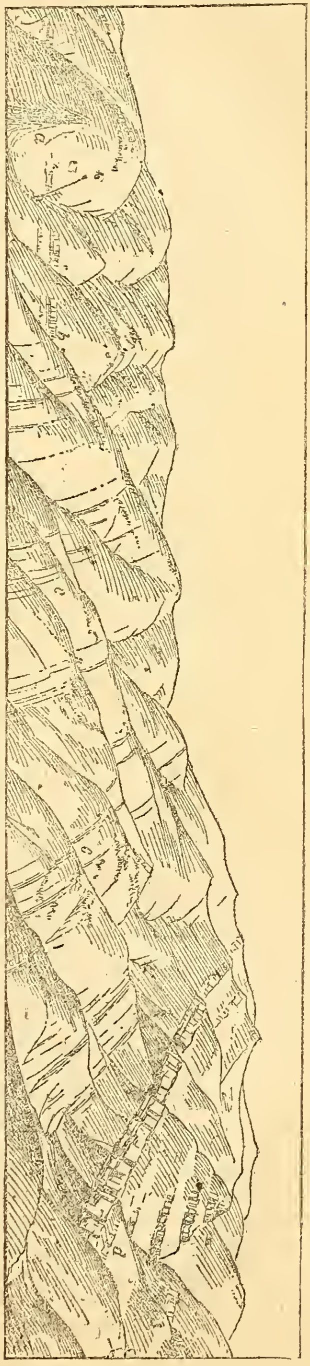


Fig. 19.

EXPOSURE OF SILURIAN SHALES EIGHT MILES BELOW THE THREE FORKS.

a, Dike; *b*, Horizontal strata; *cc*, Silurian shales; *d*, Carboniferous limestone.

Silurian beds extend I do not know, but they were visible at least fifty miles below the junction of the Three Forks. It will at some future day be an interesting and profitable task to study the geology of this region in detail. The few facts that I am able to present at this time may serve to call attention to it. There is here the largest development of the Silurian strata I have ever seen in the West. They are, however, only shown over restricted areas. There seems to have been very little system in the upheaval of the rocks. Here and there they are brought to the surface. The lake-basin is about five miles long, and on an average two miles wide, and the aggregate thickness of the modern deposits about 800 feet.

On the west side of the Missouri, immediately below the Three Forks, there is a most interesting synclinal, which will be shown in the illustration. The river, as it enters the cañon at the Three Forks, may have started in a rift, but it seems to have immediately disregarded it and cut across the ridges, so that the channel now cuts diagonally across all the ridges of the Carboniferous series and a large portion of the Jurassic within a distance of ten miles. The ruggedness of this region is very great, the little branches that flow from the hills on either side gashing deep cañons, exposing the strata in high walls on either side. By following one of these little streams from the main river up to the divide, we get a fair section of the strata. About five miles below the Three Forks, on the west side, the Jurassic ridges come in close to the river-side. In the ridges of limestone above this point is an abundance of characteristic Carboniferous fossils, so that we regard the age of these rocks settled. Above them comes a remarkable series of quartzites and sandstones, with intercalations of sandy clay. The limestones seem to pass gradually up into quartzites, so that the upper beds are compact, brittle, gray quartzites. The want of continuity of the strata between the Jurassic series and the Carboniferous group below is shown in the absence, in most cases of some hundred feet, of strata which are well shown here. The first ridge of quarzite is about 300 feet thick, with a dip of 45°. In the lower part is an intrusive bed of igneous rock. The second ridge is a rusty-brown sandstone, with layers composed of fossils, mostly fragments, as *Ostrea*, and some beautiful but undescribed forms. The inclination of the strata is 35° to 40°. There is in this ridge a remarkable intrusive bed of igneous rock, very irregular in thickness and horizontal extent, sometimes 50 to 100 feet thick, pinching out and then re-appearing in full force. The calcareous sandstones above and below are full of fossils, and do not seem to have been affected by contact. There is a kind of cleavage in the igneous rocks that gives to the entire mass the appearance of stratified rocks, but precisely opposite in inclination to the sedimentary beds which inclose them. Then comes a series of beds weathering a dull, purplish color, composed of sandstones, quartzites, with loose clays and shales, passing up into brown sandstones, then a bed of dark-brown quarzites. Then comes a series of layers of reddish-yellow sandstones of various textures, with intercalations of arenaceous clay. Still farther above are a series of red and purplish clays with greenish-blue bands passing up into gray marls and arenaceous limestone. The aggregate thickness of the mass of Jurassic strata was estimated to be about 1,500 feet. The direction of the dip is about northwest. Then comes a series of brown and rusty-yellow arenaceous clays and sandstones 500 to 800 feet in thickness, with an abundance of well-defined Cretaceous fossils. In the middle of the synclinal is a limited thickness of the Coal strata, with layers of impure coal. At the junction of the two sides of the synclinal the beds are much crushed, so that they are rendered very obscure. On the opposite side we pass over the upturned edges of the same series, commencing with the Coal strata, but with a reversed dip. The complete series has been tilted beyond a vertical, so that some of the high ridges of limestone incline 45°. (Figs. 20 and 21.)

Near the upper portion of the Jurassic group there is a bed of gray limestone six feet thick, made up of an aggregate of small Gasteropodous shells. This bed is well exposed in both divisions of the synclinal. Patches of the lake-deposits are thinly scattered over the surface, filling up the irregularities, occasionally showing a moderate thickness either of marls or conglomerates. As we pass up the Gallatin Valley from its mouth we observe that the river flows along a high-bluff wall on the east side. There are several local synclinals as well as anticlinals, but none of the Carboniferous beds seem to have been affected. In the low hills east of the river, about five miles above the mouth, is a sort of local depression, in which are remnants of the Jurassic group. As I have so often repeated in this report and in my previous reports, the evidence is continually shown that the formations all originally extended over the country in a horizontal position at one period; that they have since been removed to a great extent by erosion, but here and there we find indications of their former existence. The section will show a most extensive series of Carboniferous limestones rising gradually as we ascend the Gallatin. I described these beds somewhat in detail in my report for 1871. The series of Carboniferous limestones is remarkably well shown for a distance of about five miles above the mouth of the Gallatin. Just opposite the grist-mill the very compact, brittle beds, which are supposed to be of Silurian age, come in, forming massive bluff-exposures. Just beneath these massive beds of limestone is a series of loose, brown shales and clays with thin layers of impure limestone. In the shales are layers of lime

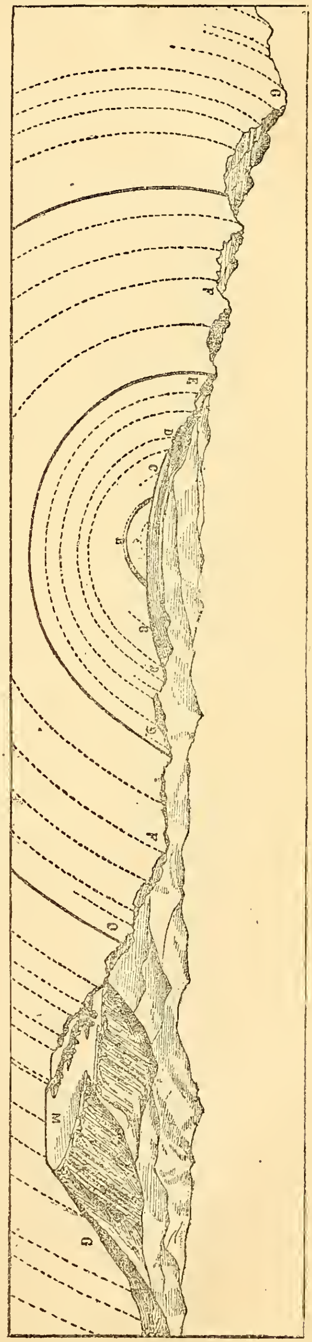


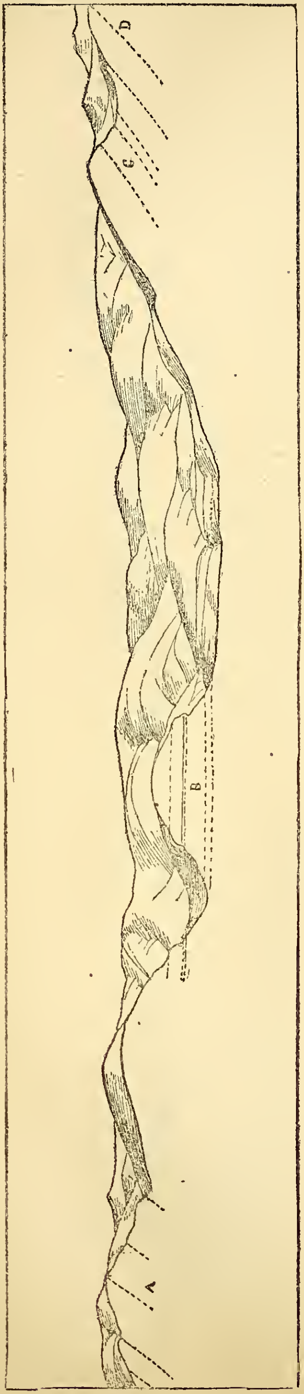
Fig. 20.

SECTION ACROSS THE MISSOURI BELOW THE THREE FORKS.

G G, Carboniferous; F F, Jurassic; E E, D D, C C, Cretaceous with identical fossils; A, Cretaceous igneous fossils; B, Coal-bed, lignite group; O, Intruded bed; M, Missouri River.

stone an inch or two in thickness, composed of trilobites mostly in a fragmentary condition, but with now and then a specimen so preserved as to characterize it. There were great numbers and variety of these old Silurian fossils, and they undoubtedly belong to the Potsdam group. The sections represented by Figs. 20, 21, and 22 are continuous and occupy a distance of about thirty miles. The accompanying illustration will show the consecutive series of strata with their inclination. (Fig. 22.) The thickness of the entire series of Lower Silurian strata here is estimated at 1,600 feet. The massive limestones which I have referred to the Potsdam group are about 400 feet thick, then gradually pass down into 50 feet of thinly-laminated, cherty limestone or calcareous mud-layers, with abundant organic remains. Then come layers of greenish sand and clays with shells and trilobites quite distinct from those above. Some of the layers of sandstone have small rounded pebbles, though not properly a conglomerate. Then comes a purplish sandstone, and below these variegated shaly clays, yellow, green, &c., then hard, dull purplish-brown quartzose sandstone, inclining 45°, apparently metamorphosed in part, 80 feet. Then comes a grassy interval, and then a ridge of very compact brownish-gray quartzite, with irregular layers of sandstone, inclining 45°. Then alternate layers of brown calcareous sandstone and yellowish-brown shaly clays. Then drab-brown quartzites and black slates alternate, 150 feet. Then comes the steel-brown quartzite, which has the appearance at a little distance in the fracture of compact basalt, 100 feet. Then a series of black slates 150 feet thick. Then comes a dark micaceous sandstone, alternating with calcareous slates or shales, 300 to 500 feet in thickness. This last group of beds continues along the river in high bluffs for about five miles and presents a great variety of structure. In some instances the shales weather to a soft, yellow, chalky material, and remind one at a distance of the yellow-chalk beds of the Middle Cretaceous. Then we have a brown somewhat worn

Fig. 21.



CONNECTION BETWEEN MISSOURI AND GALLATIN.

A, Carboniferous limestone; B, Soft conglomerate, modern lake-deposits; C, Jurassic; D, Carboniferous.

sandstone, which has much the look of basalt or a compact, fine quartzite. Then come one or two rather thick beds of cherty limestone in the beds of shale, and in some instances immense rounded, flat concretions of cherty limestone several feet in diameter, but not more than 6 or 12 inches thick. So far as I could ascertain, these brown micaceous sandstones and shales continue down to the metamorphic rocks. In the interval between the Flat-Head Pass and the Missouri River there are several local anticlinals and synclinals, in which all the series of rocks are exposed in their order from the Lower Silurian to the Cretaceous, inclusive. Here and there are patches of igneous rocks which appear to have produced in some instances these short anticlinals. Far up in the valleys of all the little streams that flow into the Gallatin River may be seen the modern deposits, which show the extent of the old-lake waters, and as they slowly subsided the present drainage was marked out. It is by the stripping off of these modern beds that the position of the underlying strata is rendered apparent. In minutely describing the geological features from point to point much repetition is necessary. There is a certain variety in the outlines of the surface in different localities, even if the geological formations are the same or similar, and the shades of difference strike the eye, but cannot always be expressed clearly in words. In the valleys of all the little streams that flow into the Gallatin from the Gallatin Range, there is a greater or less thickness of the lake-

SILURIAN BEDS OF THE GALLATIN.

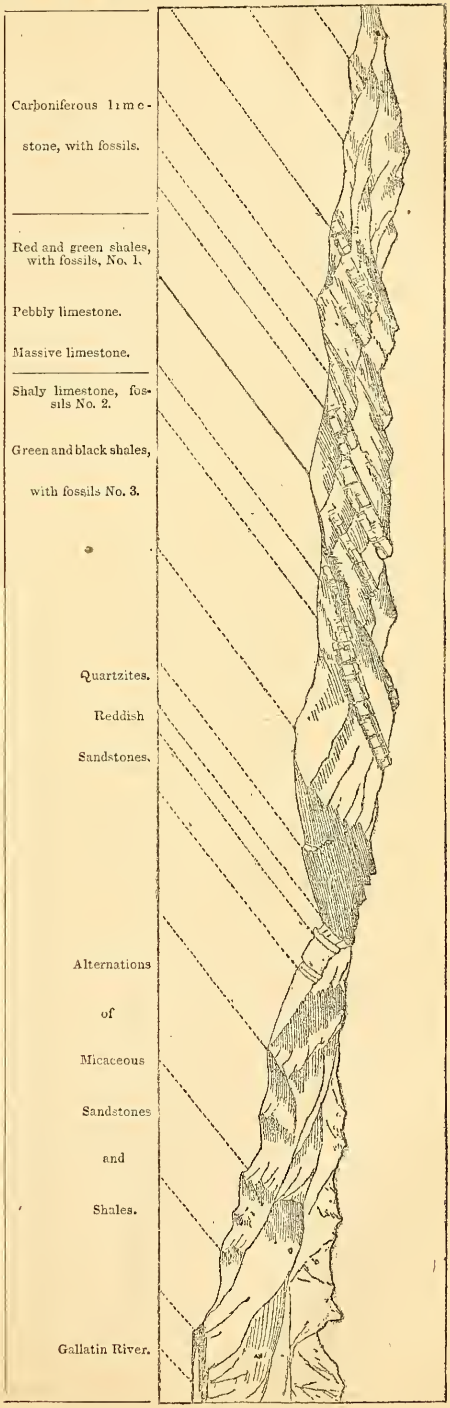


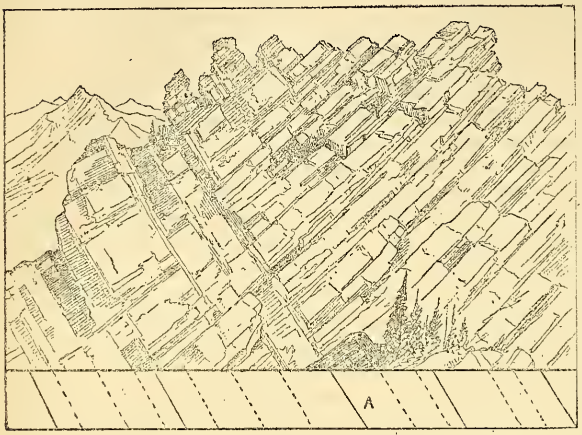
Fig. 22.

deposits, with here and there a large amount of modern drift. The surface is covered with water-worn bowlders, the remains of the last acts in the drama. I have so often called attention to these very modern drift-deposits that it is only necessary to state that they cover the entire surface of the country, except the summits of the highest peaks. The origin of the forces that transported these bowlders and scattered them over the surface in this irregular manner will be discussed in another place. The details of the structure of the Gallatin Range are numerous, and could be best presented by an account of the different routes traveled in exploring it, but I will only describe the two sides in general terms. The range itself is probably a monoclinal, that is, it is an elevated ridge with the strata all inclining in the same direction, and the position of the opposite portion is not yet known with certainty. The older beds on the west side have a marked reversed dip, but the central beds of limestone are nearly vertical, while the Jurassic, Cretaceous, and Coal strata, inclining at various angles from 5° to 50°, gradually descend in step-like ridges from the summit of the range to Shields's River, eastward a distance of about fifteen or twenty miles. The aggregate inclination seems to be about northeast. Bridger Creek, near the Union Pass, flows southward along the east base of the main ridge for about ten miles, and bends around, wearing a very deep cañon through the south end of the range through the limestones, and enters the East Gallatin about five miles below Bozeman. The Jurassic beds are crushed together in the uplift to such an extent that they are quite obscure, and do not appear to much advantage, but in Union and Flat-Head Passes they are much better exposed, but the Cretaceous and Coal groups are enormously developed, reaching an aggregate thickness of more than 10,000 feet. By the Coal group I always mean the series of beds which are probably Cretaceous in part, passing up into Lower Tertiary and containing the coal-beds of the West. The axis of the Gallatin Range is somewhat zig-zag in its trend. The great mass of the mountain inclines eastward or northeastward, but bends abruptly west in two or three places, forming interesting passes, as Union and Flat-Head Passes. The outcropping edges of the limestone-strata have been rounded off by atmospheric agencies, yet for a wide belt along the very summit each layer is clearly shown, like irregular bands from one end of the range to the other, a distance of about twenty-five miles. The highest peak, which is nearly 9,000 feet, shows the upturned edges of the limestone-layers most clearly. As I have before remarked, the central mass and the highest portions are those which seem to have resisted erosion best. These beds are usually nearly vertical in position, seldom inclining past a vertical, while the Silurian group has a reversed inclination from 5° to 15°. On the west side of Union Pass the underlying granitoid rocks are exposed, dipping in the opposite direction, as if in the uplift there had been forces acting not only vertically but tangentially. The Silurian group is exposed on the foot-hills, varying from 800 to 1,200 feet in height from Bridger's Pass across to a point about five miles north of Flat-Head Pass, a distance of nearly twenty miles. The consecutiveness of the beds is much obscured by the great thickness of detritus and grass, but the rocks crop out all over the hills, so that they can be studied with confidence. Then we know that they are only an extension southward of the same group of beds which is so admirably well shown along the Gallatin, and which has been described in a previous portion of this chapter. From the Missouri River southeast to the Yellowstone River, there is a series of rather low, broken ranges of mountain-ridges, of which the Gallatin

Range is the central and the largest one. On the east side, between the Gallatin Range and the intermediate valley of Shields's River, there is a belt of country ten to fifteen miles in width, made up of Cretaceous and Tertiary beds, with an unusual somber-brown color, as if they had been affected more or less by heat. Here and there are indications of the effusion of basalt, usually in the form of a dike, without generally affecting to any great extent the position of the sedimentary strata, but sometimes throwing them into various positions. The highest hills are from 800 to 1,200 feet above the surrounding country, but descend westward in step-like ridges. The belt is exceedingly rugged from the nature of the upheaval, the beds having been lifted up at various elevations; but in addition they are cut down in every direction by the little streams that flow into Shields's River on one side and into the Gallatin on the other. A large portion of this belt is covered with thick pines, with patches of aspen, and the remainder thickly grassed over, forming most excellent pasturage for stock of all kinds. In the valley of Shields's River are hundreds of excellent farms, which would long since have been taken up by farmers had it not been for fear of hostile Indians.

The Flat-Head Pass is the great thoroughfare for the Flat-Head and Bannack Indians on their way to the buffalo-districts on the Muscleshell, Missouri, and Lower Yellowstone. The hostile Sioux have made several raids through this pass into the Gallatin Valley, murdering the settlers and running off their stock. The illustrative-section which was taken at Flat-Head Pass shows the situation of the range with great clearness. Passing along the west base of the range from Flat-Head Pass to Fort Ellis, we find the slope from the Gallatin River to the immediate foot of the mountains dotted with cultivated farms. Where the superficial deposits are cut through by the numerous small streams, a great thickness of the modern lake-deposits and drift is exposed. In some instances the modern beds are hardened into a calcareous sandstone that is used for building purposes. These deposits jut up against the sides of the mountain in such a manner that the old shore-line is distinctly marked. From Flat-Head Pass to Union Pass, a distance of about fifteen miles, the abrupt foot-hills are composed entirely of the Silurian group, lifted up in such a manner as to incline past a vertical. The character, as well as the order of superposition of the beds, must be the same as of those noted along the Gallatin a few miles below, but the hills are so covered with detritus and grassed over that I found it impossible to obtain a consecutive section. Nearly all the more compact strata crop out at different points, so that the principal beds were detected. In Union Pass the streams have worn a passage through the range, so that the strata are well exposed, and we find here underneath the Silurian group a granitic base, as shown in the section. In the massive limestones of Union Pass, which are probably of the Potsdam epoch, there is a singular illustration of jointage, well shown in Fig. 23, which would at once arrest the attention of the geologist. At first, one would be much puzzled to determine the true stratification from the false. It forms a portion of Liberty Peak, which rises about 8,000 feet, and is probably due to partial metamorphic action. The granitic rocks continue to increase in thickness up to Bridger Cañon, a distance of fifteen miles. Here there seems to have been a less powerful force exerted, so that only the limestones are exposed, and the Cretaceous and Coal strata are found on the summits of the range. Bridger and Bozeman Passes are low depressions in the range. As we pass across the numerous branches of the Gallatin, as they emerge from the mountains, we see the Carboniferous and Silurian limestones inclining from the sides of the lower hills and passing under the valley. Here and there a high ridge is observed jutting up against the base of the mountains, a remnant of the lake-deposit which has escaped erosion. The central portion of the range, in which the different branches of the East Gallatin have their origin, is composed mainly of basalt, basaltic tuffs, and breccia. These have been worn into the most fanciful architectural forms. Mr. Jackson, the photographer of the survey, penetrated this region for the first time last summer, and obtained from it some most marvelously beautiful views of the scenery. I doubt whether there is a portion of the West where all the elements of landscape beauty are more happily combined. Palace Cañon and Palace Butte are formed of stratified tuffs and breccia, and these palace-like forms are carved out of the solid beds by the slow process of erosion by water. In the cañons, the limestone-strata frequently crop out from beneath 1,500 to 2,000 feet in thickness of this volcanic material. The reader is referred to the report of Dr. Peale for the details of the geology of this most interesting region. From the East Gallatin to the West Gallatin Cañon there are perhaps fifteen or twenty little branches, each of which rises near the crest of the range and carves out a gorge from five to fifteen miles in length. Each of these cañons would afford a grand study for the geologist as well as the photographer. But we could examine only a few of them. From the entrance of West Gallatin Cañon the view down the valley cannot be surpassed for beauty in this land of picturesque scenery. The gently-rolling, grass-covered hills; the little streams meandering through them, fringed on either side with a thick growth of cottonwoods; the numerous farms, golden with their fields of wheat; and over all, in the distance, that peculiar, soft, golden haze, which characterizes the autumn-days in this mountain-region, lends to the whole vision a charm that is long remembered. As the setting sun of autumn shines upon the valley and surrounding mountains, all objects seem to be invested with an unusual beauty, which reminds one of the lines of the poet:

Fig. 23.



DECEPTIVE WEATHERING, LIBERTY PEAK

A, True dip of beds.

> And sweet, calm days, with golden haze,
> Melt down the amber sky.

The little side streams that come in from the mountains, and the various main branches as they traverse the broad, grassy, rolling valley, with their fringes or belts of green cottonwood foliage, added much to the charming beauty of the scene. Then, hemming it in on every side, are fine ranges of mountains, which now seem depressed into low passes or are isolated, then rise or swell into lofty peaks, which seem as it were to have been thrust up from the level plains around. Late in the day the atmosphere appears unusually clear and transparent, and every peak and cañon stands out in a relief so bold that one seems able to look into the very recesses of these grand ranges. So close do they appear to the beholder, and so distinctly are the details brought out, that they seem to lose a portion of that dignity which arises from their grand loftiness. The mountains on the south side of the valley from Spring Cañon to the cañon of the West Gallatin are not very rugged, and are covered more or less with timber and a vast amount of superficial material, concealing the rocks, except in the valleys of the streams. The valleys or gorges of the streams that issue from the mountains disclose the strata of Carboniferous and Silurian limestones, and, though the beds are thrown into remarkable confusion, yet the general inclination is evidently northeast. The great mass of the bowlders that are brought down the cañons into the bottoms below is of igneous origin.

In the morning the east ranges are usually covered with a smoky haze which makes them appear distant and indistinct, while the ranges opposite the sun are brought out with a singular relief. In no country are the varied phases of scenery better shown than in this. For the artist this country must open up a new world.

We will now ascend the Gallatin Cañon to the source of the river. This cañon had never been explored by any scientific party previously, and even the settlers in the open valley below knew nothing about it. A few hardy miners had ascended it in search of precious minerals. The Gallatin River seems as it were to be crowded in between the two great rivers, the Yellowstone and the Madison, and it has therefore cut a continuous gorge through the rocks for more than seventy miles, with walls on either side rising from 1,000 to 2,000 feet. As a geological section it has hardly a parallel in the West. On this account, as well as from the novelty of the region, I wish to describe the cañon in detail.

Just on the west side of the Gallatin, about half a mile below the cañon, is a ridge of Pliocene sands and sandstones, inclining at a slight angle from a thin series of arenaceous limestones. Then comes a ridge or two of the older limestones, probably Silurian, inclining 10°. Then underneath, and farther up the cañon, the reddish feldspathic quartzites and other rocks apparently conforming at this locality. The river at the mouth of the cañon is 100 to 150 feet wide, and rolls swiftly over its rocky bed, with an average depth of 12 to 18 inches. There are well-marked terraces along the river, though not peculiar, like those on the Madison. At the lower portion of the cañon the gneissic rocks are well exposed, the hills on either side rising to a height of 600 to 1,000 feet, with the strata nearly vertical or inclining northwest. At first view the limestones seem to conform with the granitic strata, but the former dip northeast, the latter northwest, 50° to 80°. The peculiar banded appearance of the gneiss is shown in a marked manner.

About three miles up the cañon, near the entrance of Spanish Creek, the Gallatin flows between uplifted ridges of limestone. The river flows nearly north, while the inclination of the limestone-beds is about northeast, and the channel is cut partly across the ridges and partly in the intervals between. So that on the east side the limestones present a remarkable wall of the outcropping edges of the strata, 1,000 to 1,500 feet in height. In looking directly at the wall the strata seem nearly horizontal, but a side view shows the dip to be 15° to 25°. On the west side of the Gallatin the strata incline like a steep roof and the ridges of arenaceous limestone rise to a height of 1,800 to 2,500 feet, and are undoubtedly of Silurian age. Underneath the arenaceous limestone on the west side of the river is a considerable thickness of the rusty-brown sandstones, pudding-stones, clays, &c., that characterize the Silurian near the Three Forks; but these beds are thinning out very rapidly in their southward extension. Spanish Creek flows into the Gallatin from the divide on the west side, and nearly separates the unchanged strata above from the gneissic rock below. A few patches of limestones occur here and there. In the limestones on the east side of the Gallatin, great quantities of fossils occur, *Productus semireticulatus*, *P. longispinus*, *Strophomena analoga*, *Hemipronetes crenistria*, and many others (see catalogue of Mr. Meek) of Carboniferous age. On the west side of the river the limestone-ridges soon disappear and the massive granitoid rocks appear, rising to an enormous height, covered with great quantities of huge fragments. On the east side, the Carboniferous and Silurian beds extend up for about five miles, when they slowly disappear over the summits of the granitic mountains. At first the Carboniferous limestones extend down to the water's edge, but in ascending the river the strata rise rapidly until the entire mass is exposed, resting upon the granitic group. Although there is no positive non-conformity between the Carboniferous and Silurian, yet there appears to be a well-defined physical line of separation. The Silurian limestones are more massive, brittle, cherty, and have an ancient look, while the Carboniferous beds are more pure limestone, and with thin, well-defined layers. These upper limestones also have a more modern appearance. The sides of the mountains on both sides of the Gallatin, from crest to crest, are wonderfully rugged and picturesque. The limestones are frequently weathered into the most peculiar columns, while the granites are worn into grand, castellated forms. The crest of the ranges on the entire divide on the east side is composed of volcanic rock, while on the west side the central mass is granitic, rising in high, sharp peaks, 10,000 to 10,500 feet above the sea. The pines cover the sides of the mountains quite thickly in many places, sending their roots among the rocks where the descent is almost vertical. About ten miles above the entrance of the cañon the granitic rocks rise to the surface on the east side of the Gallatin, and extend ten miles up the river in full force on both sides, rising quickly to a height of 2,000 to 2,500 feet above the bed of the river. At first, detached beds of limestone may be seen upon the high granite-walls, as they disappear upon the summits of the mountains. The little streams, as they flow down from the divides on either side, have cut fearful gorges through the granites. The narrow valley on both sides of the river is covered with immense rounded granite-bowlders, rendering the traveling very difficult. For a distance of ten miles we were obliged to travel with our pack-train very slowly and with great risk. In no part of the West have we found a more difficult trail, and this may account for the fact that so few persons have ascended the stream. As we crossed one of the little streams that flow into the Gallatin from the west side, we observed that the water was very muddy. Mr. Sloane, a prospecter, who accompanied us for protection while he was searching for mines, suspecting that somewhere near the head of the stream a fellow-miner had found a good thing and was working it out, quietly followed the stream up to its source. He found near the head that a few days before lightning had struck the ground, plowing it up in long lines sometimes 100 yards or more and six feet in depth. The pines grew very thickly, but over an area 150 feet wide and about 600 yards long the trees were torn down and broken in pieces. Trees two and a half feet in diameter were broken off and were thrown several hundred yards down the stream.

As the water flowed over the broken ground it became muddy, and at its entrance into the Gallatin looked like the water of a mining-gulch. A few days previously there was a terrific thunder-storm, accompanied by strong wind.

About twenty miles up the cañon the granitic rocks cease, and a remarkable ridge of limestones extends across the river with a trend about southeast and northwest. On the east side of the river the sharp ridges rise up to a height of 1,500 to 2,000 feet, with an inclination of 50° southwest. The sides as well as the summits of these ridges are remarkably rugged and jagged. A little stream comes into the Gallatin from the Sphynx, a high peak on the divide between the Gallatin and the Madison. This stream has worn its rather wide grassy valley out of the soft materials of the Jurassic beds, leaving the harder Carboniferous and Silurian lying against the sides of the mountain-range like a huge wall, extending from Cinnabar Mountain northwest across the Gallatin and Madison Rivers. The Gallatin River cuts this ridge nearly at right angles. In the bed of a little stream on the west side several of the outcropping edges of the limestone-strata are seen which have been worn down to the level of the valley. This group of sedimentary strata forms the southwest portion of the anticlinal of which the group of limestones described a short distance above the entrance of the cañon is the northeast portion. We see, therefore, that all these rivers, the Madison, Gallatin, and Yellowstone, have cut their channels directly through the range. Just above this range the valley expands to a mile in width, and the hills on either side are much broken and are so covered with the sedimentary beds that the granitic rocks are seldom seen. In the bottom is a group of springs flowing from beneath the limestones that are full of rank, algous vegetation. The temperature of the water is respectively 54°, 56°, 55°, 54°, 43°, 44°. These springs may once have been very hot, like those about the sources of the Madison. Warm springs are not uncommon at various points far down the valley of the Yellowstone as low as the mouth of Big Horn River. The Silurian and Carboniferous strata are the same as those noticed on the opposite side of the range. Conforming to the Carboniferous limestones, so far as can be detected by the eye, is a group of sandstones, arenaceous limestones, clays, &c., which are undoubtedly of Jurassic age. High up on the range on the east side of the Gallatin are patches of the Cretaceous and Coal groups, as seen on the Yellowstone near Cinnabar Mountain. Above the granitic portion of the cañon there is a marked depression on both sides of the Gallatin, and small streams flow into the river over the softer Jurassic beds. These beds incline at so great an angle for a distance of only about half a mile, when they abruptly become horizontal. In the elevation of the mountain-range in which the granitic nucleus bursts through the sedimentary mass, tipping off on either side the strata, the whole country was elevated to a greater or less extent. The central or granitic mass was raised up in the form of peaks from 9,500 to 10,500 feet above tide-water, and the sedimentary beds were broken off and lie on the sides of the granitic nucleus in a nearly vertical position; while, a short distance above them, the crust was not so much affected by the force, the same beds, though they may have been elevated to a greater or less height in mass, still retain their horizontal position nearly. So we find a group of brown sandstones, conglomerates or pudding-stones, and quartzites passing down into clays, sandstones, and arenaceous limestones. Some of the limestone-strata are made up of an aggregate of shells which appear to be of the Jurassic age. We pass up the open valley of the Gallatin a distance of about four miles, with high walls of Jurassic strata on either side, forming an aggregate of about 1,200 feet in thickness. At the upper end of the little basin or open valley, the Carboniferous limestones rise up from beneath the Jurassic and soon form high vertical walls on both sides of the river. From this point to the source of the river, Carboniferous limestones prevail to a greater or less extent. For about fifteen miles the river has carved out a cañon with the nearly horizontal strata of limestones rising with vertical walls on either side 800 to 1,200 feet. The inclination of the strata appears slight, not more than 1° to 3°. The limestones are mostly in rather thin layers, but some of them form massive beds. The entire group presents the usual variety of texture common to limestones of this age. The fossils are quite abundant, and all, so far as could be determined, of well-known Carboniferous types. This part of the cañon is most picturesque; the high limestone-walls on either side are weathered into towers and Gothic pinnacles and in some instances wonderfully grotesque forms. It would hardly be possible to find as complete a section of the strata anywhere in the Northwest as is shown in this cañon.

For the entire distance of seventy miles the river has carved its channel out of the solid mass, most of the way hemmed in with narrow vertical walls, but here and there expanding out a little with a narrow open basin, but soon closing up again. We can here obtain something like a correct estimate of the thickness of these groups of strata. I estimate the Jurassic group at 1,200 feet and the Carboniferous at 2,500 to 3,000, the Silurian group 800 to 1,000 feet. From time to time we see some irregularities in the strata, but these seem to arise from local influences. But at a point in the Gallatin Valley, about opposite Cinnabar Mountain, the entire mass of sedimentary beds is again suddenly tilted at an angle 50° to 70° about west or southwest. The entire series of beds seems to be exposed here from the Silurian to the Coal group inclusive. The Jurassic group of beds inclines about 50°, but a little farther up on the west side of the Gallatin, and extending up toward the divide, are the Cretaceous and Tertiary (coal) groups, nearly in a horizontal position, capped with basaltic rocks. In this valley, from crest to crest of the divide, the strata have been thrown into the most chaotic positions. No system could be wrought out of the confusion. Sometimes the lower limestones capped the highest hills and the youngest beds, as Cretaceous and Tertiary would be found nearly horizontal in the lowest valleys on the divide between the Gallatin and Yellowstone. At one point we discovered a group of springs that deserves a notice here. These springs gush out of the side of the mountain from the limestones about 100 feet above the river, and in the aggregate form quite a stream of water. Great quantities of Calcareous tufa surround the springs, and the vegetation is remarkably luxuriant. Helices are scattered thickly for some distance in every direction, sometimes giving the surface a snow-white appearance in the distance. These land-shells occur in greater or less abundance among the limestones. The river is now fed almost entirely by springs which issue from beneath the limestone-strata which prevail everywhere. The Jurassic, Cretaceous, and Tertiary occur only in isolated patches. As we continue on up the valley we find it sufficiently open for good roads, sometimes extending out one-fourth to one-half a mile in width. Grass is good, and in many places quite wide ravines extend down from the divide on either side that have excellent grass. For this reason this valley, or cañon, as it might be called, has been in times past a great resort for Indians. Traces of the camps are seen everywhere. The high walls that hem it in on either side furnished a protection, not only from their enemies, but from high winds and severe cold. A tribe could remain here an entire season well protected, while the young men could go out on either side among the mountains in search of game. At one point great quantities of dry pines have been washed down from the mountain-side as if by a sort of local flood. The fires frequently run over the mountains, killing the green pines, so that soon after they fall down covering the ground. Here they had accumulated in immense piles, and the Indians had at some period employed them in building fortifications for themselves and their animals, as protection from their enemies.

The well-known Bannock trail passes by this valley. Near the forks of the Gallatin some igneous rocks rise up from beneath the limestones 200 to 600 feet high. They are exposed for a mile or more, and appear to be the same as those composing the dike in the Devil's Slide on the Yellowstone. The limestones have been pushed up, as it were, so that they incline from either side, passing down beneath the general level from the igneous exposure. Several quite large streams come in on either side to form the Gallatin, each cutting a deep gorge through the rocks from the crest to the river-bed. The main branch rises at the foot of Mount Gallatin. A dome-shaped peak, which overlooks the valleys of the Yellowstone and Gallatin, is one of the finest mountains in the range, and commands a most extended view in every direction. The forces seem to have operated with great irregularity, breaking the limestone-crust in every direction and producing chaos. Sometimes a great thickness of the beds is found in the lower valleys in a nearly horizontal position; again they cap the highest mountains, either inclining at a greater or less angle from the sides or lifted up bodily to the summit. We have thus attempted to describe in some detail the geological structure of this remarkable valley. No man had ever looked upon it before with the eye of the geologist, and very few persons had ever visited it for any purpose. The topography was entirely new. In a subsequent report, when we have to present a general view of the geology of the Northwest, we hope to make the subject still clearer by means of the beautiful illustrative-section taken by the artist of the expedition, Mr. Holmes.

We will now return to the Three Forks and record the few hasty notes taken on our return homeward by way of Helena. It is not possible to do justice to the geology of this most interesting region now, but at some future time we hope to return to this work again.

I have already described briefly the geological features of the country about the Three Forks. The interesting synclinal shown in the cut extended toward the northwest. The stage-road to Helena passes along the northwest end, so that we could see the relations of the sedimentary beds to the underlying granites. We thus ascertained, what we had previously suspected, that the entire series of beds had been lifted up in such a way that they now all inclined more or less past a vertical, varying from 20° to 45°. On the west side of this ridge the granitic rocks rise up from beneath the Silurian beds over a broad area. Many of them are much rounded from having formed the bottom of the old Pliocene lake. The irregularities of the surface are now filled up with these lake-deposits. Passing beyond the ridge northward toward Helena, we come to the broad valley of Crow Creek, about twelve miles wide, a stream which flows into the Missouri from the west. The area which forms the drainage of this creek is underlaid with granitic rocks, and rich placer-mines are wrought in the gulches of the small branches. Radersburgh was founded on the discovery of the placer-mines, and is still sustained more or less by them. The limestone-ridges, which can be seen on either side of this broad valley, are only remnants of what must once have extended over a large area of country. In the ridge west of the town of Radersburgh the lower strata are inverted, inclining past a vertical 45°, while the Carboniferous limestones stand nearly vertical, though the quartzites and red sandstones of the Jurassic are either vertical or incline past 5°. These red Jurassic beds I think are the same as those shown along the banks of the Missouri, at the Great Falls. The thickness of these beds is greatly increased as we proceed northward, and at this point must be 1,000 to 1,500 feet thick. The sedimentary beds extend to Indian Creek, and then suddenly disappear, and then along the flanks of the mountains on the west side of the road only a great thickness of drift-material is seen. The little streams, which have worn deep gulches into the mountain-sides, have also worn channels through the drift, exposing its thickness and character very clearly.

The placer-mines are very extensive. Some valuable silver-mines have been discovered in the mountains. The Missouri Valley here is about twenty to twenty-five miles in width, with high ranges of mountains on both sides. From Radersburgh the road passes over the vertical edges of the dull, purplish Jurassic beds for twelve miles, to Indian Creek. The drift is made up of rounded bowlders mostly, and must be 300 to 500 feet thick. Extending eastward toward the Missouri, in the belt of sedimentary beds between Radersburgh and Indian Creek, may be seen a rather level, rounded, cretaceous hill, so grassed over that few out-croppings could be observed. I had very little opportunity of examining the rocks about Helena, but believe that they are mostly granitic, capped here and there with strata of the Silurian age. It is also probable that there are remnants of Carboniferous beds in some places in the vicinity.

In passing along the stage-road a little west of south from Helena to the valley of the Jefferson Fork, a few patches of the older Silurian beds are seen, while among the low hills the lake-deposits show that the entire country was a vast fresh-water lake at a comparatively modern period. The high hills on either side of the road are weathered into curiously rounded forms and covered with grass. Prickly Pear Cañon is a remarkable district for placer-mines. Water seems to be abundant. The rocks are mostly rusty-brown gneisses, weathering into forms much like those in the Laramie Range near Sherman, Union Pacific Railroad. These granitic rocks extend to the source of Prickly Pear Creek, and the high hills on either side are covered thickly with pines. Jefferson City is located among the reddish-granitic hills. From the head of Prickly Pear Creek we crossed the divide to the valley of North Bowlder, and in the valley on either side the massive granites rise in low, singularly-shaped columns, piles, &c., giving to the region the appearance of old ruins. Wherever gold-mines are found, whether in the lodes or gulches, we may be assured that the gneissic rocks are exposed.

We have up to this time been able to do little more than make a reconnaissance of one of the most interesting and instructive portions of the West, in a geological point of view. The reports of the surveys for 1871 and 1872 can certainly claim to be valuable contributions toward the geology of Montana and Idaho, and at some future period, when the country has become more easily accessible, the work may be resumed and carried on to completion.

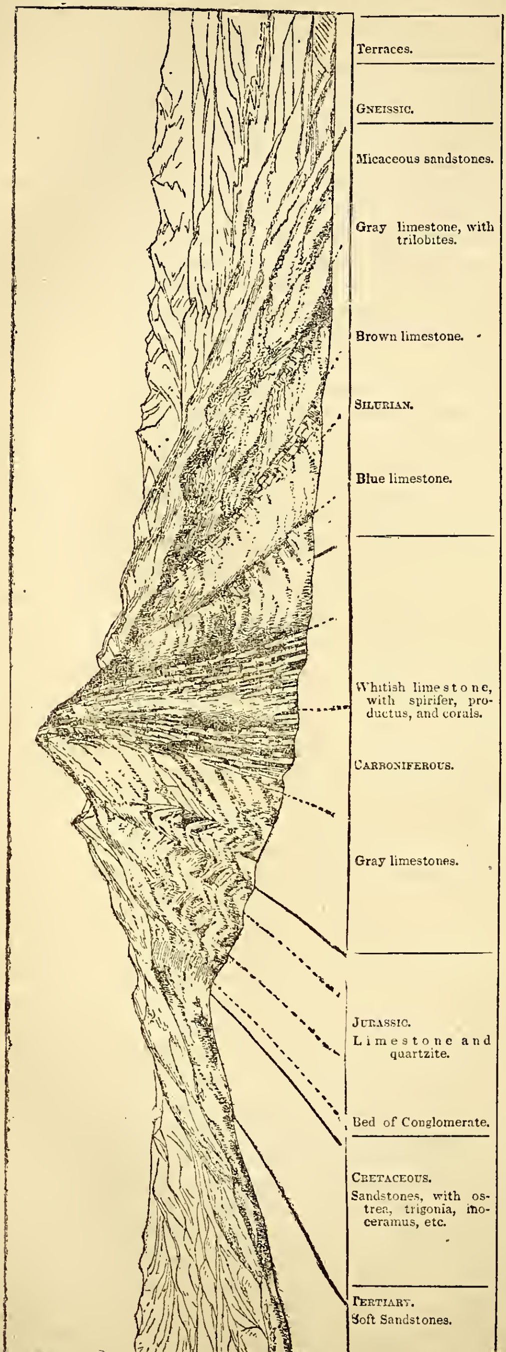
We have thus far attempted to describe briefly the main geological features of the district explored by the party during the past season.

Nowhere in Montana have I found the anticlinal folds or the synclinal valleys so distinctly defined as in the interior basin of Utah. Still, there are frequent local synclinals and anticlinals, as we find them developed below the Three Forks. The prominent features, however, are the widely-extended areas of elevation, though a single anticlinal may embrace several apparently distinct ranges of mountains. The operations of the survey during the past season more strongly convince me of the position that I have so often taken in my reports, of the originally wide-extended and continuous character of the entire group of sedimentary strata; that where that continuity is broken it is the result of upheaval attended with erosion. It is possible that the later Tertiary group may not have been continuous, but existed in basins. But from the Silurian to the Upper Lignite group, inclusive, a thickness of 10,000 to 15,000 feet extended, in an unbroken, horizontal mass, over nearly or quite the entire area of Montana, and probably much more widely; and that what we find remaining at the present time are only remnants of this vast mass. Occasionally the entire series of formations is exposed, as in the East Gallatin Range, where for twenty miles, on a line from east to west, the entire series of sedimentary strata may be seen from the Silurian to the top of the Lignite group in consecutive order. (See Fig. 24.) The groups of limestones and other rocks, as we see them inclining from the Yellowstone Range, in the Yellowstone Valley, show that they once extended uninterruptedly over the entire area, where now mountain-peaks rise amid perpetual snows, 11,000 feet above the sea. The Silurian group increases in importance as we proceed northward from the Three Forks, and southward from that point it diminishes in thickness and changes very much its mineral texture. Toward the south we find little of the thin shaly and mud layers with the variegated sandstone, but in their stead, a quartzite passing up into a very hard, brittle limestone. Still, we believe that this group in some form and with greater or less thickness underlies the greater part of the Rocky Mountain region. About the Black Hills of Dakota and the Big Horn Range, the Potsdam group presents a different mineral structure from the rocks of the same age about the sources of the Missouri.

The Carboniferous group, like most sea-deposited rocks, is very widely distributed. It is probable that it will eventually appear that this group of beds, as it is known, west of the Mississippi will be found to cover a wider extent of territory and to maintain a more uniformly similar mineral texture than any other formation in the scale. By reference to the list of fossils prepared for this report by Mr. Meek, it will be seen that, even in the most widely-separated localities, there is a similarity or identity in the organic remains. Old Baldy, at the head of Alder Gulch, forms a portion of a limestone-ridge in which the series of beds is shown with a vertical thickness of 1,000 to 2,000 feet and extends off to the southwest, giving origin to the Stinking Water, Black Tail Deer Creek, Red Rock Creek, and many others. These beds have a general dip to the southeast. We believe also that the Jurassic and Cretaceous group had a very wide extension, though perhaps not as great as that of the older formations. They have been more extensively worn away so that at the present time they occur in fragments among the upheaved mountain-ridges and covering restricted areas. So far as the position of the sedimentary rocks is concerned, they may occur at any elevation. The beds may pass under the lowest valleys or be found capping the gneissic rocks upon the summit of the highest mountains. This is certainly not due to any inequality of the surface of the gneissic rock prior to the deposition of the succeeding beds, but unquestionably to upheaval.

There is one feature in the geological structure of the mountains of Montana, observed by the survey of the past seasons for the first time and not noticed in such a marked degree in any other portion of the West, and that is the inversion of the sedimentary beds, so that the oldest incline at a greater or less angle on those of more modern ages. This phenomenon occurs at a number of places, but the most marked are in the middle cañon of the Madison, at the head of Jackass Creek, and in the East Gallatin range. Several illustrations are given in this report which will render this matter clear. The following illustration represents a section from east to west through the East Gallatin range. (Fig. 24.) The Silurian strata incline past a vertical 30° to 50°. The central portions of the range are Carboniferous limestones and are nearly or quite vertical, while eastward the Jurassic, Cretaceous, and lignitic strata incline at various angles and pass down in step-like ridges to the valley of Shields's River, as they were gradually elevated by the uplift of the range. We will not enter into a discussion here of the origin of the forces that brought about these results, but it would appear that there were two in operation, one which raised the mass vertically, and a side or tangential force which crowded the Silurian beds over past a vertical. In some

Fig. 24.



SECTION THROUGH FLATHEAD PASS.

instances all the beds are inverted from the Silurian to the lignite inclusive.

Another interesting point I have reserved for discussion at a more favorable time is the formation of cañons and valleys of the rivers, which enter into the scenery of the country as a most conspicuous feature. The fact that the streams seem to have cut their way directly through mountain-ranges, instead of following synclinal depressions, indicates that they began the process of erosion at the time of the commencement of the elevation of the surface. This is shown all along the valley of the Yellowstone, and more conspicuously in the valleys of the Madison and Gallatin, which have carved immense cañons or gorges directly through two of the loftiest ranges of mountains in Montana. We believe that the course of these streams was marked out at or near the close of the Cretaceous period, and as the ranges of mountains were in process of elevation to their present height the erosion of the channels continued. The details of the observations which contribute to form this opinion would occupy a chapter or two.

The superficial or drift deposits which some times attain a great thickness are regarded as of local origin. As I have so often stated in my previous reports, I have never been able to find any evidence in th Rocky Mountain region of what is usually termed a northern drift. There are many other points of great interest which, if time and opportunity occur in the years that are to come, we hope to treat as exhaustively as our observations will permit, and we regret that we have not been able to make more than a passing allusion to them in this report.

The brief report of Hon. N. P. Langford, superintendent of the Yellowstone National Park, who accompanied the Snake River division, will be read with great interest for its practical character. The thanks of the survey are extended to him, not only for the interesting and valuable report, but also for the great services he rendered the party while on the route. The remarkable feat of Messrs. Stevenson and Langford in ascending the Grand Téton, which will soon become familiar to the reading public through the pages of Scribner's Monthly, will always invest this region with an interest second only to the wonders of the National Park.

I had expected a valuable report from Mr. William Blackmore, who accompanied the survey for several weeks as a guest. The survey is under many obligations for most valuable services from this very liberal and intelligent gentleman, and it is proud to regard him as one of its four honorary members. It is probably due to Mr. Blackmore's absence in Europe that we are deprived of his valuable views in regard to the laying out of the park.

I would also call attention to the report of Mr. Hering, which we hope will be useful to railroad-men as well as to the general public.

REPORT OF N. P. LANGFORD ON THE RESOURCES OF SNAKE RIVER VALLEY.

DEAR SIR: In compliance with your request, I herewith submit for your use a connected report of the observations I was enabled to make while accompanying that portion of the geological survey under the superintendence of Mr. James Stevenson, from Fort Hall, Idaho, to the Geyser Basin, Fire-Hole River, and thence down the Yellowstone and on to the Three Forks of the Missouri. The only knowledge that could be obtained of the country through which we were to pass was derived from old trappers, and such accounts as, upon the faith of his informants, Mr. Irving had incorporated in his interesting volumes of Astoria and Bonneville's Adventures, neither of them very flattering pictures.

One grand object of the survey, next to a topographical description of the country, was to ascertain its adaptability for wagon-road and railroad improvements and its industrial resources. If it could be made accessible by these means, it would present a new, practicable, and much shorter route for travel from the Union and Central Pacific Railroads to the settled portions of Montana Territory and to the great wonders of the Upper Yellowstone; and it was especially with a view to determine this question that I noted the general appearance and character of the country.

To any one who has ever read in the writings of Mr. Irving the various descriptions of the Upper Valley of Snake River, the idea of penetrating it by a railroad would seem ludicrous in the extreme; but in these days, when railroads go everywhere that civilization goes, we may venture the confident assertion that the day is not far distant when the obstructions of this hitherto unpromising region will be wholly subdued by them.

On that part of our route lying between Fort Hall and the North Fork of Snake River, the country is in a great measure barren, being, for most of the distance, a sandy plain. There are a few rocky eminences between Snake River Bridge and the North Fork of the river; none, however, which would require a grade of over 50 feet to the mile or any great deviation from an air-line. Any road along this part of the route would follow the general course of the river, crossing its meanders, which are neither numerous nor large. Much of the Upper Valley of Snake River presents on either shore a level table of trap-rock, which could be utilized as a road-bed with great advantage. The most difficult part of the entire route, as I conceive, would be between Market Lake and the mouth of the North Fork. Our party deflected on this route from a direct course of travel so as to visit the Three Tétons, the famous mountain land-marks of Snake River Valley. This journey took us some twenty-two miles out of our course. Soon after crossing the North Fork, we began to meet with evidences of a more promising country. Bunch-grass was found in the richest profusion, and after a few days' travel we entered the Téton Basin, which lay spread out before us like the land which Lot saw when he parted from Abraham. This basin is more than eight hundred square miles in extent, is covered with perennial grasses, well watered by large streams fringed with an abundant growth of cottonwood, furnishing sufficient timber for all the practical purposes of life, while the adjacent mountains are covered with tall pines, furnishing the finest timber in the world. The soil, receiving its nutrition from the detritus washed down from the mountains and from the deposits of frequent overflows, is rich, deep, and strong, yielding readily to culture. Ample facilities for irrigation are afforded by the river and small streams that feed it. There is not a finer stock raising region on the continent. Favored in its location with a dry, pure atmosphere, rain occurring only for a few days in the spring, snow seldom falling in the valley of sufficient depth to bury the herbage, and the weather, with the exception of an occasional day in winter, never so cold as to render a shelter necessary for cattle, it seemed to us to unite more of the needful elements for successful stock-raising than any other equal portion of the mountain-region. My opinion in this respect has been fully realized by the experience of cattle and sheep raisers in like regions of Montana, who upon these extensive valley ranges, which afford constant and abundant food both winter and summer, producing beef and mutton equal in fatness and superior in flavor to the best stall-fed meats of Illinois, have found the country peculiarly favorable to the increase of their flocks and herds. Heifers give birth to young oftener at the age of fifteen to eighteen months than at any later period. Frequently those of more mature age produce twins, and with many flocks of ewes a single lamb at a birth is an exception to the common experience. Disease of any kind is unknown among cattle and sheep, and it is only when the snows are very deep and the weather very cold that they suffer from exposure. With ordinary care and provision this exigency could be easily anticipated. In addition to the Téton Basin, there is enough of the Territory which we passed through that is thus favored to feed millions of cattle and sheep for all time to come.

Nature has furnished this far-away region with a valley and river system peculiarly adapted to its isolated geographical position, and without which, even in its present form, it would be comparately valueless. Cast your eye upon the map at the junction of the three streams which form the Missouri, the Jefferson, Madison, and Gallatin. Each of these rivers, divided from the others by lofty mountain-ranges, flows through a broad and fertile valley of great extent and beauty. These valleys are from sixty to eighty miles in length, with an average width of ten miles. The Gallatin is the largest and most picturesque, and, perhaps, the best adapted of the three to all the purposes of culture. The river, which from its source to its mouth is a continuous torrent, divides the valley centrally, and furnishes, by its deposits, a black soil of a mile in width on either side, which is covered for the most part with a dense, heavy growth of cottonwood, sufficient for all the purposes of fencing and fuel for many years to come. Outside of this continuous grove of cottonwood, the valley spreads away on either side of the river a distance of six or eight miles, to the low grass-covered foot-hills, which in their turn extend to the base of parallel ranges of lofty mountains. Every foot of the land thus inclosed, embracing a territory nearly as large as Vermont, affords in its natural condition the richest pasturage in the world. By the simple cultivation of the plow and harrow, it can, in a single season, be converted into a wheat-field which will yield an average crop of forty bushels to the acre. Crops of vegetables raised in this soil will average, in size, one-third more and some—cabbages, turnips, and especially beets—one-half more than the best root-crops of the Western States. I have never seen such abundant and perfect crops of wheat, oats, barley, potatoes, and all vegetables, as are commonly raised in these valleys. Indian corn, unless of the small flint variety, is an uncertain crop, on account of the early frosts, and but very little has yet been raised for harvesting.

The climate of these valleys is very dry, no rain of any consequence falling during the summer months, but this want is supplied by a cheap and simple process of irrigation, under which, from the fact that water can be supplied in abundance whenever it is needed, crops thrive much better, are much larger, and more perfect than when they are depending upon the uncertain, capricious, and often untimely visits of rain. Ditches for irrigating purposes are either connected with the river or some of the mountain-streams that feed it, and are extended through contiguous ranches by farmers, who make of them a joint-stock property. The two enemies which have been most dreaded by the farmer thus far are the grasshopper and early frost. The first of these has now disappeared; the latter is overcome by early sowing and planting; and the wheat-crop is now regarded as more certain in these valleys than in any of the States. It is also, as a general thing, from twice to three times more abundant. But few experiments have yet been made in fruit-raising, but the prospect for the successful culture of the hardy varieties of apples and pears is very good.

What I have here said of the valley of the Gallatin is true of all the valleys embraced within the limits of the summer's explorations.

At the agricultural fair held in Helena in September last, the exhibition of farm-products from these valleys would have been creditable to a much older community, and the stock, mostly of our own native variety, would have put to shame many similar exhibitions in the best of our stock-raising States. There is not one-tenth part of the arable lands of these valleys yet occupied, though the development of their productive qualities during the past two years has turned the attention of many of the inhabitants engaged in other pursuits to that of agriculture.

There is another resource to which I have barely alluded, which, for years to come, must render this region a desirable locality for a large class of producers. I mean its facilities for stock-raising. It is covered with the richest pasturage in the world. The bunch and buffalo grasses of the plains and mountain-regions, unlike the tame grasses of the States, are perennial. At the earliest approach of spring, and before the snow has left the hills, they begin to appear fresh and green. The spring rains, which, though of brief duration, are in many localities profuse, give them strength and expansion and they retain their verdure through the heat of midsummer. The dryness of the season prevents their decay, and the heat of the sun gradually cures them in the blade, so that they retain all the nourishment in the dried stalk and leaf of the best-preserved hay. They continue in this condition throughout the winter, and, at all times, except when storms are excessive or snows are very deep—not common occurrences in the valleys—the cattle feed upon them and grow fat through all the cold months. Farmers and owners of large herds of cattle, who put up hay as a precautionary measure, seldom have occasion to use it at all, and never unless an exigency like that I have just mentioned occurs. In the spring the green blade shoots out from the root of the previous year, imparting renewed life to the entire herbage of the valleys and adjacent foot-hills. With the exception of the mountain-ranges, which are either bare rocks or covered with pines, the surface is one entire pasture. No country in the world affords superior facilities, uniting convenience with economy, to stock-raisers. The meats perfected on these grasses are extremely fat and succulent and of rich flavor. The products of the dairy are proportionably larger, and the ranchman who owns a dozen good cows in the vicinity of any of the larger towns has in his possession the elements of a comfortable present subsistence and of a certain fortune in the future. Milk, butter, and cheese command a ready sale, at high prices. Already numerous flocks and herds are to be seen in these valleys, and those who, but five or six years ago, engaged in the business of stock-raising, with a dozen cows, are now the owners of herds numbering hundreds.

There are large bodies of land in the Téton Basin, and in the valleys along the streams flowing into Snake River, which may be profitably cultivated with wheat and vegetables. Water for irrigation in abundance, flowing from the surrounding mountains, may be cheaply and easily utilized. A railroad along the north fork of the Snake would pass within ten miles of this basin, and the route for this distance could be readily improved by a wagon-road. The foot-hills and mountains surrounding the valley are covered with dense forests of pine. Lumbering must ultimately become a very extensive and profitable branch of business over nearly all parts of the route from Market Lake to the Yellowstone. The streams are very numerous, and all furnish abundant water-power for both saw and grist mills. There is no better market for this product in the west than western and northern Utah. This business alone will, in time, warrant the construction of a railroad over this route, to say nothing of its various sources of revenue derivable from a connection with the settled portions of Montana Territory.

We carried out the intention, with which we started, of visiting and properly locating the three Tétons, and of ascending to the summit of the highest of them. Assured by our guide, and others who had long been familiar with the country, that it would be impossible to clamber up this mountain, that though repeatedly attempted it was a feat which had never been achieved, we did not undertake the task without great misgivings as to the result. The most northerly, or Grand Téton, which has received the name of, and will hereafter be known as, Mount Hayden, presents to the eye an outline very similar to that of the Matterhorn in the Alps. Its very appearance, unlike that of most of our mountains, seems to forbid all attempts to scale it, and for most of the distance the ascent can only be accomplished by climbing with both feet and hands. The face of the mountain presents an angle never less than 45° and frequently 60°, much more abrupt than the steepest stairways. Glaciers of greater or lesser dimensions are met with every few hundred feet, and in several instances they proved almost insurmountable. The irregular stratifications of the rocks were often such as to leave us with no support other than our hands at points and turnings where a failure in our hold would have precipitated us hundreds of feet down the face of the mountain. At one or two points when nearing the summit we would have been obliged to abandon the task but for the aid we received by casting a rope over prominent projections and pulling ourselves over them, to places where we could obtain secure footholds. In one of these efforts Mr. Stevenson came near losing his hold and falling down a precipice nearly a thousand feet. Another of our company, while ascending along the edge of a glacier, losing his hold, slid down a smooth ridge of ice, a distance of 40 feet, with fearful rapidity. His own presence of mind, in hastily throwing himself astride the edge of the glacier and descending it in that position, caused him to fall into a snow-bed at the bottom, and on the extreme edge of the precipice. This saved him from falling at least 800 feet. Of nine of the company who commenced the ascent Mr. Stevenson and myself were alone successful.

We found on one of the buttresses, a little lower than the extreme top of the mountain, evidence that at some former period it had been visited by human beings. There was a circular inclosure about seven feet in diameter, formed by vertical slabs of rough granite, and about three feet in height, the interior of which was half filled with the detritus that long exposure to the elements had worn from these walls. It could not have been constructed less than half a century ago, when Indians only inhabited this region.

The summit of the Téton is very small, not more than 30 by 40 feet in diameter, with a precipitous descent on all sides. Its height, by triangular measurement, is 13,833 feet. The view from it embraces the valley of the Snake River and territory contiguous, over a diameter of at least one hundred and sixty miles. For grandeur, vastness, and variety it is nowhere excelled in the region of the Rocky Mountains. Should the railroad to the Upper Yellowstone pass through this valley, the Téton Range would form one of the attractive features of a visit to that wonderful country.

On our descent of the mountain, while yet at a height of 10,300 feet, we crossed a lake, 600 yards long by 200 wide, of perpetual ice, which in thickness was about three feet, not unlike in character the descriptions given of the most elevated glaciers of the Alps. Passing over the immense snow-fields which covered the plateau adjoining, we descended into the grass-covered valley which bordered the Téton River, and pursued the most direct course to the north or Henry's Fork of Snake River. Along the margin of this stream we traveled over a solid natural road-bed to its source in Sawtelle's or Henry's Lake. This part of the country is peculiarly favorable for railroad improvements. The grades would be very light, not exceeding 20 feet to the mile, and for much of the distance very little, if any, excavation would be necessary to prepare the ground for the track. There are some obstructions from fallen timber along the entire route, which can be removed without difficulty. Doubtless in a country so full of irregularities of one kind and another, the foot-hills and mountains would present occasional interruptions to a direct course, but it surprises one, in passing over the country, to see how few these interruptions are and how readily they may be overcome.

In our explorations from the Téton Basin to the north, we carefully observed the four passes on the north, east, west, and south of Sawtelle's Lake, each one of which will doubtless be particularly described by Mr. Stevenson. These passes are equally favorable for all kinds of road improvements. Our company passed through the east or Tyghee Pass, entering the valley of the Madison. No person unacquainted with the topography of the country would believe while crossing this pass that he was crossing the summit of the Rocky Range. The same may be said of the other three passes in the immediate vicinity, each pointing to a separate point of the compass. From the point of entrance into the valley of the Madison, down that river to its junction with the Jefferson and Gallatin at the Three Forks, there are no serious obstructions to a railroad. Two of the cañons would require, perhaps, to be shelved for a roadway, in all, for a distance of about twenty-five miles. No more direct route for a railroad from Utah to the settled portions of Montana can be found than that from the junction of the Union and Central Pacific Railroads to Fort Hall; thence up Snake River to the head of the North Fork; thence by either the Sawtelle or the Targee Pass, down the Madison to the Three Forks, passing within twelve miles of Virginia City, the capital of Montana; thence, through the valleys of the Missouri and Prickly Pear, to Helena; and there are no engineering difficulties which cannot be easily overcome.

An enterprise of such comprehensive utility as this road should not suffer a moment's delay in the work necessary to its speedy completion for want of capital; for where can an investment be found which will be safer or more certain of a profitable return?

A single calculation based upon one source of its revenues will demonstrate how speedy, certain, and abundant must be the return made by this enterprise after its completion. The present population of Montana, at a very moderate estimate, is twenty-five thousand, who are all anxiously looking forward to the time when they will be connected with the States by rail. Suppose (and this calculation, at the prices which now prevail in Montana, and which the inhabitants of that Territory can afford to pay for all the necessaries of life not obtainable from the soil, is much too low) that each one of this number pays an average sum of $200 more per annum for groceries, dry-goods, wearing apparel, &c., than at Omaha or San Francisco for like articles. As the merchants of Montana do not make greater profits on their sales than do the merchants of those cities, this $200 per capita, aggregating $5,000,000 per annum, is paid for the transportation of goods, the larger portion of it being now received by the Upper Missouri River transportation companies, but which will nearly all go into the treasury of this road when completed, to be shared by it with the Union Pacific and Central Pacific Railroads. With the tide of emigration flowing into this Territory in anticipation of the completion of this road, it is but reasonable to suppose that this population will be doubled when that event occurs. Of course the revenue will be correspondingly increased from this one source, but by no means the most profitable source of income to the road.

To this is to be added what the road may reasonably anticipate from the great-wheat fields of Montana, from its inexhaustible timber, from its silver-mines, from its stock-growers, and from the great stream of transient travel for business, pleasure, and observation. A few years only can elapse before the marvels of the Upper Yellowstone, its geysers, boiling mud-springs, and sulphur mountains, the Great Falls of the Missouri, the singular scenery of the Bad Lands below Fort Benton, the picturesque beauties of the Prickly Pear Cañon, and the stupendous architecture of the Rocky Mountains will attract thousands of visitors annually to that distant country to view the wonders of nature and the grandeur of our mountain-scenery. This enterprise cannot without sacrifice be delayed a day longer than competent force, abundant means, and ample material require to convert the project into an established fact.

There were very many incidents connected with our journey which would prove of great interest to the general reader. Many of these have met the public eye through the correspondence of the gentlemen who accompanied us, and others doubtless will be used to embellish the various articles which may hereafter appear in our magazines, descriptive of the marvelous region which we explored. Let us hope that the time is not far distant when the geysers, cataracts, lakes, hot springs, and magnificent mountain scenery of our national park will become as familiar to the world of art as Niagara and Yosemite, both of which they so greatly surpass.

N. P. LANGFORD,
Superintendent of the Yellowstone National Park.

Dr. F. V. HAYDEN,
United States Geological Survey, Washington, D. C.

MEANS OF ACCESS TO THE YELLOWSTONE NATIONAL PARK BY RAILROADS.

SIR: As the park will soon become an object of general interest, and be the resort of thousands of visitors, the question of proper and convenient access is of great importance at present. A journey by wagon from the Central Pacific or Northern Pacific Railroads would prove long and tedious; we must, therefore, look for a railroad to carry tourists within a much shorter distance from the park, allowing, if any, but one or two days' journey by wagon. A project for such a road has already been conceived, but encountered pecuniary difficulties sufficient to impede its immediate construction. As this line would become the main route connecting the Central Pacific or Union Pacific Railroad with the Northern Pacific Railroad, and also furnish the best means of reaching the land of wonders, a few detailed remarks in regard to distances and elevations will show its entire practicability.

Branching off from the Central Pacific Railroad at Corinne, Utah, the line would run up Malade Valley with a very gradual and regular ascent toward the north, cross the divide from Salt Lake waters into Pacific waters, with a grade of not more than 100 feet per mile, follow down Marsh Valley to the Port Neuf River, and wind with a grade of less than 30 feet per mile into the open and flat country west of Fort Hall. The distance from Corinne to this point would not exceed one hundred and twenty-five miles. It would then take a northeasterly course for about sixty miles and cross Snake River at a point about five miles east of the mouth of Henry's Fork. This country being generally level, the question of grade could not be of interest. From that point the route would be unquestionably taken toward the north-northeast, following up the valley of Henry's Fork to the lake near its source, where it would be two hundred and thirty-five miles from Corinne. Thence crossing the very low divide in Raynold's Pass at about 50 feet per mile into the Madison Valley, it would follow it down to the settlements of Montana and connect with the Northern Pacific Railroad.

From points along this line either wagon or rail roads can be built with no unusual expense to all the principal parts of the park, and I will now endeavor to give as detailed a statement of the most practicable lines as a general reconnaissance of the ground will permit. This railroad would give access to the park from the south and west. The country east of the park appears to be unfitted for approach by roads, as the Big Horn and Wind River Mountains form a continuous, steep, and rough barrier.

The principal objects of interest within the limits of the park to be reached by roads are the Geyser-basins, the Yellowstone Lake, with Mount Sheridan to the south, and the Grand Cañon of the Yellowstone, including the Falls. Mammoth Hot Springs can be passed on a line of a northern approach from Fort Ellis, which has been examined by Mr. Gannett. As these points are all situated on the Atlantic slope, and the proposed railroad from Corinne to Montana is in the valley of Henry's Fork, which drains into the Pacific, and where we intend to branch off, it will first be necessary to examine the passes over the main Rocky Mountain water-shed. There is in the southern part of the park a very flat, open pass, if at all deserving that name, situated between Lewis and Yellowstone Lake, which can be crossed with a grade of only

90 feet per mile. Farther west another low divide is found between Shoshone Lake and the Fire-Hole River, which can be passed with a grade of not over 105 feet per mile. Following the water-shed in a northwesterly direction it gently varies in elevation and can be crossed by wagon-roads at many points. For a railroad the Tyghee Pass is the next and last available one. Another obstacle in the way of approach from the south of the park might be seen in the Téton Range, but on closer examination a pass is discovered near the southwest corner of the park where that grand chain diminishes so considerably in height and ruggedness that comparatively easy grades for a railroad can be obtained. Finding no serious obstruction, therefore, we proceed to consider the special localities best adapted for lines of approach.

Commencing in the south we first propose a route which is equally well suited for a wagon or rail road, as the grade is easy and water and timber are abundant.

Leaving the above-described proposed railroad from Corinne to Montana a few minutes north of the forty-fourth parallel, in the valley of Henry's Fork, it would run eastwardly, following up the valley of Falls River. For thirteen miles the average grade would be 41 feet per mile, for the next twenty miles it would be 61 feet per mile, which would bring the road to the western slope of the Téton Range through a slightly undulating country. At the mouth of Falls River Pass the most difficult portion of the whole line would commence and extend for six miles up to the divide near the Beulah Lakes. It would require an average grade of 96 feet per mile, reaching an elevation of about 7,525 feet. The valley ascends gradually and presents no serious difficulty in obtaining a uniform grade for the entire distance. In entering Falls River Pass we, at the same time, enter a gateway of the park, as the boundary-line crosses at the entrance. Gradually ascending, the road leads through a fine valley a few miles wide, bordered on both sides with rocky bluffs, inclosing a beautiful river which, taking its source from five enormous springs breaking out of the steep rocky walls and thence flowing through the Lower Beulah Lake, descends the valley in a number of rapids and falls which have suggested its name. The largest fall, 145 feet in height, is surrounded by a grotesque group of columns of rock much like Tower Falls near the Yellowstone River. After reaching the lakes, the road would continue eastwardly for about six miles, rising with a very slight grade and following the northern slope of the valley over a divide hardly perceptible, and not to be located without careful examination. Here it reaches the valley of the Union or Lake Fork of Snake River, entering upon a plateau or mesa from which the river can be seen several hundred feet below, flowing through a steep and gloomy cañon. On either side of the cañon the ground is gently rolling and is well fitted for a road, especially upon the eastern bank. Following nearly parallel with the river a distance of eleven miles, we would be brought to Lewis Lake, at the foot of Mount Sheridan, which could be easily visited from this point. It is the loftiest peak of a prominent group, entirely surrounded by comparatively flat country and affording the most extensive panoramic view of any mountain in the park. A more minute description of this peak can be found elsewhere in the report. From Lewis Lake it would be advisable to separate into two branches, one taking a northwesterly course to the Geysers and another a northeasterly to the Yellowstone Lake, River, and Cañon. The first-mentioned could take the following route: About ten miles on a level to Shoshone Geyser Basin; thence four miles, with a grade of 70 feet per mile, to the main Rocky Mountain divide, at an elevation of 8,717 feet, from whence a descent of 105 feet per mile for five miles would bring the line into the valley of the Fire-Hole River; following this river for an additional five miles, with a grade of 37 feet per mile, the railroad would be amidst the grand geysers of the Upper Basin. Proceeding eight miles further, with a descent of 17 feet per mile, it would arrive at the Lower Basin, which would form the terminus to this branch of the line. The other, diverging northeasterly from Lewis Lake, would cross the main Rocky Mountain water-shed within five miles, at a grade of 43 feet per mile, and descend to the Hot Springs at Yellowstone Lake within three miles, at a grade of 94 feet per mile. No difficulty in grade would now be met with either along the shores of the lake or down the valley of the Yellowstone River to the falls and Grand Cañon.

The following is a review of distances and elevations on this route, commencing at the point where it would leave the main railroad in Henry's Fork Valley.

	Distance from Henry's Fork in miles.	Distance from Corinne in miles.	Elevation in feet.
Henry's Fork Valley	0	145	5,130
Falls River	13	158	5,670
Entrance to pass	33	178	6,950
Beulah Lakes	39	184	7,525
Union Fork	45	190	7,800
Lewis Lake	56	201	7,828
Hot Springs, Yellowstone Lake	64	209	7,788
Yellowstone Falls	94	239	7,700
Shoshone Geyser Basin	66	211	7,880
Divide	70	215	8,717
Upper Geyser Basin	80	225	7,390
Lower Geyser Basin	88	233	7,260

Having thus followed the entire line of the route through Falls River Pass to the principal points of interest, we now will examine a second route running through the Tyghee Pass, which presents equal facilities for a railroad.

Leaving the proposed Corinne and Montana Railroad at Henry's Lake, a distance of six miles with a slight upward grade would bring it to the Tyghee Pass, and the divide could be reached within four miles, at a grade of 130 feet per mile. The Madison or Fire-Hole River Valley now lies open before us, and, gradually descending, the line would follow the northern slope of the mountains down to the level of the river. With a gradual ascent of 10 feet per mile it would follow up the valley, entering the park at the entrance to the cañon to Gibbon's Fork, a distance of twenty-three miles from Tyghee Pass. From this point the Lower Geyser Basin is reached within eight miles, at a grade of 70 feet per mile, where the line would connect with the first route described as approaching the park through the Falls River Pass.

The following statement of distances and elevations along the second route, starting at Henry's Lake, will review the line:

	Distance from Henry's Lake.	Distance from Corinne.	Elevation.
Henry's Lake	0	235	6,443
Tyghee Pass	10	245	7,063
Gibbon's Fork	33	268	6,808
Lower Geyser Basin	40	275	7,260
Upper Geyser Basin	48	283	7,390
Divide	58	293	8,717
Shoshone Geyser Basin	62	297	7,881
Lewis Lake	72	307	7,835
Hot Springs, Yellowstone Lake	80	315	7,788
Yellowstone Falls	110	345	7,700

A distance of six miles may be saved by running from divide directly to the outlet of Yellowstone Lake. By a comparison of the two tables of distances an opinion may be formed as to the best route. Both are within a short distance of rivers which never run dry, and both run over thickly-timbered lands. In all the high regions of that country there is but little soil and, therefore, excavations are mostly rendered very expensive by being in rock. However, this is a disadvantage pertaining equally to both routes and, therefore, favoring the shorter distance. All the trappers throughout the whole region state, concerning the climate during the winter, that, although there is heavy snow, it is rarely accompanied by winds, so that drifts are rare exceptions. This will also apply equally to both routes and the maintenance of railroads generally.

Hoping sincerely that the above will furnish an incentive toward opening this grand and wonderful park to the multitudes, both at home and abroad, that are ever anxiously seeking instruction and pleasure, I remain, yours respectfully,

R. HERING.

Professor F. V. HAYDEN,
United States Geologist.

REPORT

OF

A. C. PEALE, M. D.

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WASHINGTON, D. C.

DEAR SIR: I have the honor to transmit herewith my report for the season of 1872. I have divided it into six chapters. The first I have devoted to the description of a short trip into Colorado and Utah, made before the organization of the party was completed. The second chapter contains an account of our progress from Fort Ellis, Montana Territory, to Gardiner's River, in the Yellowstone National Park, including an account of the Hot Springs at the latter place. The third chapter contains a description of the springs in the Yellowstone Valley from Gardiner's River to Yellowstone Lake. The fourth chapter is devoted to the geyser-basins of Fire-Hole River.

The time we were in the geyser-basins was somewhat limited, and the observations must therefore be to some extent necessarily incomplete. To work up this most interesting section thoroughly will require the time of at least one entire season, so that data may be obtained as to the influence the different portions of the year may have upon the geysers. Then, also, more could be definitely learned in regard to their regularity or irregularity. As far as the time permitted, I have endeavored to make the observations as complete as possible.

At this point I wish to express my thanks to Dr. F. M. Endlich, of the Smithsonian, for assistance rendered in analysis. That I am able to present so many analyses, especially of specimens from the geysers, is due largely to his assistance. I wish also to refer to Mr. W. B. Platt, of the expedition, who also assisted in analysis.

My fifth and sixth chapters I have devoted to the consideration of the Madison and Gallatin Valleys. Appended to the report are catalogues of the rocks and minerals collected during the summer. I have incorporated in them the specimens collected by both branches of the expedition. I have also done the same in the catalogue of thermal springs, which is appended to the report. In the latter catalogue I have, for the sake of comparison, included observations of some of the springs taken in previous years (principally by Long and by Frémont) wherever there was no doubt as to the localities being the same.

The collections of geyserite this year are particularly large, and present all the varieties in form and texture to be found in the region.

In conclusion I wish to express my thanks to all the members of the expedition for their uniform kindness and co-operation. I would refer particularly to Mr. T. O'C. Sloane, who for a while acted as my assistant, and who, by his zeal and activity, contributed largely to the collections.

To the editors of the "New York Illustrated Christian Weekly" I am indebted for some of the best wood-cuts illustrating my report.

Trusting this report may prove satisfactory, I have the honor to be your obedient servant,

A. C. PEALE.

Dr. F. V. HAYDEN,
United States Geologist.

CHAPTER I.

COLORADO AND UTAH.

While the expedition was being organized at Ogden, Utah Territory, Mr. W. H. Jackson was ordered to make a photographic tour through a portion of Colorado. Fortunately, I was able to accompany him, and while assisting him took a few notes in regard to the lithology and geology of the places we visited. Colorado City and Golden City were our principal points, and it is of them I will speak more particularly. We were limited as to time, and the area over which we passed was so small that I shall have to restrict all I have to say to each immediate locality; still I hope it may not be without some little interest. We left Omaha on the 20th of May, and the following evening reached Denver, in Colorado Territory. In passing, let me say a word or two about Denver. Thirteen years ago a log-cabin represented this city, that now contains a population of over 14,000 people, and which is in every way a thriving and prosperous place, bidding fair to become the metropolis of the far West. Four years ago there was not even a mile of railroad in the Territory, and to-day Denver is the center of five distinct lines of railroad, and still more are being built. The city is beautifully situated on the banks of Cherry Creek, about twelve miles from the mountains. The plain upon which it is built is so covered with the superficial drift of the mountains that the underlying rocks are entirely concealed. There is little doubt, however, as to what they are, for, as we proceed toward the mountains, we come upon the upturned edges of Tertiary sandstones, containing beds of coal, the tipping up of which is explained by the grand range immediately in front of us, from which Gray's Peak and Long's Peak raise their snowy heads, seeming almost to pierce the heavens. Leaving Denver we took the Denver and Rio Grande Railroad to Colorado Springs, some seventy-six miles farther south. This railroad is a narrow-gauge road, and the first of any length that has been built. It threatens to work an important revolution in the railroad-system of the West. The road gradually ascends upon leaving Denver until we reach the summit of the Colorado divide. This is a spur or high ridge, projecting from the mountains at right angles to their trend. It forms the dividing line between the waters of the Platte River and those of the Arkansas. It is very thickly timbered, and lumbering is carried on quite extensively. The ascent from Denver to the summit of the divide is very gradual, and it is a little difficult to believe that one has ascended 2,000 feet. The elevation of the divide at the summit is 8,000 feet above the sea. Smoky-quartz crystals are found here quite abundantly, and are called topaz by the people. I was shown several good specimens said to have been picked up near the railroad. The rocks as seen from the cars seem to be mostly red and gray Tertiary sandstones. From the divide the railroad has a gentle descent, and after a ride of twenty-four miles, passing some beautiful scenery, we reach Colorado Springs. This is a new colony, just established on the line of the railroad. It is about eight miles from the mountains. Its site is covered with local drift from the hills. To the east the country spreads out into the plains. We spent several days at Colorado Springs, making excursions to the various points of interest. Our first day was spent in the "Garden of the Gods," about four miles northwest from Colorado Springs and two miles north of Colorado City. This interesting and peculiar place is a valley in the foot-hills of the range, and is inclosed by an almost vertical wall of massive sandstone of Cretaceous age. The rocks which we find inside have been subjected to an immense deal of erosion, and the many ridges and tower-like forms left standing throughout the garden are the remnants of the parallel strata which dip to the northeast at a very great angle. In some places they seem to dip a few degrees in the opposite direction. As we go toward the mountains, the dip decreases. These rocks are fine-grained sandstones, of a deep brick-red color, with here and there layers and spots of a lighter red, and sometimes white. The ridges are exposed for some distance to the north, while to the south, after bending toward the east, they appear to be covered by the *débris* from the mountains. The entrance to the "garden" is through the "Beautiful Gate," an opening through one of the highest ridges of red sandstone. We estimated the height of this ridge to be 300 feet. The northern end is considerably higher, and viewing it so as to see the end alone the resemblance to the tower of a grand cathedral induced us to call it "Cathedral Rock." Another collection of rocks inside the "garden" had the name of "Montezuma's Cathedral." On the western surface of the ridge mentioned above, the water has worn quite a large cave. The sandstone is very soft in most places and can be readily crushed in the fingers. The softness is due probably to the effect of the weather. As we go toward the west the hardness increases. Outside of the red layers, and a few hundred feet farther to the east, there is a layer of white sandstone parallel to the red and tipped up at the same angle, about 70°. Outside of this, and in contact with it, is a bed of gypsum which is of considerable thickness. From it I obtained specimens of selenite and satin-spar. The specimens of amorphous gypsum I obtained are exceedingly beautiful, the white variety being of course the most abundant. I got also some very pretty pink varieties.

The following day we spent in visiting Glen Eyrie and the Soda Springs on the "Fontaine qui Bouille." Glen Eyrie is also sometimes called the "Little Garden of the Gods," from its resemblance to the "Garden of the Gods," which we first visited, and which is farther to the south. The entrance is through a natural gateway, cut through a massive ridge of gray sandstone by Camp Creek, which flows through the glen. The sandstones are covered with moss, giving them a most picturesque appearance, and General Palmer, who has made his home here, has given them the name of "Painted Rocks." The ridge forms a high wall, dipping northeast at an angle of 60°. The age of this sandstone is Cretaceous. Just inside of it there is a layer of limestone, which is probably Jurassic, and next to this is a layer of gypsum, the continuation of the bed I mentioned above. Then follow soft, red sandstones, corresponding to those in the "Garden of the Gods," although they are lighter in color, at a distance seeming to be of a flesh-color. They are eroded into curious, fantastic forms. One in particular deserves mention. It is a mass of red rock, 30 feet in diameter, and rising to the height of 200 feet. It is a monolith, the top of which is larger than at the base, and looking at it one almost expects to see it toppling over. It is called "Needle Rock." The area included in the "Little Garden of the Gods" is much less than in the other garden. The red sandstones, as we approach the hills, become harder, seeming to be almost crystalline, and have a deeper color. The angle of the dip has decreased, and at this point is only 20°. Where Camp Creek has cut its way through these hard layers there is a fine exposure of the strata. Here is Glen Eyrie proper, and a wild, weird-looking place it is. The dark-red rocks and the bright-green foliage, through which we catch an occasional glimpse of the stream, form parts of a picture well worthy the visit of one who loves the beautiful. We did not have time to penetrate farther up the cañon, but below these sandstones I believe there are Carboniferous limestones. The thickness of these rocks, however, is not very great. I cannot give the exact thickness, as I had no means of measuring them.

Leaving Glen Eyrie we passed a second time through the "Garden of the Gods", and after a ride of some six miles reached the Springs on the Fontaine qui Bouille, a branch of the Arkansas River. There are five principal springs. The first one is the "Manitou" or "Doctor Spring." It is on the left bank of the river, and is quite small, measuring hardly a foot in diameter. The water contains a large percentage of carbonic acid, and there is a slight bubbling, caused by the escape of the gas. The water is more agreeable to the taste than that of any of the other springs. There is quite an abundant deposit of carbonates about the spring reaching to the edge of the river. The overflow of water is very small. The water contains about two drachms of solid matter to the gallon. Its temperature was 57° F. It is feebly alkaline. An analysis, made by Mr. Frazer in 1869, revealed the following contents:

Carbonate of soda.
Carbonate of potassa.
Carbonate of lime.
Chloride of sodium.
Alumina.
Trace of iron.

The next spring is the "Comanche." This is a chalybeate spring, situated in a small thicket, on low, marshy ground, on the right bank of the river, near the water's edge. There is no deposit about, save a slight one of oxide of iron, and the escape of gas is very insignificant. The iron is quite perceptible on tasting the water. Its temperature was 48°.5 F.

The next spring, in size the second, is the "Shoshone." It is also on the right bank of the river, and is close to the wagon-road. There is a continuous escape of carbonic-acid gas from it, but the taste of the water does not compare with that of the Manitou. It is surrounded by considerable deposit, consisting mostly of carbonates of soda and potassa, with also a trace of sulphur. (Frazer, 1869.) Its temperature is 55°.5 F. Below the Shoshone Spring, on the edge of the river, is the "Nashataga," an unimportant spring, having a temperature of 52° F.

The largest spring is the "Bathing Spring." It is almost opposite the Manitou, and has a very abundant deposit, in which the opening of the spring is about five feet in diameter. The escape of gas is more violent than in any of the other springs. Its temperature is 60° F. Water is conveyed from it in iron pipes to a bath-house, which has been recently erected. An analysis of the deposit from these springs, made by Dr. Drown in 1871, is as follows:

	Per cent.
Chloride of sodium	36.69
Chloride of potassium	10.01
Bicarbonate of soda	24.01
Sulphate of soda	4.78
Bicarbonate of lime	15.62
Bicarbonate of magnesia	8.89
Total	100.00

The names of some of the other unimportant springs are the "Iron Ute," "Navajo," the "Arapahoe," and the "Pawnee."

Frémont visited these springs in 1843 and took the temperature of two of them. I will give his temperatures and those I took in tabular form, so that they can more easily be compared. His upper spring corresponds, I believe from his description, to the Bathing Spring, and the lower spring to the Shoshone.

Temperatures of Frémont, July, 1843.

Time.	Temperature of upper spring.	Temperature of lower spring.	Temperature of air.
11 a. m.	69° F.	60°.5 F.	73° F.
Sunrise	61	58	66
Sunset	54.3	57	57.5

Temperatures, May, 1872.

Name of spring.	Time.	Temp. of air.	Temp. of spring.
Bathing Spring	Afternoon.	70° F.	60° F.
Shoshone	Afternoon.	70	55.5
Comanche	Afternoon.	70	48.5
Manitou	Afternoon.	70	57
Nashataga	Afternoon.	70	52

A comparison of the above tables would seem to show that in the last twenty-nine years the water of the springs has become cooler. Some of the difference in temperature may, perhaps, be due to the difference in thermometers used. A large hotel has been built near the springs for the accommodation of invalids and tourists, and there is no doubt that before long this will be one of the favorite sanitariums of the West. The site of a village has also been laid out, to which the name of Manitou has been given. Leaving the springs we followed the road up the cañon to the Ute Pass. The road through this pass leads to the silver mines of the South Park. It has been cut through solid granites. The cañon is a most romantic one, and the stream rushes down the deep, narrow gorge in a series of cascades and falls. The largest fall, Ute Fall, is 60 feet in height. The granite through which the stream has cut its way is a red porphyritic granite, presenting a beautiful appearance, due to the large red crystals of feldspar, (*Orthoclase.*) The mica is somewhat smaller in quantity and of a black color. The rock would doubtless be capable of a very high polish. As a building-stone I do not think it will have much value, as it readily breaks down on exposure to the weather. I noticed at various places on the walls of the cañon stains and discolorations, due to the infiltration of mineral waters.

The junction of the sedimentary rocks with the granites is well shown in the pass. In some places the former are lifted high upon the hills, dipping northeast, at angles varying from 10° to 30°. The rock immediately upon the granites is a hard fine-grained sandstone containing irregular seams of pebbles. Its color varies from a yellowish gray to red. The dip was north 40° east; angle, 20°.

Our next trip was made to Chiann Cañon, through which Chiann Creek flows to join the Fontaine qui Bouille. In company with Messrs.

Nettleton, Fuller, and Potter, and Dr. Gatchell, of Colorado Springs, we started early in the morning, and after a ride of four miles over the mesas, reached the mouth of the cañon, where we left our wagons and mules and proceeded the rest of the way on foot, carrying the photographic apparatus and materials on our backs. The cañon is very narrow and the granite walls rise precipitously on either side to the height of 600 feet above the bed of the stream. We were obliged to cross and recross the stream many times in order to get along, as the banks in some places were too steep to allow our passing along them. After a walk of about a mile and a half we came to a fall, or rather a series of falls, which prevented any farther progress up stream. There were three distinct falls, one above the other, the entire height being 300 feet. The water in falling strikes numerous ledges, which churn it into a mass of foam. It has worn in the solid granite a rounded basin surrounding which are walls reaching the height of 800 feet. The best view of the falls is to be had about a quarter of a mile below on the side of the cañon. At a point 300 feet above the bed of the creek we have a magnificent view of the entire falls, while back of them rise the hills which stand at the foot of Pike's Peak, and in the fore-ground, far below us, we catch a glimpse of the creek as it reflects the sunlight through the foliage of the pines.

The following is a list of the minerals I obtained while at Colorado Springs: Snowy gypsum, pink gypsum, selenite, satin-spar, (fibrous gypsum,) yellow calcite, (crystallized,) amazon stone, (orthoclase,) amethyst, smoky quartz, white quartz, opal, and agate.

We left Colorado Springs on the 27th of May, and on the 29th arrived at Cheyenne, Wyoming Territory. On the 3d of June we started on a second trip, our destination this time being Golden City. Golden City is about twenty miles, almost due west, from Denver, at the base of the foot-hills of the main range of the Rocky Mountains. It is situated in a valley, between the hills and two mesas, or table-like mountains. They stand between the town and the plain, and between them is the Golden Gate, through which Clear Creek flows out to the plains. Both the mesas are surmounted by layers of basalt. The north mesa, called Table Mountain, is about a mile in width and a little more than two miles in length. On the western side, overlooking the town, is a prominent mass of bare rock, which is called the Castle. The south mesa has the same width as the one on the north, but is longer, extending for four miles. The upper portion of the basalt capping these mesas is more compact than the lower layers and is somewhat columnar. Beneath the basalt are Tertiary formations—sandstones and clays. The surface of the mesas is somewhat irregular and covered with grass. They form the grazing-grounds for large herds of cattle. The Tertiary beds continue some distance west of the mesas, and contain coal. The principal bed varies in thickness from a few inches to eight feet. It is almost vertical. There are four openings into it, three of which are owned by the Mineral Land Company and leased to the Hazleton Company. Only one of them, however, is worked at present; one of the others has been burned out—since which work has not been resumed—while the third is filled with water. A fourth opening is owned by Judge Johnson. Only enough coal is mined to supply the local demand. The ridge above the coal is a white sandstone containing impressions of deciduous leaves, while beneath the coal is a bed of clay. The strike of these beds is almost due north and south. Below the coal-beds are red and gray sandstones with a layer of limestone. These sandstones rest immediately on the metamorphic rocks at an angle of about 45°. The effect of erosion here has been to so level these beds that it is difficult to trace the succession of the various layers.

We made several excursions while at Golden City, one of which was up Clear Creek Cañon, through which the Colorado Central Railroad, a narrow-gauge road, runs. When finished it will penetrate to the mining-districts of Georgetown and Central City. When we visited it the road-bed was graded some ten miles above Golden City. The creek has cut its way through the hills in a tortuous course, leaving high walls of gneiss and granite standing on either side. In the gneisses I obtained garnets and magnetite. There has been some gold-mining carried on in Clear Creek Cañon, but I judge it was with but little profit. At any rate, at the present time the diggings are abandoned.

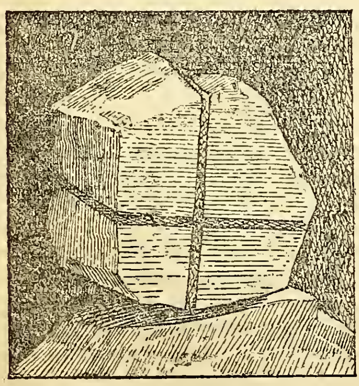
From the office of the Colorado Central Railroad I obtained specimens of ores from Central City, consisting mainly of gold quartz, pyrites, and argentiferous galena.

Having completed our work we left Golden City and started for Ogden, Utah Territory, where we joined the main party in camp on the 8th of June. The Wasatch Range, at the foot of which the town of Ogden is built, has a trend north and south. Its geological structure is beautifully shown in the many cañons which cut deeply into it almost at right angles to the trend. It is in these cañons that the profitable mines of Utah are situated. The cañons near Ogden are Ogden Cañon and Weber Cañon. Through the latter the Union Pacific Railroad finds its way into the Great Salt Lake Basin. Between these two there are a number of smaller cañons which cut the mountains only partially. Two of these, immediately back of our camp, are Taylor's Cañon and the Waterfall Canon. In the former there is a limekiln in operation. Here also some miners claim to have discovered tin. An examination of specimens proves, however, the absence of any metal and showed the specimen to consist almost entirely of hornblende. The Waterfall Cañon is named from the occurrence in it of a fall some 300 feet in height. The water falls over a ledge of white quartzite. Above it rises Mount Bechler, whose height is 9,716 feet. The base of the mountains near Ogden is for the most part a red syenite, whose specific gravity is about 2.6. This syenite passes into granite and gneiss. It contains, in places, veins of hornblende, and the gneisses have veins of quartz with specular iron. Several of these veins have had openings made into them by prospectors. The largest is just south of the Waterfall Cañon. It is four feet in width and penetrates the rock to a depth of thirty feet horizontally. The walls on either side are gneisses, stained with the green carbonate of copper, (malachite.) The gangue is quartz and serpentine. Associated with the specular iron or micaceous hematite are iron pyrites and stainings of copper. The iron is in veins varying from the fraction of an inch to two inches in thickness. On the north side of Ogden Cañon I found another opening, much smaller, in chloritic schists, which, at this point, lie just above the syenite. The gangue here was white quartz, containing veins of micaceous hematite. The schists contained numerous veins of quartz. Above the metamorphic rocks there are heavy beds of quartzite, the lower bed of which is conglomerate, the siliceous matrix containing pebbles of bright-red jasper. The quartzites have a specific gravity of 2.6 and are mostly of white color, although in some places they are pink and again dark brown, becoming highly ferruginous. Above the quartzites are heavy beds of dark-blue magnesian limestones of Silurian age, above which are Carboniferous limestones. I was shown a specimen of graphite from near North Ogden, a village six miles above Ogden. At the upper end of Ogden Cañon galena is found associated with carbonate of copper in limestones. This corresponds to the location of the most productive silver mines in Utah. They are almost situated in limestones at the heads of the cañons, and the ores are ores of lead containing silver. The minerals I obtained at Ogden are the following: micaceous hematite, iron pyrites, galenite, magnetite, graphite, azurite, malachite, garnets, quartz, chlorite, talc, serpentine, jasper, hornblende, serpentine, and calcite.

On the 19th of June Mr. Jackson started on a photographic trip to Little Cottonwood Cañon, on which trip I accompanied. From Ogden to Salt Lake City we took the Utah Central Railroad, which skirts the edge of the mountains. The granitic rocks extend for some distance below Weber Cañon, but as we near Salt Lake City the limestones form the base of the mountains, near which are a number of limekilns. The limestone for the kilns seemed to be taken from the upper layers, probably because the lower ones are siliceous, as at Ogden.

The cañons which cut through the Wahsatch Range near Salt Lake City are as follows, in their order from north to south: Red Butte, Emigration, Parley's, Mill Creek, Big Cottonwood, and Little Cottonwood. At the head of the latter are some of the best silver mines to be found in Utah, and among them is the famous Emma mine. Leaving Salt Lake City we take the State road, and after a ride of ten miles in a southeasterly direction, passing between thriving farms dotted with comfortable-looking houses, we turn to the left and strike across the country to the mountains. Directly before us is the highest point in the Wahsatch Range, the Twin Peaks, over 12,000 feet above sea-level. As we ride along we see distinctly marked on the sides of the mountains in front of us the water-lines of the former shore of the Great Salt Lake. These old shore-lines are distinctly marked on the mountains, on all sides of the lake, and on the islands in the lake. We pass over numerous terraces and at length reach the mouth of the cañon. Here there are no less than seven distinct terraces, some of them, however, due to the action of the Cottonwood Creek. Near the mouth of the cañon there are smelting-works, to which ore is brought from the mines at the head of the creek. Inside the cañon we find ourselves between high granite-walls, rising precipitously on either side of the creek. The first thing to attract our attention is the conspicuous bedding of these granites. The dip is east at an angle of 50° to 70°. The granite is of a light-gray color, composed of white feldspar, (orthoclase,) quartz, and black mica. The bottom of the cañon is strewn with bowlders of granite, which lie scattered over it in inextricable confusion. In many of them (Fig. 25) I noticed veins of feldspar of about two inches in width crossing each other at right angles. Another noticeable feature in these granites is the occurrence of rounded pebble-like masses, of a dark color, inclosed in the gray matrix. Professor Silliman, (Silliman's Journal, vol. iii, page 196,) referring to these, says "These granites are probably metamorphic, of coglomerates, an opinion first suggested to me by Professor W. P. Blake." As he also further states, there is a pebble-like roundness in

Fig. 25.



BLOCK OF GRANITE WITH FELDSPATHIC SEAMS.

the particles of quartz in this granite which points to a mechanical origin. The rock is quite uniform in its structure. A mile or two in the cañon we came to a small village called Graniteville. It is near here that the granite, of which the Mormon temple is being built, is quarried. Instead of working into the rock on the sides of the cañon, the quarrying is confined to the huge blocks of granite which are scattered over the bottom on both sides of the creek. Some of these blocks are immense, measuring 30 feet square. They are split into the required size. Our road for about five miles leads us between the granite walls that tower far above us, surmounted by dome-like masses, whose summits are covered with snow, giving origin to the numerous falls and cascades which abound on the sides of the cañon. The Little Cottonwood Creek flowing past us falls about 500 feet to the mile. It rushes along furiously over its rocky bed, seeming to be at war with the immense bowlders that dispute its right of way. As we proceed we leave the granites behind us, and above us project the sharp, jagged edges of quartzite beds. These quartzites have a reddish color, and are followed by slates upon which rest thick beds of white limestone. The lower beds are crystalline and probably Silurian, although I was unable to find any fossils in them. The upper layers are dolomitic, and are Carboniferous in age. It is in these limestones that the ores occur. The principal mine is the Emma. Unfortunately, owing to a disturbance at the time of our visit, I was unable to see the Emma mine, but visited the Flagstaff and the Silver Star. I quote the following analysis and remarks upon the ore of the Emma mine from an article by Professor Silliman:*

I am able to present an analysis of an average sample of 82 tons (=183,080 pounds) of first-class ore from the Emma mine, made by James P. Merry, of Swansea, April, 1871, which is as follows:

	Per cent.
Silica	40.90
Lead	34.14
Sulphur	2.37
Antimony	2.27
Copper	0.83
Zinc	2.92
Manganese	0.15
Iron	3.54
Silver	0.48
Alumina	0.35
Magnesia	0.25
Lime	0.72
Carbonic acid	1.50
	90.42
Oxygen and water by difference	9.58
	100.00

The quantity of silver obtained from this lot was 156 troy ounces to the gross ton of 2,240 pounds.

This analysis sheds important light on the chemical history of this remarkable metallic deposit, and will aid us in the study of the paragenesis of the derived species. It is pretty certain that all the heavy metals have existed originally as sulphides, and we may, therefore, state the analysis thus, allowing 8.52 per cent. sulphur to convert the heavy metals to this state:

Silica	40.90
Metallic sulphides	52.60
$\dot{Al}$, .35, $\dot{Mg}$, .25; $\dot{Ca}$, .72; $Mn^2 \dddot{Mn}$, .20	1.52
	95.02
Water, carbonic acid, and loss	4.98

*American Journal of Science and Arts, vol. iii, page 198.

This calculation assumes that the sulphides are as follows, viz:

	Per cent.
Galenite	38.69
Stibnite	3.30
Bornite	1.03
Sphalerite, (blende)	3.62
Pyrite	5.42
Argentite	0.54
	52.60

This statement excludes the presence of any other gangue than silica, and, considering that the ores exist in limestone, the almost total absence of lime in the composition of the average mass is certainly remarkable. The amount of silica found is noticeable, since quartz is not seen as such in this great ore-chamber, nor, so far as I could find, in other parts of the mine. The silica can have existed in chemical combination only in the most inconsiderable quantity, since the bases with which it could have combined are present to the extent of less than 1½ per cent.; nor do we find in the mine any noticeable quantity of kaolin or lithomarge resulting from the decomposition of silicates, nor are there any feldspathic minerals. It is most probable that the silica existed in a state of minute subdivision, diffused in the sulphides as I have seen it in some of the unchanged silver-ores of Lion Hill, in the Oquirrb Range.

The absence of chlorine and of phosphoric acid in the analysis corresponds well with the absence of the species cerargyrite and pyromorphite, of which no trace could be found by the most careful search among the contents of the mine.

From the Flagstaff and Silver Star I obtained specimens of wulfenite, aurichalcite, galenite, lithomarge, massicot, cervantite, and cerussite. The wulfenite I found in minute, brilliant, yellow, tabular crystals, in cavities in ochraceous ores, and also associated with cerussite. Other minerals found at this locality are azurite, malachite, calamine, anglesite, sphalerite, pyrite, argentite, antimonial, galenite, anglesite, kaolin, and limonite.

A specimen of galena from the Vallejo tunnel of the Silver Star mine yielded, on examination, a small percentage of silver.

Among the rocks I obtained while at Ogden were specimens of aplite, protogine, hornblendic gneiss, protogenic gneiss, chlorite, schist, and micaceous schist.

Before closing this chapter I wish to express my thanks to Messrs. Nettleton and Somers, of Colorado Springs, and the officers of the Colorado Central Railroad in Golden City, for favors and information afforded us while in Colorado.

CHAPTER II.

FORT ELLIS TO GARDINER'S RIVER.

On the 22d of June the expedition was divided into two parties at Ogden, and I found myself a member of the party which was to make Fort Ellis, Montana, the base of operations. Accordingly, after a long and tedious stage-ride, we pitched our tents near Fort Ellis on the 29th of June. Fort Ellis is situated at the head of the Gallatin Valley, on one of the many small streams that contribute to form the East Gallatin River. The Gallatin Valley is one of the most fertile in Montana Territory, and is surrounded by ranges of mountains which contain choicest bits of scenery as well as contribute to the wealth of the Territory. The principal towns of the Gallatin Valley are Bozeman, Hamilton, and Gallatin City. The former contains a population of about five hundred inhabitants. Between Bozeman and Gallatin City there are numerous well-cultivated and productive farms.

The streams that form the headwaters of the Gallatin River have cut profoundly into the mountain-ranges, exposing their structure in the most beautiful manner. The first of the cañons to which I will refer is Spring or Rock Cañon. This cañon forms a most interesting subject of study, and will answer admirably as a type of the others. It is a V-shaped chasm, cut through the end of an anticlinal range by the stream. The trend of this range is northwest and southeast. The first thing that attracts our attention after we are fairly inside the cañon is the occurrence, on the left-hand side of the creek, of an arch that crosses the road, and, describing a semicircle on the hill, again crosses the road at the upper end of the cañon. (Fig. 26.) The first prominent bed we meet is a layer of coarse, gray calcareous sandstone, containing fragments of fossils. Proceeding up the cañon we find the center of the arch is occupied by masses of Carboniferous limestone, which tower far above the creek, giving a most picturesque appearance to the cañon. Still farther along we come to the other extremity of the arch and find the same layer that we saw at the opposite end. Following this layer at the western end of the cañon, that nearest Fort Ellis, we find the dip at the bed of the creek to be south 45° west; angle, 30°–40°. Farther along we find it to be south 80° west, the angle remaining about the same. Still higher up on the ridge it is north 50° west; angle, 15°–25°; and when we reach the highest point on the ridge it dips due north at an angle of about 25°. Taking this same layer again at the level of the creek, this time at the eastern end of the cañon, we find the dip to be in the same direction, although the angle is greater. As we go toward the south it approaches more and more to the vertical, until the dip becomes northeast and the range therefore becomes a true anticlinal. The reading just above the creek on the northern side gives a dip of south 45° west; angle, 70°. As we follow

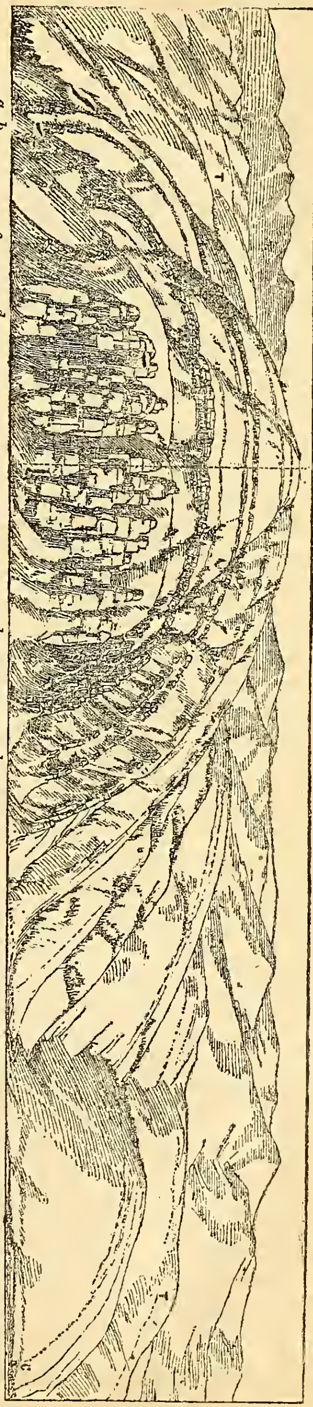
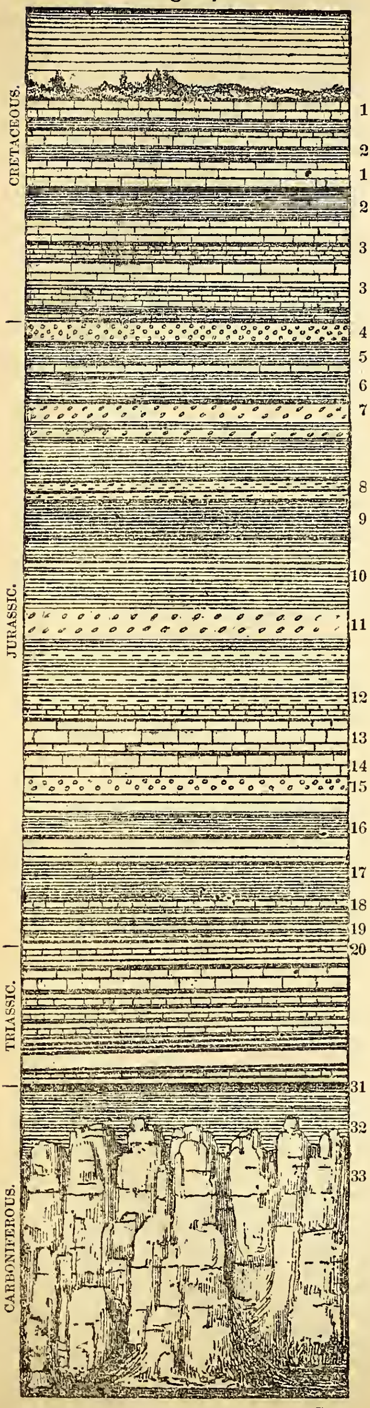


Fig. 26.

ARCH IN SPRING CAÑON.

a a, Brown sandstone; *b b*, White limestone; *c c*, Quartzites; *d d*, Massive Carboniferous limestone; T T, Tertiary beds; C, Coal bed; B, Bridger range; S, Section-line.

Fig. 27.



SECTION OF THE BEDS IN SPRING CAÑON.

the ridge toward the north, it is south 30°–35° west; angle, 80°–85°. Still higher up it is south 20° west; angle, 85°; and then becomes, within a very short distance, south 10° west; angle, 88°–90°. As we progress it passes the vertical and dips northeast at a high angle, which gradually decreases, the dip becoming more and more northerly until the arch is completed. At the western end of the cañon beneath the limestone, which immediately succeeds the fossiliferous sandstone, there is a fine exposure of quartzite-beds, the top layers of which are somewhat calcareous. Then comes a layer of conglomerate made up of green and brown flint pebbles, varying from the size of a walnut to eight inches in diameter. Associated with these pebbles are geodes of quartz, some of which contain calcite.

The best section of all the beds exposed in Spring Cañon is obtained in the center of the cañon at the point marked in Fig. 26 by the dotted line S. We commence at the top of the hill, which rises 1,160 feet above the level of the creek. The first bed we notice is a highly metamorphic-looking quartzite, which crops out along the summit of the hill. Its general color is a dull red, passing in places into a dull purple and again becoming light gray, with bright red and yellow streaks. Some of them have an almost flinty fracture. We estimated the thickness of the beds at 50 feet. Next below these beds are quartzites and light gray sandstones followed by conglomerates, in the lower layers of which the pebbles are very fine. The conglomerates are followed by brown limestones and sandstones, the weathering of which gives a red tinge to the soil. These beds are succeeded by fine, dark-gray calcareous sandstones, which break into laminæ of from two to four inches thickness. Next to these are the coarse-grained fossiliferous sandstones that I have referred to above, (layer No. 7 in the section,) containing fragments of *Ostrea* and *Camptonectes*. They might almost be called siliceous limestones from the amount of lime they contain, but they are made up of coarse grains of sand and more properly deserve the name of sandstones. Interlaminated with them are light-brown shale-like sandstones, which are quite soft and break into numerous laminæ. The layers of this sandstone vary in thickness from a few inches to eight feet. Just below these beds are very coarse-grained limestones. The thickness from the bottom of these limestones to the top of the light-gray sandstones mentioned above is 260 feet. The coarse limestones are followed by fine-grained compact limestones, the weathered surfaces of which are white. These pass by gradations into bluish argillaceous shales, containing a large percentage of lime, (layer No. 11 in the section.) These shales weather of a white color and contain the following fossils: *Trigonia Americanus*, *Pinna*, *Camptonectes*, and *Modiola*, proving their Jurassic age. They are very fine-grained and separate into laminæ of half an inch to two inches thickness. They are very brittle also, and break readily, the plane of cleavage being at right angles to the plane of deposit. The angle of dip of these beds is 20°. The distance from the bottom of these layers to the top of the compact limstone is 100 feet. All the above beds to the conglomerates are probably Jurassic, while those above are Cretaceous. Next below the limestones are five feet of yellowish-brown sandstone, followed by a bed of quartzite containing veins of quartz and calcite in geodes, from which I obtained large crystals of calcite of the variety known as dog-tooth spar. The lower portion of this bed, which is about ten feet thick, is very irregular in composition, seeming to have been deposited in rough waters. It is succeeded by four feet of very compact quartzite, which in turn is followed by a pebbly conglomerate of two feet. Next comes eight feet of quartzite succeeded by alternate beds of quartzite and limestone, the thickness of the whole being 110 feet. Next come 30 feet of red sandstones, which are probably Jurassic, although not even a trace of any fossils can be found in them to prove it. The upper layers of these red beds contain lime, the percentage of which decreases as we descend. The angle of the dip is about 25°. The succession of these beds is shown in the section given below. Below the red beds are immense beds of carboniferous limestone, reaching to the bed of the creek, a distance of 435 feet. The upper layers of this limestone are arenaceous. The force that caused the tipping up of the strata in Spring Cañon was some distance to the south and was dying away at this end of the range, so that the older beds were not elevated sufficiently to be exposed to the action of the stream and are therefore not shown. The carboniferous beds are crushed together in a confused mass, and it is difficult to get at the true dip. The creek cutting through them has left huge masses standing out on the sides, resembling castles, towers, &c.

The following section, corresponding with Fig. 27, will perhaps show the succession of the beds more clearly. The thicknesses are estimated. The section is in descending order.

	Thickness in feet.
1. Red, purple, and gray metamorphosed sandstones	50 (1–2)
2. Brown limestone	
3. Gray sandstones	175 (3–4)
4. Conglomerates	
5. Brown limestone and interlaminate sandstones	360 (5–11)
6. Gray sandstone	
7. Coarse calcareous fossiliferous sandstone	
8. With interlaminated shaly sandstones	
9. Coarse limestone	
10. Compact limestone	
11. Shaly argilaccous limestone	
12. Yellow-brown sandstone	5
13. Quartzite with veins of calcite	10

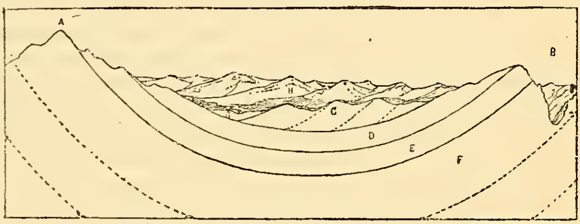
	Thickness in feet.
14. Compact quartzite	4
15. Conglomerate	2
16. Yellow limestone	3
17. Cherty limestone	15
18. Quartzite	5
19. Limestone	20
20. Calcareous sandstone	4
21. Limestone	4
22. Sandstone	15
23. Quartzite	15
24. Yellow calcareous sandstone	5
25. Red sandstone	5
26. Purple and greenish sandstone	2
27. Spotted purple sandstone	4
28. Brick-red sandstone	4
29. Purple sandstone	3
30. Greenish-white quartzite	2
31. Purple sandstone	5
32. Arenaceous limestone 33. Limestone	435

Outside of the quartzite bed, with which I have headed the above section, there is a succession of beds of hard quartzites and conglomerates followed by soft sandstones of steel-gray colors. Just below these sandstones, which are Cretaceous, there is a layer of hard, green shale containing fossils. Outside of them there occurs a bed of limestone. All these beds curve around the Spring Cañon layers, to which they seem to be conformable. Above the Cretaceous beds there is an immense thickness of brown and dark-gray Tertiary sandstones, (Eocene,) containing beds of coal. They also follow the curve of the Cretaceous beds and are seemingly conformable to them. They extend for four or five miles.

About five miles north of Spring Cañon there is a range, the Bridger Range, the trend of which is north and south. I shall here refer only to the southern end and western side of this range, reserving any further consideration of it to a subsequent chapter. Near the southern end of the range there is quite a high peak known as Bridger's Peak, which is 9,000 feet above the sea. The crest of the range is made up of Carboniferous limestone, dipping southeast, containing *Hemipronites crenestria*, *Productus longispinus*. Then follows a succession of beds as we found them in Spring Cañon. Following these, and still dipping southeast, are the Cretaceous beds that we noticed outside of Spring Cañon. In a layer of hard, green shales I found *Gryphæa*, *Avicula*, *Pinna*, *Inoceramus*, *Turritella*, *Crassatella*, &c., proving their undoubted Cretaceous age. Next we find the Tertiary sandstones, which are unconformable to the Bridger layers. There is therefore between Spring Cañon and the Bridger Range a synclinal valley the floor of which is Cretaceous, filled in with the Tertiary sandstones, dipping northwest, north, and northeast at an average angle of 40°. Many of these sandstones are calcareous and contain veins of calcite. The thickness of these beds must exceed 1,000 feet, and from the specimens of fossil-plants found in them they are for the most part Eocene. Some of the upper layers may be of Miocene age.

Opposite Fort Ellis, between our camp and Bridger Peak, there are bluffs composed of Pliocene sandstones, marls, and conglomerates. The strata are for the most part horizontal, although inclining sometimes at a very small angle, which is never more than 5°. The height of these bluffs above the level of the creek is 175 feet. They are the remnants of Pliocene formations that once spread over the entire valley of the Gallatin, and formed the bottom of a vast lake that spread over what are now the valleys of the Jefferson, Madison, and Gallatin Rivers, reaching to the junction of the three streams. The hills between the Gallatin and Madison, and between the Madison and Jefferson, are Pliocene, remnants of the same beds, and when we ascend the mountains on the southern border of this old lake-basin the whole plan lies spread out before us. Each of the rivers has cut deeply into these Pliocene rocks, and their valleys are the results of the erosion that has taken place since the draining of the ancient lake. The question of priority of elevation of the Bridger Range, and that into which Spring Cañon is cut, is one of some interest. That there has been more than one force at work to give the surface its present configuration is evident. The question is, whether or not they acted synchronously. The forces that elevated the layers of Spring Cañon and those of Bridger were, I take it, entirely distinct from each other and separated by long periods of time. The Bridger Range was the first to be elevated, and its elevation occurred probably about the end of the Cretaceous period, and before the beginning of the Eocene, while the range running south from Spring Cañon was elevated some time after the Eocene and prior to the deposition of the Pliocene strata. This is proved by the fact that the Cretaceous rocks on one side of the valley are conformable to the Bridger Range and on the other side to the Spring Cañon layers, while the Eocene rocks are conformable only to the latter, and the Pliocene rocks have been affected by neither range. I believe also that the elevation of the Bridger Range was the more gradual of the two. The elevation of the Spring Cañon layers was due to volcanic action, the center of which lies to the south. There have been several periods of eruption, for in the valley of the Yellowstone River we find Pliocene sandstones and marl capped by basaltic plateaus, while at Fort Ellis there is nothing of the kind, and we will see in a subsequent chapter that, some distance farther south, we find Eocene beds lifted high up on the mountains. The section shown in Fig. 27*a* will give the relations of the beds between Spring Cañon and Bridger Peak.

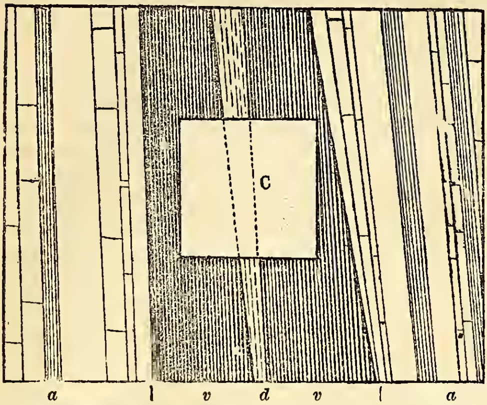
Fig. 27a.



SECTION FROM SPRING CAÑON TO BRIDGER PEAK.
A, Bridger Peak; B, Spring Cañon; C, Tertiary; D, Cretaceous; E, Jurassic; F, Carboniferous; G, Drift; H, Tertiary hills.

I have referred above to the occurrence of coal near Fort Ellis. The only rocks in which I noticed it were those of Eocene age. At only one point has there ever been any mining attempted. This one point is east of Spring Cañon, about four miles southeast of Fort Ellis. Coal was discovered here in 1867 by two blacksmiths, of Bozeman. Colonel J. D. Chestnut, hearing of the discovery, offered to furnish provisions to get men to work into the bed, if they would give him a share. This they did, and afterward left him sole owner of the claim, which includes one hundred and sixty acres. Fig. 28 is a section of the coal bed, C showing the opening into it. The shaft penetrates the bed in a horizontal direction, and has reached a depth of 250 feet from the entrance. The width of the shaft is 14 feet at the widest part. The bed of coal is considerably wider, and dips north 50° east; angle, 80°. On each side of the coal there are beds of bluish argillaceous sandstones, which are followed by coarse, gray sandstones. When the bed was first opened there were several seams of clay in it, but as the shaft penetrated deeper they gradually thinned out, and at present there is only one in the center of the coal, having a thickness of about twelve inches. The coal is a lignite, and is well adapted for blacksmiths' purposes. It is used, I believe, by blacksmiths of Bozeman, who like it very much. Some of the coal was taken to Helena, and is said to have yielded five cubic feet of gas to the pound. As the shaft goes deeper the quality of the coal seems to improve. Up to the present time there has been but little demand for coal. One reason of this, perhaps, is the abundance of timber in the mountains near Bozeman, and another reason, perhaps, is that hitherto there have been few facilities for transportation, the road through Spring Cañon having only lately been completed. There is but little doubt, however, that ultimately this coal will be extensively used. When the Northern Pacific Railroad is built through this region the utility of the coal-beds near Fort Ellis will become more and more apparent.

Fig. 28.



a a, Sandstone; *v v*, Coal; *d*, Seam of clay; C, Opening into coal.

I have made the following analysis of the coal. No. 1 is a poor specimen, No. 2 medium, and No. 3 the best. The coal is black, (brown in powder,) has a high luster, irregular fracture, specific gravity. The coke is moderately good, and has a high luster:

Analysis No. 1.

	Per cent.
Water	6.00
Volatile matters	32.90
Coke	44.10
Ash	17.00
	100.00

Analysis No. 2.

	Per cent.
Water	3.00
Volatile matters	41.50
Coke	43.50
Ash	12.00
	100.00

Analysis No. 3.

	Per cent.
Water	7.00
Volatile matters	34.50
Coke	50.50
Ash, (white)	8.00
	100.00

For purposes of comparison I insert here analyses of coal from Utah:

Analysis of coal from Evanston, Utah, (mine of the Rocky Mountain Coal and Iron Company.)

	Per cent.
Water	7.00
Volatile matters	42.00
Carbon	45.00
Ash, (reddish)	6.00
	100.00

Average of three analyses of coal from Evanston, Utah, by Persifor Fraser, jr., and F. Platt, esq., (United States Geological Survey of Wyoming, 1870, *page* 184.)

	Per cent.
Water	5.83
Volatile substances	37.40
Ash	7.46
Fixed carbon	49.50
	100.19

The following is an analysis of coal from the mine of Buel & Bateman, at Coalville, Utah Territory. This was formerly called Sprigg's mine:

Analysis.

	Per cent.
Water	6.50
Volatile substances	41.70
Carbon	44.80
Ash	7.00
	100.00

Analysis of specimen, from the same mine, by Persifor Fraser, jr., (United States Geological Survey of Wyoming, page 183.)

	Per cent.
Water and volatile substances	50.80
Ash	3.60
Fixed carbon	45.60
	100.00

About a mile or two south of Spring Cañon I visited a second cañon which another branch of the Gallatin has cut in the range. The general direction of the stream in this cañon is north 75° east. The exposure of the Upper Cretaceous beds is perhaps better here than in Spring Cañon. The first exposure is a bed of white crystalline limestone, dipping south 50° west; angle, 50°. This limestone is followed by red and yellow sandstones, which are themselves succeeded by a bed of brown limestone, weathering bright yellow. These occupy between one and two hundred feet. Then follow the soft, gray sandstones that I noticed near Spring Cañon and Bridger Peak. They continue for about half a mile, when we come to Jurassic rocks, the first bed of which we recognize as one of the Spring Cañon layers. It dips south 40° west; angle, 85°. It is followed by the same beds we saw in Spring Cañon. They are in fact only a continuation of the same. The Carboniferous limestones form the center of the ridge, the outer layers on either side dipping in opposite directions, on the eastern side dipping northeast and those on the western side southwest. The general strike is south 30° east. The exposures in the cañon were very fine, but I found nothing differing from what I have described in Spring Cañon.

On the 13th of July I started on a trip to Mystic Lake, about twelve miles nearly south from Fort Ellis. After a pleasant ride over the grassy plain that slopes gently from the mountain's edge we began to ascend and soon found ourselves entangled in a mass of dead and fallen timber. After considerable trouble we reached the summit of the hill to find that we had to descend again on the opposite side. The hills are so covered with vegetation and *debris* that the character of its rocks cannot be made out certainly. High up on the sides, however, there are small exposures of limestones and sandstones, and it is probable that the valley is underlaid by Cretaceous formations. What their exact relation is to the ridge running south from Spring Cañon it is rather difficult to determine, though it is probable that the trail runs through a synclinal valley on one side of which lies the Spring Cañon Ridge.

The trail leads us now through pine-forests and anon across beautiful little valleys, each a garden of wild flowers. At last, after crossing several ridges, we reach the lake. Mystic Lake is the head of Boseman Creek, one of the branches of the East Gallatin River. Near it, on a level fully one hundred feet higher, are two exquisitely beautiful lakes, whose beauty is half hid by the trees fringing their banks. One of them we named Emerald Lake, from the deep-green tint of its waters.

The valley in which these lakes are situated is synclinal, one side being the continuation of the Spring Cañon Ridge and the other a spur running south from Mount Ellis. Opposite the lake, to the southeast, there is a volcanic range, at the base of which we find the Spring Cañon layers, having a general dip to the southwest. The other side of the synclinal cuts obliquely across the lower end of Mystic Lake, the strata dipping north 40° east; angle, 50°–60°. At present the lake is about three-fourths of a mile in length and about one-fourth of a mile wide. It once extended farther up the valley and lay in a saucer-like depression. From the gradual elevation of the valley or some other cause, as the draining of the lake by the erosion caused by its outlet, at present it occupies the lower end of the valley, lying on the edges of the Cretaceous, Jurassic, and Carboniferous strata.

The course of the stream of which Mystic Lake is an expansion is about south 20° west, making an angle of about 60° with the strike of the strata. On the western shore of the lake there are exposures of Jurassic sandstones and limestones precisely like those of Spring Cañon, and in which occur *Ostrea* and *Camptonectes*. Below the Jurassic come immense beds of quartzites and limestones, the upper layers of which are undoubtedly Carboniferous, containing *Productus longispinus*, *Spirifer lineata*, *Hemipronites crenestria*, *Productus scabriculus*, *Zaphrentis*, &c. The thickness of these beds is over 2,000 feet, and the lower strata should probably be referred to a lower geological horizon than the Carboniferous. As we go south the strata turn more and more toward the west. As we go toward the north we find Mount Ellis, the extreme northern end of the spur or ridge. The elevation of Mount Ellis is 8,419 feet above the sea. It is composed mainly of Carboniferous limestones, while to the west and at the base are gneissic rocks. The elevation of this ridge was probably contemporaneous with that of the Bridger Range, as its formation seems to be similar. As we follow the ridge southward it curves until the trend is almost east and west. It probably once formed a portion of the southern shore of the ancient lake, as the Bridger Range did part of the eastern shore, while Mount Ellis and Bridger Peak may have been promontories projecting into it. The action of volcanic forces within a very short distance, however, has complicated matters to such an extent that any opinion must be conjectural, and future careful study will be required to prove or disprove. The elevation of the lake above sea-level is 6,468 feet, which is 1,533 feet higher than the elevation of our camp at Fort Ellis. The synclinal valley, which I referred to above, has no later rocks than the Cretaceous. Why there should be no Tertiary beds here is perhaps a little difficult to understand. That there have never been any is evident, or there would be some remnant or trace of them left. Erosion could scarcely have removed all without some trace being left. Moreover, this is not a valley caused by erosion. Perhaps the elevation of this point, which may have been greater in the past, precluded the possibility of the Tertiary beds reaching this point.

Bozeman Creek, leaving Mystic Lake, flows at first a little west of south, and turning flows more toward the west, until finally it flows in a northwesterly direction. At first it cuts its way in a deep gorge almost at right angles to the strata, over which it rushes in a series of cascades half hidden by the overhanging vines and brush. Within a quarter of a mile it falls about five hundred feet. Just below the lake it is joined by a stream coming in from the left. It heads at the base of the volcanic range, which lies to the east of Mystic Lake. Following the course of this creek there is a bed of volcanic breccia which has flowed from the head of the valley. It is composed of sharp angular fragments of basalt, varying in size from three inches to a foot. The prevailing colors are black and a brick red. The cementing material of this breccia seems to contain fragments of sandstone like those seen in the Eocene beds. The belt covered by this bed of breccia is not over a quarter of a mile in width.

The minerals I obtained while at Fort Ellis are as follows, viz: rhomb-spar, dog-tooth spar, quartz, agate, red and yellow jasper, and coal.

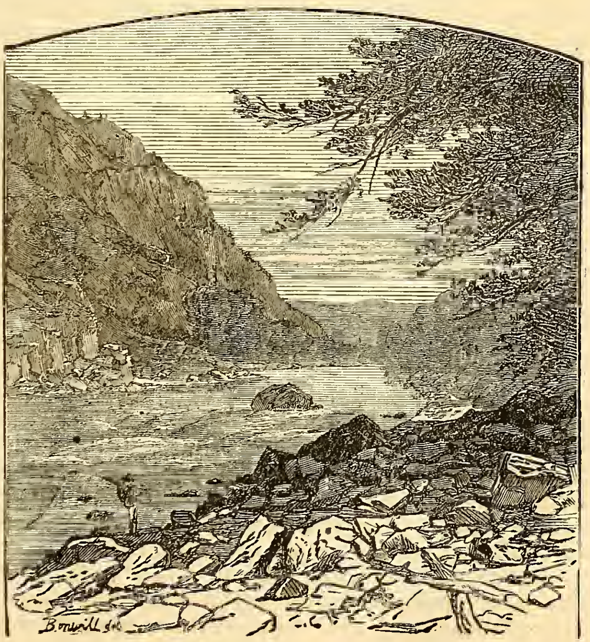
We left Fort Ellis on the 20th of July and started for the valley of the Yellowstone. For about three miles our course was in an easterly direction, when we turned toward the southeast and followed one of the branches of Mill Creek, the stream that flows through Spring Cañon. Our road led us over Tertiary sandstones. Camp No. 2 was in a monoclinal valley, near the head of Mill Creek. The hills on the east side of the valley were Tertiary, while those on the west, dipping in the same direction, were Cretaceous. The former were about 400 feet high and composed of sandstones, the texture of which varied, some of the layers being quite soft, while others were very hard, seeming to have been metamorphosed. Many of them contained impressions of deciduous leaves, which Professor Lesquereux has determined to be Eocene. Among them he found *Platanus aceroides*, *Fagus antipofi*, *Salisburia polymorpha*, *Juglans denticulata, and Gymnogramma Haydenii.* He says, "The most interesting discovery is that of *Salisburia polymorpha*, described from Evan's specimens of Vancouvers Island, a long time ago." This would indicate a correspondence in the Tertiary flora of the Pacific coast, and that on the east side of the Rocky Mountain divide as at present constituted, and thus points to the modern elevation of the range. Mr. Meek finds also a correspondence in the Cretaceous shells of the two localities referred to, and says also that they do not correspond to the forms found farther east, which would lead us to suppose that at the period of their deposition the divide of the Rocky Mountain must have been more to the eastward of the present divide. One of the layers containing the best fossils showed a plane of cleavage that was oblique to the plane of deposit, rendering it extremely difficult to get perfect specimens. The color of these sandstones was mostly a gray, passing in places into a greenish tint. Intercalated with them were some beds of basalt, which was probably the cause of the metamorphism observed. In climbing over these hills I found numerous indications of coal-beds, one of which was just above our camp. There was no outcrop visible, but a prairie-dog in burrowing had penetrated the bed, and revealed its presence by the coal he had dug out. On the 21st I visited the hills west of camp. The first ridge was 416 feet above the level of the creek, and composed of gray and green sandstones contain ing *Inoceramus* and other Cretaceous fossils. The dip of these strata is 50° northeast; angle of inclination, 65°. The layers between this ridge and the Eocene on the opposite side of the valley, having been soft sandstones, have been washed away to form the bed of the stream. From this first ridge I ascended to the next, still higher, but parallel to the first. The first strata were light-gray sandstones, very much metamorphosed. These beds, which I take to be of Cretaceous age, continued for about half a mile, and were followed by 50 feet of coarse, reddish sandstones, the lower layers of which were conglomerate. Next came a layer of very hard sandstone containing fragments of fossils. This was about 10 feet in thickness, and is followed by 30 feet of white quartzite. The summit of this ridge is 818 feet above the valley and 402 feet above the top of the first ridge. I followed it until the timber obstructed my passage, and I returned to the valley. These beds are a continuation of those exposed at Spring Cañon, and are underlaid by the Jurassic and Carboniferous. Our course on the 21st was up the valley to its head, when we crossed the divide to Trail Creek, a tributary of the Yellowstone River, which we followed and camped in the valley of the Yellowstone. This divide is 5,821 feet above the sea. The strata here have been so leveled and covered with *débris* and vegetation that it becomes very difficult to trace the various beds. It is probable, however, that they curve toward the east and cross the valley, for a few miles after leaving the divide there is on the left-hand side of the road an exposure of Carboniferous limestones dipping a little east of north. On the right hand, a few miles to the south and west, there are numerous volcanic peaks, their sharp, jagged edges standing out boldly against the sky. As we neared the valley of the Yellowstone, we came to a bed of volcanic breccia, resembling that at Mystic Lake and originating evidently in the same center of eruption. Trail Creek has cut through this breccia, leaving a high butte standing on the left bank of the creek a few miles from its mouth. The top of this butte seems to be composed of compact rock. A few miles from the divide on Trail Creek there are coal-beds, none of which, however, have ever been mined.

Camp No. 3 was in the Yellowstone Valley, on Eight-Mile Creek, a few miles from its junction with the river. The valley of the Yellowstone is filled with Pliocene deposits of about 150 feet thickness, on top of which there are horizontal beds of basalt, which once probably extended over the whole valley, forming an immense plateau through which the river has cut its bed, removing immense quantities of material. The basalt is covered with local drift from the mountains. The foot-hills on the western side of the valley are composed of volcanic breccia. There has evidently been more than one period of eruption, for farther up the valley there are several layers of basalt, between which there are Pliocene sandstones. The columnar form is beautifully shown in many places throughout the valley.

From Camp No. 3 I ascended the foot-hills which lie to the west, bordering the Yellowstone Valley. These hills rise about 3,000 feet above the level of the river. Proceeding three miles from the river we reached the base of the hills and found the lower ones composed almost entirely of breccia, while farther back we find laminated trachytes, which are inclined at an angle of about 40°, as though the lava had been poured forth in successive layers and, after cooling, had been tipped up by subsequent volcanic action. It is probable that under this volcanic mass we would find all the sedimentary rocks, from the Cretaceous to the Carboniferous or even lower. A few miles from the river, where the small streams have cut deeply into the hills, we find rocks containing Cretaceous fossils. Farther up, however, the volcanic rocks conceal all the underlying formations.

Our next camp, No. 4, was some eight or ten miles farther up the valley, on a basaltic plateau near Bottler's ranch. The general elevation of this plateau above the river is between 100 and 200 feet. Near Bottler's there are several good exhibitions of basaltic columns, and on the opposite side of the river the underlying marls and white sandstones. A few miles west of Bottler's we find ourselves in the midst of volcanic rocks of all kinds and colors, basalts predominating. The prevailing color of these rocks is a brick-red and dull purple. Scattered over the hills, as well as throughout the entire valley of the Yellowstone, we find chips of black obsidian, chalcedony, agate, and jasper. I got some very good specimens of red jasper associated with blue chalcedony, and also specimens of olivine from the basalt.

Fig. 29.



SECOND CAÑON OF YELLOWSTONE RIVER.

We left Bottler's on the 24th, and started up the valley, camping in the afternoon (Camp No. 5) on Cañon Creek, eleven miles above Bottler's. Cañon Creek joins the Yellowstone just after the latter has emerged from the second cañon. (Fig. 29.) The rocks of the second cañon are all gneissic, and as I described them in the report for 1871, I will pass them here. Between Bottler's and the second cañon the trail leads us along the western side of the Yellowstone, being part of the way at a considerable height above the river on bluffs of volcanic breccia. The prevailing color of this breccia is a gray, but the included masses have an almost infinite variety of color, green, purple, and red masses being abundant.

On the 24th of July, in company with Messrs. Wakefield and Savage of the expedition, I started up Cañon Creek from camp No. 5 with the intention of crossing the hills west of the second cañon and striking the Yellowstone River near Cinnabar Mountain, where the party expected to camp. The valley of Cañon Creek is quite wide and well watered, there being several small lakes bordering it. We followed the course of the stream but a short distance, when we struck up on the hills. The volcanic rocks here seem to be in contact with the gneisses. Scattered among the volcanic rocks I found silicified wood in abundance. After a long and arduous climb over the lower hills we reached a long ridge of volcanic breccia, which seemed to be a spur of the main ridge, and to the summit of which it led. It projected from it at a right angle. So following it up we at last gained the top, and found ourselves on the edge of a precipice, which formed a portion of the opposite side of the ridge. Looking over the precipice we saw we were on the top of a blank vertical wall of over 2,000 feet in height. The elevation of the mountain we were on was 9,478 feet above sea-level and 4,377 feet above the camp (No. 5) we had just left. The view from the summit, however, repaid us well for our toilsome climb. To the south and west the entire country seemed to have been subjected to the most intense volcanic action, followed by an immense amount of erosion. Somber-colored ridges, with sharp, piercing peaks and conical crater-like points, with deep gorges between, testify to the former disturbances. All about us were deep banks of snow. In order to descend we were obliged to follow the ridge toward the north until we came to a spur projecting at right angles from it. This spur sloped gradually to the valley of Cinnabar Creek, a small stream tributary to the Yellowstone River. We descended on this spur to Cinnabar Creek, and then followed it around Cinnabar Mountain, reaching camp at night-fall. Cinnabar Mountain shows a patch of the sedimentary rocks that everywhere else near here seemed either to have been covered by the outflow of lava or to have been washed away. It is probable that both causes have operated. The northern portion of the mountain is made up of granitic rocks, a continuation of those seen in the second cañon. Upon these rocks rest quartzites, followed by limestones, the upper layers of which are undoubtedly Carboniferous. The limestones are followed by quartzites again. One ridge of this quartzite forms the northern wall of the Devil's Slide, while the southern wall is formed of a dike of dark-green porphyritic rock. This dike probably separates the Carboniferous from the Jurassic. Between these two almost vertical walls the softer material has been washed out. Adhering to the dike are pieces of a blue-clay slate, and following it we find Jurassic beds of slates and limestones containing *Myascites subcompressa*, *Pholadomya*, and *Camptonectes*. Next come Cretaceous beds, in which there are indications of coal, and containing *Scaphites*, *Ventricosa*, *Baculites*, *Ostrea*, *Inoceramus*, and *Trigonia*. All the beds I have mentioned above have a dip to the southwest and an inclition of from 50° to 80°. About a half mile above the Devil's Slide we find that the beds seem very much crushed together, and within a very short distance dip southwest, and are horizontal and dipping northeast. A visit to one of the high peaks in the neighborhood gave us a clew to this curious contortion of the strata.

On the morning of the 26th of July Messrs. Gannett, Brown, and myself started to make the ascent of the peak, which lay to the southwest of camp. Our way was up a long ridge, which seemed to us to lead to the summit of the peak. The rocks immediately beneath us were Cretaceous sandstones. On reaching the timber-line (9,442 feet above sea-level) we found we would have to finish the ascent on foot, as the slope became too steep for the horses. So dismounting we picketed them, and started for the summit. The sandstones over which we passed reach within 500 feet of the top, dipping to the northwest. The summit of the peak seemed to be made up of an immense pile of broken-up volcanic rock, (a rusty-gray trachyte.) When we were within about 500 feet of the top a storm came up, and we were enveloped in clouds. The ascent here was very difficult, as the fragments of rock were very sharp, and most of them loose, sliding from beneath us as we climbed over them. Mr. Gannett succeeded in attaining the highest point and depositing his instruments, when he discovered that he was in the midst of an electrical cloud, and his feelings not being of the most agreeable sort he retreated. As he neared us we observed that his hair was standing on end, as though he were on an electrical stool, and we could hear a series of snapping sounds, as though he were receiving the charges of a number of electrical frictional machines. Mr. Brown next tried to go up, but received a shock which deterred him. The cloud now began to settle about us, and we descended some 500 feet, and waited until the storm passed over. About 4 o'clock in the afternoon we succeeded in reaching the top, and Mr. Gannett found the altitude of the peak to be 10,992 feet above the sea. We named it Electric Peak. The eastern side is hollowed, and from the base two small creeks flow to join the Yellowstone. Between the peak and the Hot Springs, on Gardiner's River, there must have been a center of volcanic action, for the sedimentary beds opposite the springs dip in the opposite direction to that of the beds on the western side of Electric Peak, and the space between is filled with volcanic material, from which a cone-like mountain rises. This will also explain the crushing together of the strata above the Devil's Slide. Descending the peak after completing our observations we reached our horses about 6 o'clock in the evening, and soon were on the way toward camp, with, however, but little hope of reaching it that night, as the main party had started up the river in the morning after we left camp. After dark we camped on the banks of Cache Creek, some miles from the valley of the Yellowstone. The next day about noon we reached

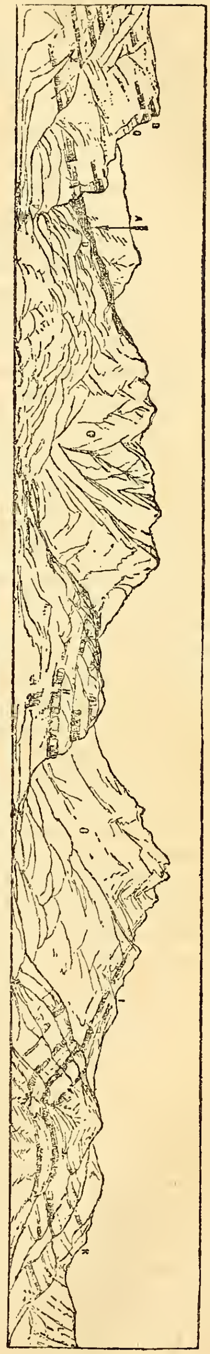


Fig. 30.

SECTION FROM GARDINER'S RIVER TO CINNIBAR MOUNTAIN.

A, Gardiner's Springs; B, Basalt; C, Cretaceous; D, Carboniferous; E, Jurassic; F, Gardiner's River; G G, Volcanic; H, Modern beds; I J K, Cretaceous; L, Devil's Slide.

camp at the Hot Springs, on Gardiner's River. Opposite the springs there is a high wall, which presents the edge of Cretaceous and Lower Tertiary strata for a vertical distance of nearly 2,000 feet. The river has cut its way through a sort of a monoclinal valley, resting on either Carboniferous or Jurassic beds, while on the east side of the river we have the Cretaceous beds I spoke of above. The lower layers are very calcareous, and contain thin beds of limestone, from which I obtained good specimens of calcite and Iceland or double-refracting spar. Near the forks of the river, about half a mile above the springs, we have exposures of lower beds, in which there are seams of earthy lignite, associated with which I observed selenite, coating some of the argillaceous sandstones. There is an exposure of this earthy lignite some four miles farther down the river, a continuation probably of the same beds. Near the top of the wall there are Tertiary beds intercalated with basalt. The topmost layer of the latter stretches away to the east in a broad plateau, and on the edge the columnar form is well shown. It probably once extended on both sides of the river, and came from a point west of the springs. All the beds mentioned above dip to the northeast at an angle which averages about 15°. The limestones which dip under Gardiner's River extend under the Hot Springs, and are probably the source of the lime observed in the waters and deposits. The section shown in Fig. 30 will perhaps show more clearly the relations of the various beds near the Hot Springs. The springs were so fully described in the report of last year (1871) that I will not take the room to describe them again, inasmuch as it would be a mere repetition. We spent two days in camp there this year, during which time I made a more complete record of the springs and their temperatures and noted the changes that have taken place since our last visit. Since then there have been a number of cabins and bath-houses erected, and notwithstanding the difficulties of reaching the springs there were about thirty persons there enjoying the benefits to be derived from drinking and bathing in the waters.

The top of the gorge in which the springs are situated is 1,285 feet above the level of the river. I will commence with the springs at the level of the river. These are seven in number, and remain about the same as they were last year, with the exception that some of them have been artificially enlarged. The temperatures here are lower than we find higher up, and the springs are filled with bright-green *Confervoidea*. The following table gives all the points of interest in regard to these springs:

Springs at the level of the river.

Time of observation, 8.30–8.40 a. m., July 29, 1872.—There was no perceptible gas given off.

No.	Size of spring.	Depth.	Temperature of air.	Temperature of spring.	Elevation above sea-level.
	Inches.	*Inches.*			*Feet.*
1	12x12	3	70° F.	104° F.	5,750
2	30x30	12	70	104	5,750
3	....	....	70	111	5,750
4	24x24	....	70	114	5,750
5	Artificially enlarged.	....	70	112	5,750
6		....	70	94	5,750
7		....	70	132	5,750

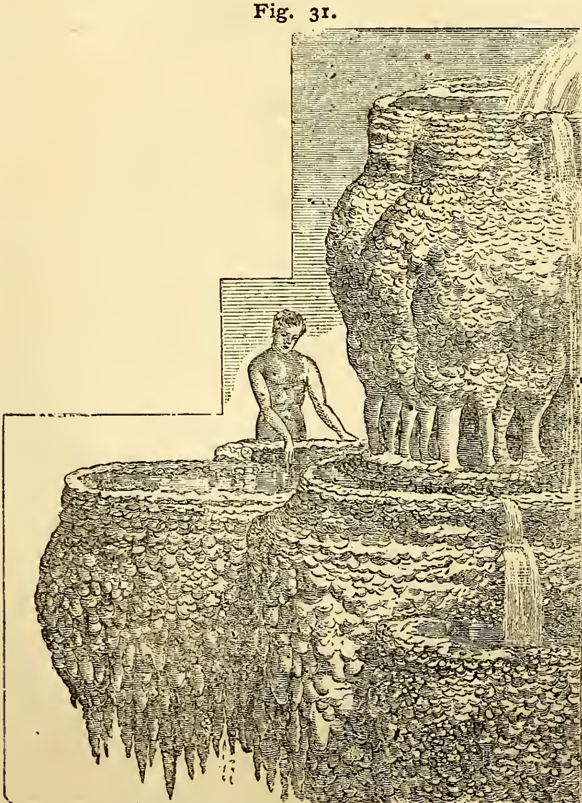
As we go from the river up the hill toward the main springs we meet with a large pool of hot water of about 100 feet diameter. It is 230 feet above the level of the river, and on its edge there are several springs. Of two I took the temperatures, and found them both to be 140° F., the temperature of the air being 65° F. and the time of observation 8 a. m. A short distance farther up we came to the main mass of springs, arranged on a series of terraces at different levels. The first terrace is 528 feet above the level of the river. The principal springs are on the first ten terraces, and as we go up the valley we find that, although there were once many springs here of a most active character, at the present time they have nearly all died out. The first four or five have the hottest springs. The boiling-point at these springs varies from 199°.5 to 200°.9. I give the temperatures, &c., below in tabular form. The observations were all made on the 28th of July.

Number.	Position of spring.	Time of observation.	Size.	Depth.	Gas given off.	Temperature of air in Fahrenheit.	Temperature of spring in Fahrenheit.	Elevation above sea in feet.
						°	°	
1	First terrace...	8.40 a.m.	5 ft. × 7 ft.......	6 in.	Sulphuretted hydrogen	70	150	6,278
2	....do	8.40 a.m.	Fissure of 30 ft..	......	......do	70	152	6,278
3	....do	8.40 a.m.	Fissure of 14 ft..	......	......do	70	160	6,278
4	....do	8.40 a.m.	Fissure of 6 ft..	......	......do	70	158	6,278
5	Second terrace..	9.00 a.m.	20 in. × 20 in....	12 in.	......do	69	144	6,304
6	....do	9.10 a.m.	15 in. × 35 in....	12 in.	......do	69	162	6,304
7	....do	9.20 a.m.	40 in. × 50 in....	16 in.	......do	69	162	6,304
8	Fourth terrace..	9.25 a.m.	29 in. × 20 in....	36 in.	......do	72	152	6,412
9	Fifth terrace....	9.30 a.m.	50 in. × 60 in....	24 in.	......do	74	152	6,465
10	Sixth terrace ...	12.30 p.m.	....	......	......do	80.5	150	6,491
11	....do	12.30 p.m.	....	......	......do	80, 5	148	6,491
12	....do	12.30 p.m.	....	......	......do	80.5	148	6,491
13	....do	12.30 p.m.	....	......	......do	80.5	142	6,491
14	....do	12.30 p.m.	....	......	......do	80.5	152	6,491
15	....do	12.30 p.m.	....	......	......do	80.5	148	6,491
16	....do	12.30 p.m.	....	......	......do	80.5	152	6,491
17	....do	12.30 p.m.	....	......	......do	80.5	152	6,491
18	Seventh terrace.	10.00 a.m.	150 ft. × 70 ft ...	10 ft.	Carbonic acid	72	150	6,551
19	....do	10.00 a.m.	100 ft. × 50 ft ...	10 ft.	Sulphuretted hydrogen	72	154	6,551
20	Eighth terrace...	9.45 a.m.	9 ft. × 13 ft	3 ft.	......do	72	122	6,556
21	Ninth terrace....	10.10 a.m.	20 in. × 2 in......	6 in.	......do	74	157	6,591
22	....do	10.12 a.m.	100 ft. × 25 ft....	5 ft.	......do	74	162	6,591
23	....do	10.14 a.m.	4 ft × 7 ft	18 in.	......do	74	162	6,591
24	....do	10.14 a.m.	2 ft. × 3 ft	3 ft.	......do	74	162	6,591
25	....do	10.15 a.m.	2 ft. × 3 ft	1 ft.	......do	74	162	6,591
26	....do	10.15 a.m.	2 ft. × 3 ft	6 in.	......do	74	162	6,591
27	Tenth terrace...	10.30 a.m.	2 ft. × 3 ft	1 ft.	......do	74	120	6,596
28	....do	10.30 a.m.	3 ft. × 3 ft	6 in.	......do	74	162	6,596
29	Eleventh terrace.	10.35 a.m.	6 in. × 6 in.......	7 in.	......do	74.5	154	6,603
30	....do	10.40 a.m.	6 in. × 2 in.......	6 in.	......do	74.5	148	6,603
31	....do	10.40 a.m.	10 in. × 12 in....	5 in.	......do	74.5	150	6,603
32	Twelfth terrace.	12.20 p.m.	....	......	......do	78.5	160	6,681
33	....do	12.20 p.m.	....	......	......do	78.5	162	6,681
34	....do	12.20 p.m.	....	......	......do	78.5	160	6,681
35	....do	12.25 p.m.	....	......	......do	78.5	162	6,681
36	....do	12.25 p.m.	....	......	......do	78.5	160	6,681
37	....do	12.26 p.m.	....	......	......do	78.5	162	6,681
38	....do	12.26 p.m.	....	......	......do	78.5	160	6,681
39	....do	12.28 p.m.	....	......	......do	78.5	160	6,681
40	Thirteenth terrace.	11.00 a.m.		......	......do	78	142	6,758
41	....do	11.00 a.m.	Fissure of 3 ft..	......	......do	78	140	6,758
42	....do	11.00 a.m.		......	......do	78	142	6,758
43	....do	11.00 a.m.		......	......do	78	142	6,758
44	....do	11.00 a.m.		......	......do	78.	108	6,758
45	....do	11.00 a.m.	Geyser-like tubes.	......	......do	78	130	6,758
46	....do	11.00 a.m.		......	......do	78	144	6,758
47	....do	11.00 a.m.		......	......do	78	144	6,758

Number.	Position of spring.	Time of observation.	Size.	Depth.	Gas given off.	Temperature of air in Fahrenheit.	Temperature of spring in Fahrenheit.	Elevation above sea in feet.
48	....do	12. 05 p. m.	Geyser-like tubes on mounds.	......	......do	78	148	6, 758
49	....do	12. 05 p. m.		......	......do	78	146	6, 758
50	....do	12. 07 p. m.		......	......do	78	130	6, 758
51	....do	12. 07 p. m.		......	......do	78	140	6, 758
52	....do	12. 10 p. m.		......	......do	78	140	6, 758
53	....do	12. 10 p. m.		......	......do	78	142	6, 758
54	Fourtee'h terrace	11. 11 a. m.	12 in. × 12 in....	8 in.	Carbonie acid.........	74	96	6, 779
55	....do	11. 11 a. m.	3 in. × 4 in......	12 in.	......do	74	92	6, 779
56	....do	11. 12 a. m.	6 in. × 6 in......	4 in.	......do	74	108	6, 779
57	....do	11. 12 a. m.	1 ft. × 2 ft	4 in.	......do	74	102	6, 779
58	....do	11. 13 a. m.	1 ft. × 1½ ft......	2 in.	......do	74	110	6, 779
59	....do	11. 13 a. m.	8 ft. × 3 ft	3 ft.	......do	74	112	6, 779
60	....do	11. 15 a. m.	4 ft. × 3 ft	2 ft.	Sulphuretted hydrogen	74	108	6, 779
61	....do	11. 40 a. m.	Fissure 60 feet long.	......	......do	74	145	6, 779
62	....do	11. 40 a. m.		......	......do	74	145	6, 779
63	....do	11. 40 a. m.		......	......do	74	140	6, 779
64	....do	11. 45 a. m		......	......do	74	130	6, 779
65	....do	11. 50 a. m.		......	......do	74	116	6, 779
66	....do	11. 50 a. m.	Fissure 54 feet long.	......	......do	74	118	6, 779
67	....do	11. 50 a. m.		......	......do	74	120	6, 779

The elevation of the ridge just above the fourteenth terrace is 7,035 feet.

Fig. 31.



BASINS OF HOT SPRINGS AT GARDINER'S RIVER, YELLOWSTONE NATIONAL PARK.

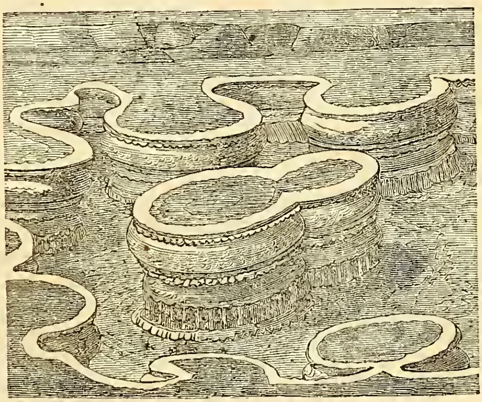
The greatest change in the springs was noticed on the ninth and twelfth terraces. The former in 1871 was almost entirely covered with water, through which the various springs could be noted by the points of ebullition. It was impossible to walk anywhere but around the edge. Now, however, the most of the water has disappeared, and only the springs remain, and one can walk almost anywhere on the terrace. On the twelfth terrace there are a great many new springs, all of which have a high temperature. Carbonic-acid gas can be detected in the springs of the fourteenth terrace by the taste. These springs are hid in the grass, and it is only by careful searching that they are found.

Dr. Endlich has made the following analysis of the deposits from these springs:

	Per cent
Loss at 110° C.... 1.75 per cent. } Loss at ignition.. 30.35 per cent. }	32.10
Lime	57.70
Silica	3.32
Ferric oxyd	3.62
Alumina	3.31
Magnesia	Trace.
Soda*	Trace.
	100.05

Figures 31 and 32, drawn by Mr. Holmes, will perhaps give the reader a good idea of some of the peculiar formations noticed at these springs. Fig. 31 shows the pools or basins which were so fully described by Dr. Hayden in the report for 1871, and which form one of the most beautiful features of the springs. The water in all of them is either warm or hot according to their position, the lower ones having the coolest water. The water has also that exquisitely beautiful blue tint which is beyond description, and which forms such handsome contrasts to the white, marble-like basins in which it is. The water pours from one basin to another and forms stalactitic processes, which hang from their sides as seen in the picture. At the bottom of the upper basin in the illustration the processes have united with those formed from below by the dropping of the water, while in the lower basin they have not yet come together, but still form true stalactitic processes. Over the outside surfaces of the basins we find also bead-like processes, caused also by the dropping of the water. The great amount of lime in these deposits gives them a beautiful white appearance.

Fig. 32.



ORNAMENTAL RIM OF EXTINCT SPRING, GARDINER'S RIVER.

CHAPTER III.

GARDINER'S RIVER TO MUD-VOLCANOES, YELLOWSTONE VALLEY.

We left the Hot Springs on the 29th of July and made our next camp on Black-Tail Deer Creek near the Yellowstone, a few miles above Gardiner's River. Our camp was on a portion of the plateau that extends eastward from the top of the bluff-wall opposite the springs. The rock immediately beneath us was a violet-colored trachyte containing crystals of sanidine. Between our camp and the Yellowstone River there were some exposures of Carboniferous limestone, evidently the direct

*By spectroscopic examination.

prolongation of the layers noticed in the last chapter as occurring at Cinnabar Mountain. Just below these outcroppings the river passes through the third cañon, the rocks of which are gneissic, upon which the limestones rest. On the west side of the river there are fine exposures of black micaceous gneiss, inclining southeast. On the opposite side there are three streams which cut their way to the river through the solid granite. About a mile east of camp I visited a butte of limestone which rose above the surrounding volcanic rock like a huge monument. The dip was southwest at an angle of about 50°. From these layers I obtained *hemipronites*, *spirifer*, and *rhynchonella*.

The following day we moved our camp to the Yellowstone and pitched our tents in a beautiful grassy valley on Elk Creek, about one mile from the Yellowstone River. About two miles above us the East Fork of the Yellowstone joined the main river. Our camp (No. 9) was 334 feet lower than the previous one, (No. 8.) The descent from the plateau was rather abrupt, and gave us a chance to see the structure of the Eocene beds, which were here composed of coarse, yellowish-brown sandstones, intercalated with basalt and trachyte. The sandstones in some places are conglomerate, and all are considerably metamorphosed. Some of the layers contained impressions of deciduous leaves, among which Professor Lesquereux has found *Platanus nobilis*, *Fagus antipofi*, and a new species described in his report. The volcanic rocks, mostly basaltic, contained a large percentage of iron, and, on weathering, presented a rusty appearance. In some I found green jasper and chalcedony. The valley of Elk Creek below our camp presented a curious appearance. The river and the small streams have cut their way deeply through the Tertiary beds, leaving table-like buttes standing between each one, being capped with a volcanic layer, the top of which is perfectly level. They are merely the remnants of layers that once extended over the entire valley. Beneath the volcanic layers the soft gray and brown sandstones have yielded readily to the action of the water, and the cañons are deep, with perpendicular walls.

The Tertiary beds seem to rest immediately on the gneissic rocks at this point, and before their deposition there was undoubtedly a great deal of erosion. The thickness of the Tertiary beds, including the volcanic layers, is about 400 feet. Throughout the valley in which we were camped there was an immense number of granite-bowlders of all sizes, which were evidently washed down the valley of the East Fork, for we find them strewn along that river for some distance above its junction with the Yellowstone. On the east side of the Yellowstone, near Hell Roaring Creek, there are some high granite mountains, and the entire surrounding country is very rugged and will some day form a most interesting field of study. Our time was too limited to attempt to penetrate it at all. Near the junction of the two forks of the Yellowstone there has been a bridge thrown across the main stream. Just at this point we find an exposure of granite. This passes into micaceous gneiss, which is overlaid by sandstones, on top of which there is a bed of conglomerate, made up mostly of volcanic fragments. Crossing the river we soon find ourselves surrounded with volcanic rocks. A short distance from the river there is an isolated table-like butte, rising 600 feet above the level of the river. It is capped with basalt of considerable thickness, beneath which are soft Tertiary sandstones. The floor of the butte is quite level, and is strewn with granite-bowlders. It is evidently only another remnant of the basaltic layer I have referred to above, which once extended over an immense area. As we proceed up the Yellowstone, it becomes thicker. Following the river we found that a short distance above the bridge it emerges from a deep cañon. At the lower end of this cañon there are a number of hot springs on the edge of the river. We could distinguish at least four. They were surrounded by a considerable deposit of sulphur and iron. They give off sulphuretted hydrogen abundantly. We were some 500 feet above them, and yet the surrounding air was strongly impregnated with it. It was impossible to reach the springs to take their temperatures. The cañon is about a mile in length, extending from the mouth of Tower Creek, opposite Tower Falls. It is one of the finest cañons I have ever seen. The walls are perpendicular and the river flowing below is a perfect torrent, of an emerald-green tint, capped with white foam. The fall of the river for 2½ miles is 229 feet. On the western side of the cañon the rocks have been weathered into towers, with sharp pinnacles, giving it a most picturesque appearance.

The height of the eastern wall is 346 feet above the level of the river opposite Tower Falls. At the lower end the height probably reaches 500 feet. This wall, from top to bottom, is composed as follows:

1. Soft, gray sandstone.	346 feet.
2. Columnar basalt.	
3. Conglomerate.	
4. Columnar basalt.	
5. Trachyte.	
6. Limestone (?).	

The layers of basalt mentioned above, Nos. 2 and 4, extend the length of the cañon and present the most regular hexagonal columns that I have ever seen anywhere in the West. It was impossible to obtain the exact measurements, but I should estimate those in layer No. 2 to be 15 feet in height, while those of No. 4 were probably between 20 and 30 feet. The conglomerate No. 3 was probably about 100 feet in thickness, and composed of large fragments of all kinds of rocks, the volcanic predominating. It was so infiltrated with sulphur that the whole bed had a bright-yellow color, especially noticeable at the upper end of the cañon. The sandstones on the top were very soft, and had weathered so as to give a rounded top to the wall. The general color of the trachyte was a violet, and it rested, I am inclined to think, on limestones, although on this point I am not quite certain. Above the cañon the Yellowstone River flows through quite a wide valley, which on one side is comparatively open and on the other side bounded by high hills, which slope to within a short distance of the river's edge. Just above this valley is the lower end of the Grand Cañon. Both sides of the river above Tower Creek have once been the seat of hot-springs, whose most active period has been long passed. There are at present only a few springs remaining on the western bank, while on the east there are extensive deposits containing sulphur, selenite, and alum. We spent four days in camp No. 9, while Dr. Hayden and a small party made a side trip to Clarke's Fork of the Yellowstone. During this time, in addition to some trips to Tower Falls and the vicinity, I also made two trips up the East Fork of the Yellowstone to a locality where one of the members of the expedition discovered some very fine crystals of amethyst. This locality is some ten miles from the main Yellowstone. The specimens are found on a hill on the left side of the river. It is about 1,000 feet in height and the summit entirely destitute of timber, the rock covering it being basaltic. Over the basaltic floor, quartz, agate, jasper, and silicified wood are found in quantity. There seems once to have been a forest standing here which the lava has inclosed and silicified. Imbedded in the rock we find numerous cylindrical masses of chalcedony a foot and more in diameter. In some of these masses we can still trace the form of the woody fibers, while others have bits of silicified wood that has not been changed to chalcedony. In the center of many of these cylinders we find crystals of amethyst. They are large and have a fine color. If we had been able to penetrate to a greater depth there is no doubt but that we would have found still handsomer specimens. In other specimens the wood seems to have formed a nucleus around which the quartz has crystallized, chalcedony forming the center and milky quartz the exterior. In one place on this hill I found a great variety of jaspers, with also agates and semi-opal.

The following is a complete list of the minerals found at this locality: Amethyst, (amethystine quartz,) limpid quartz, milky quartz, (ferruginous quartz,) chalcedony, carnelian, chrysoprase, prase, banded agate, flint, red, yellow, gray, blue, and black jaspers, semi-opal, and calcite.

The calcite is found in the center of agate-geodes. The jaspers are very fine, containing three and four colors in some of the pieces. The crystals of quartz and amethyst are all large and fine.

Throughout the entire valley of the Yellowstone quartz, chalcedony, agate, and obsidian-chips are common, while almost all the trachytes contain crystals of sanidine. Among the specimens brought from Clarke's Fork were argentiferous galena; and the blue and green carbonates of copper from the Clarke's Fork mines.

We left Elk Creek on the 4th of August, and made our next camp at the foot of Mount Washburne, on the eastern side, in a small, densely-timbered valley bordering the Grand Cañon. Close to our camp there was a small gulley containing some springs, of which I recorded the temperatures. A small stream ran through the gulley, and throughout the entire bed there were springs whose presence was revealed by the bubbling of carbonic acid and sulphuretted hydrogen through the water. On either side of the stream there are abundant deposits, of a white color, containing lime, silica, and sulphur, giving evidence that at some past time this place was the seat of a large group of active springs, of which those now existing are a mere trace. It may not be many years before they will be entirely extinct. The specific description of these springs is as follows: No. 1 is eight feet by five, and gave off sulphuretted hydrogen abundantly. The temperature was only 52° F. No. 2 is three by four feet, and has a temperature of 53° F. Nos. 4 and 5 were merely small holes in the deposit on the bank of the stream. The temperature of the former was 94° F. and that of the latter 115° F. The remaining springs were as follows: No. 6, 188° F.; No. 7, 188° F.; and No. 8, 190° F. The boiling-point here would be 198°.3 F. The temperature of the air during these observations was 76° F., the time being about 7.30 a. m. The elevation above sea-level was 8,117 feet. From this group of springs we caught a glimpse of a white spot through the trees, which indicated that there were more springs to the north of these. Toward this place we turned our heads, and while riding along through the woods we came to a pool of water which would measure probably thirty yards by fifty. The surface of the water was almost all in agitation from the number of points of evolution of carburetted hydrogen. The temperature of the water was only 54° F., while the air still remained at 76° F. This pool was on about the same level as the springs mentioned above. A short ride from this pool brought us to the spot we were seeking, and we found ourselves in the midst of an active group of mud springs or salses. The springs are distributed over the side of a hill which steams from top to bottom. It was a most horrible-looking place, and brought to our minds pictures of the infernal regions. The black and red colors of the mud and iron deposits gave the hill the appearance of having been burned, while here and there were masses of bright-yellow sulphur. The air was filled with the fumes of sulphuretted hydrogen. The noise made by the throbbing and pulsating masses of mud was continuous. This, with the splashing and spluttering of some of the springs, the plop-plop of the thicker mud, combined with the unearthly appearance of the scene, made us feel that we were on dangerous ground, and in walking about the springs we did so carefully, fearing that we might break through the crust. The mud in these springs is black in some, lavender-colored in others, and again yellow, while in consistency it is of all grades, from that of a thick mush to a mere inky-black water. In the thick-mud spring the steam seems to escape with an effort after several vain attempts. The mud rises in a hemispherical mass, falls and again rises, and after several repetitions the steam bursts from it, sometimes throwing the mud to a distance of 20 feet.

I divide the springs at this locality into two groups, the second group being some distance higher up the hill. The following is the description of the springs in the first group: The first one contained a rather thin lavender-colored mud. It is a cavernous-like opening on the side of the hill, and is the topmost spring of about five springs that are situated in a line, one above the other, at different levels. There seems at one time to have been a fissure here which determined their position. It was the only spring of the five that could be approached, but the temperature even of this could not be taken on account of the steam coming from it. It was probably at the boiling point. The mud was in active motion, and the steam came from it with a continuous roar. The spring also gave off sulphuretted hydrogen gas.

No. 2 was a large pool of muddy water, through which a number of steam jets forced their way, giving the spring the appearance of a sieve full of water, through the bottom of which the stream was forced. The temperature of the water was 194° F., and the air 78° F., the time of observation being about 9 o'clock in the morning. This spring was 30 feet above No. 1. Near it there was a spring of very thick, blue mud, the temperature of which I was unable to take, it not being safe to approach near it, as the mud on the banks was very soft.

A short distance to the right of No. 2, and a little above it, is No. 3, a large, yellow, muddy pool 30 feet by 50 feet in diameter, in which there was a great deal of bubbling, the water near the edge of the spring being especially agitated. The temperature was 140 F., the air remaining at 78° F. On the banks of this pool there was an abundant deposit of sulphur and alum. No. 4 is the most active spring of the group. It is about 20 feet higher up the hill than No. 3, and is about 30 feet in diameter, somewhat irregular in shape. The mud has formed a rim about it which is 2 feet above the spring on one side and 3 feet on the other. It contains a very thin blue-black mud, which is in violent ebullition, rising at times to the height of 3 and 4 feet. A dense column of steam, mingled with sulphuretted hydrogen gas, is continually escaping from it. I was able to take the temperature only at the edge, where I found it to be 190° F.; air, 78° F. In the center it was probably at the boiling point, which at this elevation is 198°.2 F. About 20 feet below No. 4, and a little to the right, is No. 5. It is 15 feet long and 5 feet wide at the widest place, being somewhat triangular in shape. One edge of the bank overhangs the water and coated with a deposit of sulphur, which is deposited by the sulphuretted hydrogen gas. The water here is cleaner than in any of the surrounding springs. The center of the spring is in violent ebullition from the escape of steam. The temperature of the water at the edge of the spring was 184° F., the air being 78°. The second group has a general elevation of about 150 feet above the first, and is also situated on the slope of a hill. The first spring in this group we called the "Mush-Pot." It is about 20 feet in diameter, and has three openings, each about 10 feet in depth. The mud at the bottom of these holes is very thick and of a bluish-black color. The mass heaves and throbs as the steam escapes through it. It was impossible to take the temperature of the mud, as the steam scattered it in all directions, rendering it impossible even to look into it with safety.

No. 2 was named the "Paint-Pot," the mud in it resembling lead-colored paint. The entire surface was in violent agitation. The diameter of this spring is narrower at the top than at the surface of the mud, which was eight feet below the surface of the ground. The mud is scattered in all directions, as in the last-mentioned spring, rendering it impossible to obtain its temperature. At intervals of about three minutes it seems to take a rest, remaining quite for a few seconds.

No. 3 is a fissure of nearly 100 feet in length, in the course of which there are a number of black-mud springs, their average temperature being 185° F., while the air was 79° F. This fissure is about 100 feet above spring No. 1.

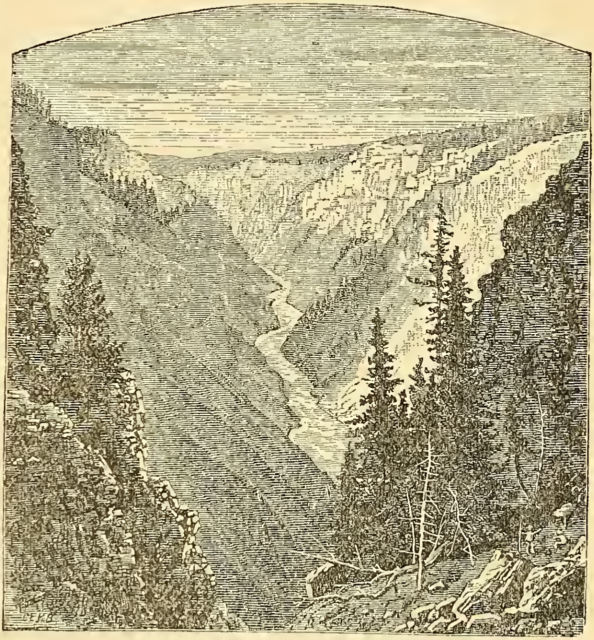
No. 4 is a similar fissure of about the same length. It is about 100 feet above the preceding one, and contains mud-springs of the same character, the average temperature being 190° F. The boiling-point at this elevation is 197°.6 F. All around this fissure there is an abundant deposit of sulphur and alum, the sulphur-crystals being exceedingly brilliant and delicate.

No. 5 is a blue-mud spring of about three feet in diameter, having a temperature of 190° F. Nos. 6, 7, 8, 9, and 10 form a small group distinguished by the abundance of sulphur surrounding them. The mud in them was very thick and varied in color from blue to black. The ground about them was too treacherous to allow of a near approach, but their temperature would probably average about 185°–190°. Besides the springs I have described above there were numerous smaller ones and a great many steam vents. I have only mentioned the most important springs. Both the groups are situated in banks of clay, and the deposits consist mainly of clay, alum, and sulphur. All the springs are acid in reaction from the presence of sulphuric acid. The sulphur results from the decomposition of the sulphuretted hydrogen which is so abundant in this locality. The oxidation of the sulphur and its union with the alumina and iron gives us the alum which we find here.

Our next camp (No. 11) was on Cascade Creek, a few miles from the Lower Falls of the Yellowstone and the Grand Cañon. Cascade Creek, near our camp, flows through a valley covered with sedimentary rocks, into which it has cut a short distance. It is made up partly of sand and particles of volcanic material. It is probably Pliocene in its origin, and was deposited at the bottom of a lake which was very likely a prolongation of the ancient Yellowstone Lake, and existed here at a comparatively recent period. The strata are soft and contain particles of obsidian in abundance, and are also in part contributed to by volcanic ashes, for here we find ourselves in the midst of a volcanic country. This sedimentary deposit extends over the entire valley of the Yellowstone at this point. The carving out of the Grand Cañon (Fig. 33) gives us an excellent opportunity to study the various rocks that underlie the valley.

At the head of the Grand Cañon is the lower fall of the Yellowstone, which was measured this year by triangulation and found to be 397 feet in height. At the foot of the fall the depth of the cañon is 675 feet. This depth increases as we go down the river, and about half a mile below it is 1,000 feet, measured with an aneroid barometer. The fall of the river from the foot of the fall to the mouth of Tower Creek, a distance of twenty-two miles, averages 40 feet to the mile. On the western side of the cañon, some distance above the top of the lower fall, there is an exposure of a very fine soft sandstone having a light-yellow color. This must have been deposited in very quiet waters and is probably of Post-pliocene age. On the eastern side we find the rocks to be as follows: The top of the cañon above the falls is made up of obsidian, which is porphyritic, containing crystals of sanidine. The rock is very irregular in composition and color, the latter varying from black to brown. It passes into a perlite-like rock of a light-bluish color, in some places is white. This has in places perlite-like trachyte-porphyry, containing small feldspathic balls with a radiated fibrous structure, (spherulites,) mixed with small bits of obsidian, the whole mass having a general color that resembles blue lead. A little farther down we find in this same rock jasper-geodes containing varieties of opal in the interior. They vary in size, some being only an inch in diameter, while others are half a foot. They are of a brown color on the exterior and botryoidal in shape, and are porphyritic, containing crystals of sanidine. Breaking them open we find that the mass often presents a beautiful appearance, some of the specimens having a rich-brown color, mingled with bright red and green, while the cavities are lined with pink, white, or blue semi-opal in some cases and in others by hyalite. The variety in the shades of color is almost infinite. Just above the fall there is a slide of rock reaching from the top of the cañon to the river's edge, and here we found many good specimens that had broken out of the more massive rock and fallen down.

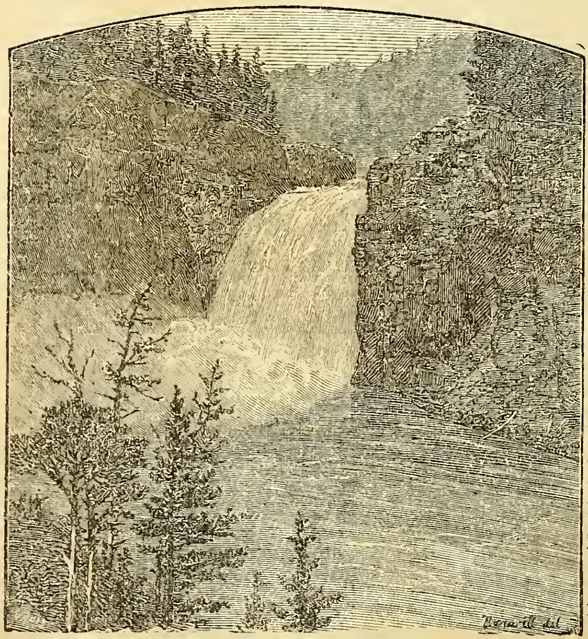
Fig. 33.



GRAND CAÑON OF THE YELLOWSTONE.

At the brink of the fall the rock over which the water pours, and which extends some 50 or 75 feet above it, is a compact trachyte porphyry of a light-violet color containing crystals of sanidine. As we proceed down the river we find that this rock is replaced by an argillo-trachyte-porphyry, the white color of which contrasts strongly with the other colors seen on the sides of the cañon. The unequal hardness of the different rocks has allowed it to weather into curious and fantastic shapes, spires, towers, and minarets standing out on either side, adding to the picturesqueness of the scenery. There have once been many hot springs throughout this region, and it is to them that the greater portion of the coloring seen in the cañon is due, the iron deposits giving the reds and the sulphur the yellows. There still are a number of springs along the river's edge, although from the top of the cañon they cannot be distinguished. The center of attraction, however, is the lower fall, (Fig. 34). The river suddenly narrows to a width of only 100 feet and rushes over a ledge of trachyte, falling 397 feet to the bottom of the cañon. The water at the edge of the fall is very deep and of a deep-green color. Huge bowlders thrown in are carried by the force of the current far out from the edge of the fall. When we approach the brink and look over into the abyss we begin to realize the littleness of man when in the presence of nature's grand masterpieces. Down, down goes the whirling mass, battling and writhing as the water dashes against the rocks with a noise like the discharge of artillery. Here and there a resisting rock is met with and the water rebounds, broken into myriads of drops, which throw back to us the sunlight resolved into its primitive colors. The bottom of the cañon reached, the immense mass of water seems to dissolve itself into spray, and then recovering, it flows down the gorge an emerald-green stream, dashed with patches of white, beating with furious waves the rocky walls that imprison it. Taken in connection with the varied tints of the cañon itself, red, yellow, orange, white, the dark-green pines fringing the top, and the bright green of the spray-nourished moss on the sides of the fall, we have a picture of almost unequaled magnificence and grandeur. It is a scene of which one never tires and in the description of which language fails. As we stand above the lower fall and look toward the south we have a fine view of the upper fall, (Fig. 35,) which is distant about half a mile. This fall differs altogether from the lower one and does not so soon impress one with its height, which is 140 feet. The water pouring over the edge

Fig. 35.



UPPER FALL OF YELLOWSTONE RIVER, 140 FEET.

Fig. 34

LOWER FALL OF YELLOWSTONE RIVER.

strikes a number of ledges of rock, which churn it into a mass of foam. A portion of the water is projected out like a broad fan, and striking the water below makes a sort of ricochet, while the main mass of water reaches the base of the fall about 20 feet from the vertical line let fall from the top. The water has cut out of the solid rock a rounded basin, from which the course of the river is almost at right angles to the course above the fall. For some distance above the fall

Fig. 36.

CRYSTAL FALLS ON CASCADE CREEK, 129 FEET.

there is a series of rapids over which the current is very swift. The cañon between the two falls is about half a mile long and the fall of the river between these two points is 68 feet. The walls of this cañon vary in height from 100 to 200 feet.

Cascade Creek flows into the Yellowstone River on the west side between the falls. A short distance above its mouth we find a beautiful fall, (Fig. 36,) or rather cascade, for it is made up of three distinct falls, the aggregate height of which is 129 feet. The stream, after passing through a deep, gloomy gorge, makes a leap of about 21 feet and then falls again in three streams a distance of over 50 feet into a beautiful, rounded basin, in which the water is perfectly clear and quiet. From this basin the final leap is taken and the water flows on to the Yellowstone River.

Leaving Cascade Creek our next camp (No. 13) was at Mud Volcanoes near the Yellowstone River, about eight miles below the lake. We spent three days here, waiting for a supply-train to join us from Fort Ellis. During this time I visited a number of the various hot-spring localities in this portion of the valley. The underlying rocks here are Pliocene and Post-pliocene, in horizontal strata, and presenting the same characters that were observed near the Grand Cañon, and probably resting, as those do, upon volcanic rocks. In some places I noticed iron as forming a prominent part of these sedimentary deposits, which, with the obsidian, makes very handsome specimens. The river flows quietly through the valley, the fall per mile, from Yellowstone Lake to the top of the upper fall, being only 8 feet, and almost all of this is in the rapids just above the upper fall. The first springs I visited were on a branch of Alum Creek about five miles northwest of camp. We named the small stream Violet Creek, from the profusion of violets growing upon its banks.

The first spring we met with was on the right bank of the creek, in a siliceous cone-like mound that rises six feet above the bed of the stream. Its temperature was 126° F., the air being at 70° F. The bed of the creek was filled with confervoidea, leading us to suspect that there were springs still farther up. After a further ride of about a quarter of a mile we came to quite a large group of hot springs lining both sides of the creek. The first spring I will describe is on the right bank of the creek, in the center of a white mound 20 feet in diameter and rising 10 feet above the bed of the creek. This mound is formed of the deposits from the water, which consist mainly of various carbonates and silica. The orifice of the spring is circular and about three inches in diameter and looks as though it had been artificially punched in the deposit, so mathematically exact is it. The water gives off carbonic-acid gas, leaving a deposit of iron. Its temperature was 190° F., the air being 70° F. Spring No. 2 is on the opposite side of the creek and has a basin measuring 4 feet by 2 feet; the temperature of the water was 160° F., the air remaining at 70° F. No. 3 has a circular basin two feet in diameter, which is lined with an abundant deposit of iron. Carbonic-acid gas bubbles through the water. Its temperature was 158° F. No. 4 is 6 feet deep and 1 foot by 3 feet in diameter, and has a temperature of 188° F. The next three springs had temperatures as follows: No. 5, 192° F.; No. 6, 194° F.; and No. 7, 188° F.; the air still remaining at 70° F. All these springs have circular orifices of about six inches diameter, and the water proceeding from them flows over a series of small terraces, resembling those of the Gardiner's River springs on a miniature scale. These basins are lined with a gelatinous form of silica, which has a leathery appearance and is coated with an iron deposit. The springs are about 10 feet above the level of the creek and all give off carbonic-acid gas. No. 8 is very irregular in shape and almost hid in the grass, about 40 feet from the creek. There is a slight bubbling in it and its temperature was 178° F. No. 9 is a small spring, 2 feet in diameter and 1 foot deep, lined with confervoidea and having a temperature of 140° F. No. 10 is a very pretty spring, about four feet above the creek, and has a beautiful scalloped edge, moss-lined on one side. Its temperature was 175° F. The boiling-point at this locality is 198°.3 F. None of the springs reached this temperature, 194° F. being the nearest approach. The rocks exposed near these springs are sedimentary and contain a great deal of obsidian.

About three-fourths of a mile farther up-stream we came to the head of the creek and found that it originated in a most important group of springs. They are situated in a semicircular basin, bounded by a low hill wooded on the summit. The sides of this hill are perfectly bare and covered with glaring-white deposit, through which steam-jets force their way. Looking down into the basin from the top of the hill is like looking into a volcanic crater. The *fumaroles*, *solfataras* and mud-springs scattered through it give it a most peculiar appearance. The general color throughout the basin is a glaring white, relieved here and there by patches of brick-red iron deposits and the yellow of sulphur-masses that are scattered throughout the basin. The crust extending over the basin is lined with beautiful crystals of sulphur. On the left of this basin there is a ravine, covered with deposits of the same character but containing no springs. There are a few *fumaroles* remaining, the evidence that once the ravine was the site of active springs. A few yards on the opposite side of the basin there is a second ravine similar to the first, and in which also the springs are all dead, nothing remaining but the rust-colored deposits. I will give the different springs in this basin below in tabular form.

Springs at the head of Violet Creek.

August 10, 1872; time of observation, 12.30 a. m.; general elevation above sea-level, 8,059 feet; boiling-point, 198°.1 F.

No.	Character of spring.	Size.	Gas evolved.	Temperature of spring.	Temperature of air.
1	Siliceous	8 × 10 feet	Steam	185° F.	72° F.
2	....do	3 feet diameter	....do	172	72
3	....do	2 feet diameter	....do	194	72
4	....do		....do	194	72
5	Sulphur	20 feet diameter	Steam and sulphuretted hydrogen.	Not taken.	72
6	....do	30 feet diameter	....do	165	72
7	Mud-spring	2 × 4 feet	....do	170	72
8	Sulphur	8 feet diameter	....do	140	72
9	Blue-mud spring	6 × 10 feet	....do	162	72
10	White-mud spring	1 × 3 feet	....do	168	72
11	Blue-mud spring	3 feet long	....do	188	72
12	Yellow-mud spring	4 feet diameter	....do	180	72
13	Blue-mud spring	2 inches diameter	....do	190	72

Besides the springs enumerated in the table there were many smaller ones and a few large pools through which the gases bubbled at various points. The ground near the majority of them was too treacherous to allow of our approach. There are also a great many steam-vents lined with sulphur-crystals. The hardened deposit about some of the mud-springs is an indurated clay, that has been deposited by the springs. The first four springs given in the table have clear water, and the first one was in violent ebullition, the water at times rising four feet above the ordinary surface. In No. 10 I found butterflies that had fallen into the water and been killed by the heat. The odor of sulphuretted hydrogen was not so strong at this locality as at the foot of Mount Washburne.

On the way back to camp we came across another group of springs, about a mile southeast of the group given above, and have an elevation about 200 feet lower. They are situated in a ravine bordering a small branch of Violet Creek. The following table will show them all at a glance:

Springs on branch of Violet Creek.

August 10, 1872; time, 2 p. m; elevation above sea, 7,873 feet; boiling-point, 198°.5 F.

No.	Size.	Gas evolved.	Temperature of air.	Temperature of spring.
1	3 × 4 feet	Carbonic acid and steam	68° F.	160° F.
2	10 feet diameter	do	68	184
3	5 feet diameter	do	68	154
4	5 × 2 feet	do	68	188
5	3 feet diameter	do	68	180
6	5 × 3 feet	do	68	191
7	7 × 3 feet	do	68	186
8	3 feet diameter	do	68	192
9	8 × 1 feet	do	68	194

The amount of carbonic-acid gas given off from these springs is small, and, although there is considerable bubbling in some of the springs, it is caused mostly by the escape of steam. This in some is enough to cause the ground to tremble beneath. All the springs deposit iron. The first three springs given in the table are on the edge of a pool of water having a diameter of 100 feet by 50 feet, in which the thermometer stood at 120° F. There is also one spring in the midst of this pool which was beyond reach. The bottom of the pool is lined with gelatinous silica, which is coated with oxide of iron. The edge of the pool next the creek slopes to the level of the stream in a series of small basins over which the water flows. The creek itself is divided into a number of basins formed of the deposits, (mostly carbonates,) and the water flows from one basin to the other, they being at different levels. These basins are filled with a luxuriant growth of very bright green confervoidea. The temperature of the water in the creek a short distance below the springs is 140° F.

The two groups of springs given above have never before been described, not being in our line of march last year. There are doubtless many more groups throughout the same valley that have never been studied yet, especially on the eastern side of the Yellowstone River, which here is not fordable, on account of quicksands.

The next group of springs to which I will refer is that at Crater Hills, near the Yellowstone River, about four miles below our camp. This place takes its name from the occurrence here of two high buttes or hills, one of which is 150 feet from top to base, and a second 140 feet. They are made up in part of a trachytic tuff and hot-spring deposits, the prevailing color of which is white, and a red, due to the weathering of the deposits, which contain iron. All of the springs are acidulous and contain sulphur as a prominent constituent. The principal spring is the boiling-sulphur spring near the base of the hills. The description of this spring was given in the report of last year, and I will not delay to redescribe it. I again took its temperature, which I found to be 178° F., the air being 58° F., at about 10 o'clock in the morning. The temperature given in last year's report is 183°.5 F., which was probably taken nearer the center of the spring than I was able to take it this year, the water being in violent agitation.

The next spring of importance is a large blue-mud spring near the large sulphur spring, the temperature of which (164° F.) this year varies only 1° from that taken last year, when it was 163° F. All the springs at this locality are noticeable, not only for the sulphur they contain, but also for their alum, which I take to be an iron alum. The small stream to which the springs give origin is a branch of Alum Creek, and in both the main creek and the branch the water is strongly astringent. A partial analysis of a piece of deposit from the edge of the boiling-sulphur spring, made by Mr. W. B. Platt, of the expedition, gives the following result:

	Per cent.
Water	23.48
Sulphur	3.23
Silica	-----
Sulphuric acid	-----
Chlorine	Trace.
Iron oxide	-----
Soda	-----
Magnesia	Trace.
Organic matter	-----
	26.71
Specific gravity	1.800

The object of this analysis was to determine the percentage of sulphur. Silica is present in large amount.

The group of mud and sulphur springs just south of the two springs referred to above was mentioned in last year's report, but as the observations of this year are more complete, and include a large number of springs, I will present this group below.

Springs at Crater Hills.

General elevation above sea-level, 7,828 feet; boiling-point, 198°.2 F.

No.	Size of spring.	Temperature of spring.	Temperature of air.	Remarks.
1	A collection of springs covering an area of 600 square feet, and varying in size from one to three inches in diameter.	174° F.	59° F.	The water in this collection of springs has a milky hue, and the noise made by them resembles that made by a number of pots boiling simultaneously.
2		176	59	
3		182	59	
4		186	59	
5		144	59	
6		160	59	
7		168	59	
8		150	59	
9		160	59	
10	3 feet diameter	80	59	White-sulphur spring.
11	8 feet diameter	148	59	Clear spring.
12		176	59	Thick greenish-mud spring.
13	2 feet diameter	180	59	Yellow-mud spring in active ebullition.
14	8 × 2 feet	90	59	A turbid pool bubbling at the edges.
15		162	59	A collection of greenish-sulphur springs, each a few inches in diameter.
16		166	59	
17		182	59	
18		178	59	
19		108	59	
20		180	59	This spring was called Foam Spring last year.
21	2 × 4 feet	170	59	Bluish muddy water.
22	10 × 3 feet	188	59	Both the sesprings have lavender-colored mud, and No. 2 is in active agitation.
23	2 feet diameter	180	59	
24	These springs occupy a space of about 1,200 square feet.	150	59	This collection of springs varies in size from a few inches to four feet. The water in the majority is of a milky hue. In others it is yellow or lavender colored, and in some it is transparent.
25		184	59	
26		130	59	
27		170	59	
28		168	59	
29		184	59	
30		106	59	
31		154	59	
32		188	59	
33		160	59	
34		130	59	
35		162	59	
36		174	59	
37		128	59	
38		120	59	
39		106	59	
40		176	59	
41		146	59	
42		186	59	
43		168	59	
44		174	59	
45		178	59	
46		172	59	
47		90	59	
48		158	59	
49		170	59	

Having completed observations on these springs, I devoted the remainder of my time to those near camp, which presented a great deal of interest. I was enabled to make more accurate observations than were made last year, and was greatly assisted by Mr. A. E. Brown, who determined the heights of the mud-geyser for me. The mud-geyser is the principal spring in the group at Mud Volcanoes, and was situated a few yards above our camp. It has a basin of about 60 feet diameter, surrounded by a rim that slopes inward, at an angle of 30°, to a funnel-shaped orifice in the center. This basin, which is the basin proper of the geyser, is made up principally of clay and silica, and is situated in another basin which measures 200 feet by 150 feet. The wall of this latter basin rises about 8 feet, on an average, above the level of the other basin, and between the two rims there is a deposit of clay which has been left by the water and has become hard, resembling a very fine clay slate. On one side of the outer basin there is a small ravine-like opening cut into the bank, through which water evidently flows sometimes, probably during the spring when there is more water in the basin. In several places on the banks I noticed small holes lined with sulphur from which the steam escapes. Besides the geyser there are two small springs at one end of the large basin. These springs are entirely independent of the geyser, and are constantly in action, bubbling quietly. They do not seem to be affected in the least by the eruptions of the geyser. The following is the description of an eruption: The water gradually rises until the inner basin is filled, when there is noticed a bubbling in the center. Suddenly, without any further warning, it becomes violently agitated and an immense mass of muddy water, mingled with clouds of steam, is thrown into the air. This action lasts a few minutes and is followed by a lull, the action not ceasing entirely. Then it recommences with renewed violence, and the water fills the entire outer basin, the water striking the banks in a succession of waves. The water is thrown up in a succession of impulses that follow each other rapidly, and sometimes the water is thrown obliquely and seems as though it would overwhelm one standing on the bank. The mass of water and mud is immense. After the maximum height is obtained the jets become smaller and smaller, and the eruption ends as suddenly as it began. It is a very impressive sight, and the stopping is like a calm after a storm. The water of the geyser is very muddy, and bluish in color, having an acid reaction, due to the presence of sulphuric acid.

I will transcribe my field-notes below and then give the result in tabular form, so that the whole may be placed before the eye at once.

August 11.

4.02 p. m.—The temperature of water in the basin is 140° F. and the air 50° F.

4.37 p. m.—The water is rising rapidly and there is considerable bubbling in the center of the basin, the temperature remaining the same.

4.42 p. m. to 4.52 p. m.—The water is still rising and flows in currents, giving it a variable temperature of 140° F. to 180° F.

5.02 p. m.—The temperature is still 180° F. at the edge, although in the center it must be considerably higher. It is still in ebullition.

5.04 p. m.—The eruption commences.

5.10 p. m.—There is a lull in the action.

5.14 p. m.—The maximum (40 feet) is attained.

5.17 p. m.—The eruption ends and the water at the edge of the basin has a temperature of 172° F.

5.52 p. m.—Temperature of water is 148° F. and the air 48° F. The water is four feet lower than it was during the eruption, and the sides of the basin are shown sloping inward. Several steam-vents, not seen before, are now made apparent. The surface of the water is quite placid, save in the center, where a slight bubbling takes place. The water seems to be rising slowly.

6.37 p. m.—The water has risen one foot since the last observation and is still rising.

7.37 p. m.—The water is now six inches above the level last observed.

9.35 p. m.—The eruption commences.

9.48 p. m.—The eruption ends. The maximum height was estimated at 20 feet, it being too dark to take any angles.

August 12.

6.19 a. m.—The geyser has evidently had an eruption during the night. The basin is full and the center in ebullition.

6.31 a. m.—The eruption commences.

6. 35 a. m.—There is a lull.

6.42 a. m.—The eruption ends. The maximum height was 25 feet, and I noticed that the ground shook beneath me while the eruption was going on.

10.19 a. m.—The temperature of the water at the edge of the basin is 148° F. and the air is 60° F. The center is bubbling, and a black, oily substance floats on the surface.

10.29 a. m.—The temperature of the water is from 140° F. to 180° F., and it is rapidly filling the basin.

10.49 a. m.—The eruption commences.

10.55 a. m.—There is a lull.

10.58 a. m.—The maximum (18 feet) is attained.

11.02 a. m.—The eruption ends.

11.08 a. m.—The temperature at the edge of the basin is 170° F.; air, 60° F. The water has fallen a foot already.

11.15 a. m.—Water, 150° F.; air, 60° F. The water has fallen eighteen inches.

11.20 a. m.—The water has fallen five inches since the last measurement.

11.24 a. m. to 11.29 a. m.—The water still has a temperature of 150° F., and has fallen 2 feet 10 inches.

11.39 a. m.—The water has fallen 3 feet 2 inches since the eruption ceased, (lowest point.)

11.49 a. m.—The water is rising slowly.

2.39 p. m.—The water is within one foot of the top of the basin and bubbling in the center. Its temperature near the edge is 146° F., the air still being 60° F.

3.14 p. m.—Temperature outside the rim of the basin is 125° F.

3.15 p. m.—The eruption commences.

3.21 p. m.—There is a lull.

3.25 p. m.—The maximum (22 feet) is reached.

3.27 p. m.—The eruption ends. Temperature of water at edge of basin 170° F.

7.39 p. m.—The eruption commences.

7.44 p. m.—There is a lull.

7.48 p. m.—The maximum (19 feet) is reached.

7.51 p. m.—The eruption ends.

Mr. Sloane took observations of two eruptions on August 9, as follows:
12.40 p. m.—Eruption commences.
12.47 p. m.—Lull.
12.49 p. m.—Maximum estimated at 25 feet.
12.52.30. p. m.—Eruption ends.
4.58 p. m.—Eruption commences.
5.04 p. m.—Lull.
5.07 p. m.—Maximum estimated at 30 feet.
5.11 p. m.—Eruption ended.
The following table gives the result of these observations:

Date.	No. of eruption.	Length of eruption.	Interval between the eruptions.	Interval between commencement and lull.	Interval between lull and maximum.	Maximum height.
		m. s.	*h. m. s.*	*m.*	*m.*	*Feet.*
August 9	1st	12 30		6	3	25
August 9	2d	13 00	4 5 30	6	3	30
August 11	3d	13 00		6	4	40
August 11	4th	13 00	4 18 00			20
August 12	5th	11 00		4		25
August 12	6th	13 00	4 7 00	6	3	18
August 12	7th	12 00	4 13 00	6	4	22
August 12	8th	12 00	4 12 00	5	4	19

	h.	*m.*	*s.*
Average length of eruption	0	12	26.75
Average interval between eruptions	4	11	6
Average interval between commencement and lull		5	34.28
Average interval between lull and maximum		3	30

The remainder of the springs at Mud Volcanoes I will give in a table, as I did those of Crater Hills.

Last year, when at this locality, we noticed that the trees near the Giant's Caldron had their brances coated with mud, and the question was raised as to how the mud got there, we concluded that the geyser sometimes ejected its contents. This year, however, investigation seemed to prove that the mud is carried up mechanically, mixed with the steam that is constantly rising from the caldron, and that the spring never has any eruptions. We were led to this opinion first by noticing that it was only the under side of the branches that held the mud. Mr. Holmes then placed some dead branches in such a position that the steam came upon them and in a few hours they had a coating of mud. Again, some of the trees on which the branches are coated are living, which would hardly be the case had they received the mud from an eruption. Another reason also is found in the fact that the surface of the spring is constantly agitated, which is rarely or never the case with a true geyser. Still in the past it may have been a geyser and had regular eruptions.

Springs at Mud Volcanoes.

General elevation above sea-level, 7,775 feet; boiling-point 198°.5 F.

No.	Size of spring.	Temperature of spring.	Temperature of air.	Time of observation.	Remarks.
		° F.	° F.		
1	3 feet diameter	190	50	....	Very thick mud spring.
2	10 feet diameter	168	50	3. 35 p. m.	These springs are in the same basin with the mud-geyser but entirely distinct from it.
3	10 feet diameter	168	50		
4	6 feet diameter	126	48	4. 55 p. m.	At head of ravine 250 yards above the mud-geyser.
5	15 × 5 feet	156	48	5. 00 p. m.	Thirty-five hundred feet from No. 4, in same ravine at the head. There are here some extinct basins and vents for stream.
6	75 feet diameter	134	58	11. 20 a. m.	A large green-sulphur pool with many centers of ebullition, giving off sulphur, hydrogen.
7	3 feet diameter	136	58	11. 23 a. m.	Lavender-colored spring containing alum.
8	12 × 20 feet	88	58	11. 25 a. m.	Yellow-sulphur spring about fourteen feet from No. 7.
9	60 × 20 feet	140	58	11. 30 a. m.	This group is in a ravine near the Giant's Caldron. No. 9 is on the edge of No. 8, and has clear water with confervoidea lining the stream.
10	2 feet diameter	124	58	11. 30 a. m.	
11	3 × 1 feet	140	58	11. 30 a. m.	
12	Grotto, 3 feet high, 8 feet wide, 20 feet deep.	182	58	11. 45 a. m.	The grotto is an opening into a sandstone rock at the head of a small ravine. The top of the entrance resembles a gothic arch coated with moss and iron. Steam escapes in pulsations.
13	30 × 15 feet	94	58	11. 46 a. m.	A greenish alum pool.
14	2 feet diameter	180	58	11. 48 a. m.	A pool a few feet above No. 13.
15	20 feet diameter	163	58	11. 50 a. m.	Light-gray mud spring 10 feet deep. There are others too deep to get temperature.
16	Pool. 500 × 60 feet	92	58	11. 50 a. m.	Sulphur springs.
17	Small holes, 1 inch diameter.	148	58	11. 51 a. m.	
18		172	58	11. 52 a. m.	
19	....	182	58	11. 55 a. m.	Mud spring.

CHAPTER IV.

GEYSER-BASINS OF FIRE-HOLE RIVER.

We left Mud Volcanoes on the 13th of August and started for the lower geyser-basin of Fire-Hole River. Our course at first led us up an open valley that once formed part of the ancient bed of Yellowstone Lake. At the head of the valley we struck our old trail of last year, which we followed until we reached the east fork of the Fire-Hole River. The divide between the Yellowstone River and the Fire-Hole River at this point is 8,164 feet above sea-level. The summit seems to be made up mostly of obsidian, which is all porphyritic. The timber is so thick that it is difficult to trace the connection, but, as we descend, we come across trachytes that seem to underlie the obsidian. It is very compact and porphyritic, containing crystals of sanidine. The general color is a light blue, approaching violet. It is through these trachytes that the headwaters of the Madison cut their channels. Near the summit, on the Madison side of the divide, there is an old hot-spring basin in which the springs are now all extinct, although there are a great many steam-vents from which steam still escapes; these vents are lined with sulphur. Besides sulphur the deposits consist mainly of silica and iron. The descent from the divide is very steep and rocky, and through thick timber, a great deal of which is dead and fallen. The valley of the east fork of the Madison or Fire-Hole at the point we reached it is very marshy and full of springs, which cause the water in the stream to have a temperature of some degrees more warmth than the air. We followed the river to within some four miles of the lower geyser-basin, and camped at a level some 867 feet lower than the divide and 452 feet lower than our camp (No. 12) at Mud Volcanoes, having traveled nineteen miles. Some of the party who had preceded us a day came into camp in the evening and reported that they had met the advance-party of the Snake River division of the expedition, under Mr. Stevenson, so the following morning we moved down into the lower basin, and in the evening found that the main body of the Snake River division were encamped within a mile of us, having got in about the same time we did. The next day they moved their camp and joined us.

On the way from camp we passed a number of unimportant springs, which I will incorporate in the catalogue appended to my report. I shall devote but little space to the springs of the lower geyser-basin, as they were referred to at length in the report last year. During the three days and a half that I was in the lower geyser-basin this year, I was occupied most of the time in packing specimens to be sent to Virginia City, so that I was able to visit but one group of springs. As this, however, is a typical group, I will insert the description. They are situated just south of camp in an open space bounded on two sides by timber, while the front looks out into the main open basin. They occupy a space of a little over 3,000 square yards. The springs are as follows:

Gourd Spring.—This spring was named from its shape. It is in the center of a large, circular mound of siliceous material, and is 15 feet long by 10 feet wide and 12 feet in depth. The bed of the small stream, carrying away the overflow from the spring is coated with iron, and a short distance below we find the gelatinous material that we see in so many of the springs that have a low temperature. The temperature of the water in the spring was 171° F.; air, 62° F., at 9 a. m.

Thud Spring.—This spring is 375 feet southwest from the Gourd, and measures 18 feet by 16 feet. The depth varies from 8 to 13 feet. This of course refers only to the basin of the spring, as at the bottom there are orifices the depth of which cannot be ascertained by the line. There seem to be three centers of ebullition, two of which are very active. At intervals of a few minutes there seems to be an accumulation of steam, the escape of which shakes the ground, making a thud-like noise, whence its name. On looking into this spring the water seems to have an inky-green color, and had a temperature of 192° F.; air, 62° F., at 9.30 a. m.

Oak Leaf Spring.—This spring is 345 feet north of the spring next described. The deposit about it has a gray color, and the margin of the spring has the appearance of being fringed with oak-leaves. The spring is about 6 feet in diameter and 15 feet deep. The water appears of a greenish color and has a temperature of 194° F.; air, 64° F., at 10.35 a. m. About 7 feet from this spring there is a small cone of 2 feet diameter, rising five inches above the surrounding level. The temperature of the water in this cone was 190° F.

Fungoid Spring.—This spring is 140 feet west of the Thud Spring, and 345 feet south of the spring described above. The basin of this spring measures 13 feet by 17 feet and averages 6 inches in depth. The deposit is pure-white siliceous sinter, giving it the appearance of a marble basin. In the center of this basin there is another 5 feet in diameter and 7 feet deep. Here the water has a greenish tinge, which forms a pretty contrast with the white rim outside. The spring has a margin of the siliceous material that resembles a row of fungoid growths on short pedestals. There are two small streams proceeding from the spring, which are lined with orange-colored deposit. Surrounding the spring, there is a large amount of siliceous sinter, forming a mound, as is the case with the other springs of the group. The temperature of the water in the spring is 162° F.; air, 64° F., at 11.05 a. m. Near the spring there are two small holes, in which the water is at 190° F. and 180° F.

Kidney Spring.—This spring is very irregular in shape, and consists of two arms that are almost at right angles to each other. The length one way is 19 feet and the other 15 feet, the average width being about 6 feet. The depth is about 1 foot. The spring is fringed with large scallops, each one of which is made up of smaller scallops. There are three fissure-like centers of ebullition in which the thermometer records 184° F., 190° F., 184° F.; air at 64° F. at 11.10 a. m. The spring is 180 feet northwest of the Oak Leaf.

Cliff Spring.—This spring is 240 feet southeast of the spring last described and 122 feet east of the Oak Leaf. It measures 4 feet by 8 feet and is 5 feet in depth. The deepest portion is at one end of the spring, where there is a cavernous opening, overhung by a scalloped edge. The water here is of a light-green color. At the other end there is a rugged fissure, to which the edge of the spring slopes from the surface, having the form in miniature of cliffs. These, above the water, have a brown color and below a deep purple. The temperature of the water is from 192° F. to 195° F.; air, 64° F., at 11.45 a. m. The overflow of water finds its way from the spring over an orange-colored bed.

Jug Spring is 123 feet southeast of the *Cliff* and 150 feet east of the *Oak Leaf.* It measures 4 feet by 5 feet and is 3 feet deep. Its temperature was 188° F.; air, 64° F., at 12.09 p. m.

Stirrup Spring is 8 feet by 9 feet and 5 feet deep. There are two holes in the bottom of this spring from which the steam escapes, and a fissure also, which makes the spring resemble the head of an old woman with a cap on, the scalloped edge of the spring representing the ruffles of the cap and the fissure the mouth, while the other steam-vents represent the eyes. The temperature of the water was 188° F.; air, 64° F., at 12.35 p. m. There are two small holes near this spring in which the thermometer records 182° F.

Lone Spring.—This spring is some distance northeast of the other springs of the group, and is on the side of a hill some 40 feet higher. It is 4½ feet in depth and measures 9 feet by 16 feet. Its temperature at 8.30 a. m. was 186° F., the air being 62° F.

The general elevation of the group just described is 7,162 feet above sea-level, the boiling-point being about 199°.3 F. All the springs are somewhat globular in shape, widening below the surface, having overhanging edges, and narrowing below to fissures or tube-like orifices. They all belong to the class of springs that are constantly agitated, and, although this agitation is greater at some times than at others, I doubt if any of the springs in the group ever project a column of water into the air.

The area of the lower geyser-basin is about thirty square miles, and although it contains a far larger number of springs than the upper basin, there are not so many true geysers, and the water is not thrown as high into the air as in the upper basin. The geysers of the lower basin that have been seen to spout 30 feet or upwards are the "Great Fountain," "The Fountain," the "Steady Geyser," "The Jet," and two small geysers not named, which are a few yards below the Fountain. Having had no time while in the lower basin to visit these geysers, I will here insert the following excellent description, kindly furnished me by Mr. Holmes, artist to the survey:

During our somewhat protracted stay in the lower basin, I found time to observe pretty carefully all the geysers of any considerable importance. Among the six or eight which throw columns of water to the height, say, of 30 feet, there is only one that possesses the dignity and grandeur of the great geysers of the upper basin. Although, in some respects, it is much inferior to its more popular rivals, in others it is certainly superior. In approaching the crater of this geyser the observer is not at first impressed with its importance, as the outer rim of the basin or rather table—in the center of which the fissure is situated—is raised but two or three feet above the general level. This elevated part I should estimate to be upwards of 120 feet in diameter, and, with the exception of the crater, it is built up nearly to a level with the border. The surface, formed entirely of siliceous deposit, is diversified by an infinite number of forms and colors. The depressed parts in some places are so level and white and hard that a name could be engraved as easily and as well as upon the bark of a beech-tree. In others there are most exquisitely modeled basins and pockets, with ornamented rims and filled with perfectly transparent water, through which thousands of white pebbles of geyserite could be seen lying in the white, velvety bottoms. Rising above the general level are innumerable little masses and nodes of cauliflower-like and beaded silica, standing out of the shallow water like so many islands. Those near the crater swell into very large rounded masses. The whole surface is so solid that I walked, by stepping from one elevation to another, up to the very brink of the fissure, where I looked down with no little apprehension into the seething caldron, where, 12 or 15 feet below, was a mass of dark-green water in a state of constant agitation, threatening an eruption. The crater is about 10 feet in diameter, lined with an irregular coating of beaded silica. The water soon began to rise, plunging from side to side in great surges, sending up masses of steam and emitting angry, rumbling sounds. This demonstration caused a precipitate retreat, on my part, to the border of the basin, thinking that I could appreciate the beauties of a scalding shower-bath better from that point of view.

An irregular mass of water was thrown into the air in the utmost confusion, spreading out at every angle and whirling in every direction, some jets rising vertically to the height of 60 or 80 feet, then separating into large glistening drops and falling back into the whirling mass of water and steam; others shooting at an angle of 45° and falling upon the islands and pools 30 or 40 feet from the base. The eruptive force, for a moment, dies away and the water sinks back into the tube. Then, with another tremendous effort, a second body of water is driven into the air, but with a motion so much more simple than before that the whole mass assumes a more regular form and is like a great fountain with a thousand jets, describing curves almost equal on all sides and forming a symmetrical whole more varied and more grand than any similar work by man. The intermittent action continues for nearly an hour, but is so constantly changing that at no two moments during that time are the forms or movements the same. The eruptions are repeated at irregular intervals of a few hours and are not known to vary essentially from the manner of action here described; yet I have good reason to believe that at certain times there is a much greater exhibition of power. It must be borne in mind that all the elevations, such as the tubes, rims, and mounds about the crater of a geyser, are built by the evaporation of the water, and the portion of surface covered by the beaded silica indicates precisely the area over which the erupted water falls. In no case did I observe the water fall outside of a circle of 60 feet in diameter, and the additional force necessary to scatter it over twice that amount of surface must produce a display truly magnificent. That this display actually occurs is attested by one of our mountaineers and almost demonstrated by the extent of the beaded surface. During the earlier part of the eruption a considerable quantity of water flows over the rim and down the sides, where it has formed a series of basins somewhat similar in form and color to those at the springs on Gardiner's River. Falling from one to another of these it passes off down the slope and joins a large stream of hot water which issues from a steady spring not far away.

A few hundred yards farther up the ravine, and on the opposite side of the creek, I discovered a small spring that deserves in a quiet way to be one of the great attractions of this attractive region. It is isolated from the neighboring springs and nestled in against an abrupt bank, so obscured by tall pines that the visitor is liable to pass it by unnoticed. In approaching from the creek I passed up a gradually ascending slope down which the water flows, covering in its meanderings more than an acre of ground and leaving, wherever it touches, brilliant streams of color. About a hundred yards from the creek I came upon the spring, the waters of which stand nearly on a level with the surrounding surface. Approaching the border I looked down into the blue, mysterious depth and watched the large bubbles of steam slowly rising to the surface and passing off into the air. The larger of these bubbles would lift up a considerable quantity of water sometimes to the height of 3 or 4 feet, producing a kind of spasmodic boiling and dashing a succession of waves against the rim. The spring is surrounded by an irregular rim which stands a few inches above the general level of the water. The basin is 20 feet long and 10 feet wide, one end being narrower and partially separated from the main basin by an irregular row of beaded islands and projections.

Although the spring and basin are very chaste and delicate in form as well as color, there are other springs more beautiful in those respects. But when I ascended the bank and looked down upon the spring and its surroundings, I concluded, without the least hesitation, that I had never seen anything so uniquely beautiful. On the upper side of the spring, next to the bank, the water in overflowing ran into large shallow pools, painting whatever it touched with the colors of the rainbow. Beds of rich, creamy white and rich yellows were interlaid with patches of siennas and purples, and divided up and surrounded by the most fantastic patterns of delicate grays and rich browns. On the side next the creek the running water has made a net-work of streams. In those where the water is still hot, the colors are bright, varying from a creamy white to the brightest yellows, but, as the water becomes cooler, farther down, the colors grow darker and richer, the siennas greatly predominating, while the basins of the larger pools are stained with still darker colors, frequently of a purple tint and reflecting the picturesque groups of pines on their dark surfaces. Scattered irregularly over the whole surface are numberless little areas of dry deposit, from which the brighter tints have faded but which still retain such a great variety of purple and blue grays that the harmony of the whole field of color is complete.

Mr. Holmes, in his description of the Great Fountain, refers to the pebbles of geyserite in the pocket-like depressions surrounding it. These pebbles vary in size from that of a pea to two or three inches in diameter. They are made up of concentric layers. The following analysis which I have made will give their composition:

Analysis.

	Per cent.
Loss at 100° C	3.75
Loss on ignition	5.25
Silica	88.60
Alumina and iron	1.60
Lime	0.95
Magnesia	Trace.
Soda*	Trace.
Potash*	Trace.
Lithia*	Trace.
	100.15

Farther up the ravine, at the mouth of which this geyser is situated, is a group of springs around which the deposit, instead of being white, as in the case of other springs, is black. These springs were referred to in the report of 1871, page 184. I have made an analysis of this deposit and find it to consist as follows:

Analysis.

	Per cent.
Loss at 110° C	2.66
Loss on ignition	6.33
Silica	82.80
Alumina	5.64
Iron	1.49
Lime	2.13
Magnesia	Trace.
Soda*	Trace.
Potash*	Trace.
Manganese*	Trace.
	101.05

The color of the specimen I believe to be due to the large amount of organic matter included in the above analysis under the loss by ignition.

There was one quite large group of springs in the lower basin, during the summer, which escaped our notice during the season of 1871. For a

* By spectroscopic examination.

full description of it I refer to Professor Bradley's report. A specimen from this group was handed to me for analysis. Composition, irregular; color, rusty brown; fracture, conchoidal; luster, vitreous; hardness, 5.5–6.

Analysis.

	Per cent.
Loss at 110° C	4.00
Loss on ignition	5.75
Silica	85.85
Iron and alumina	1.94
Lime	1.85
Magnesia	0.30
Soda*	Trace.
Potassa*	Trace.
Lithia*	Trace.
	99.69

The Fountain Geyser is the second in importance in the lower basin, and is centrally situated. It is on a slight eminence, and from it the deposit slopes gradually toward the river, studded with innumerable springs. This geyser was fully described in the report for 1871, so I will pass it by here. Back of the Fountain are the Mud Puffs, which were also fully described last year. I wish to insert here an analysis, by Dr. Endlich, of a pink mud from this locality. A portion of the silica is doubtless combined with some of the alumina as a silicate.

Analysis.

	Per cent.
Loss on ignition	8.65
Silica	44.61
Alumina	45.09
Magnesia	2.66
Ferric oxide	1.86
Lime	Trace.
Soda*	Trace.
	102.87

Between the Fountain Geyser and the Mud Puffs, we find pieces of wood coated with geyserite, which assumed a beaded form, sometimes branching like certain forms of coral. Most of the specimens are translucent and have a vitreous luster. The color is generally a light pink. An analysis made by me of this form of geyserite gives the following result:

Analysis.

	Per cent.
Water	10.40
Silica	88.48
Alumina and iron	.88
Lime	.18
Magnesia	Trace.
Soda*	Trace.
Potassa*	Trace.
Lithia*	Trace.
	99.94

Wood may be found in various stages of silicification, and if the problem can ever be solved as to the process of silicification, I think a sojourn in the geyser-basins of Fire-Hole River will be of the highest importance

* By spectroscopic examination.

in assisting us to conclusions upon the subject. My space here is too limited to do more than refer to it.

The area of the lower geyser-basin is about thirty square miles, and the valley seems to be underlaid by a sedimentary, probably Post-pliocene, formation of which part is composed of broken bits of geyserite. The highest temperature that was recorded is 198° F., but there is no doubt that many of the springs are at the boiling-point, (199°.5 F.,) it being impossible to determine it on account of the spouting of the water. The general elevation of the lower basin above sea-level is 7,275 feet.

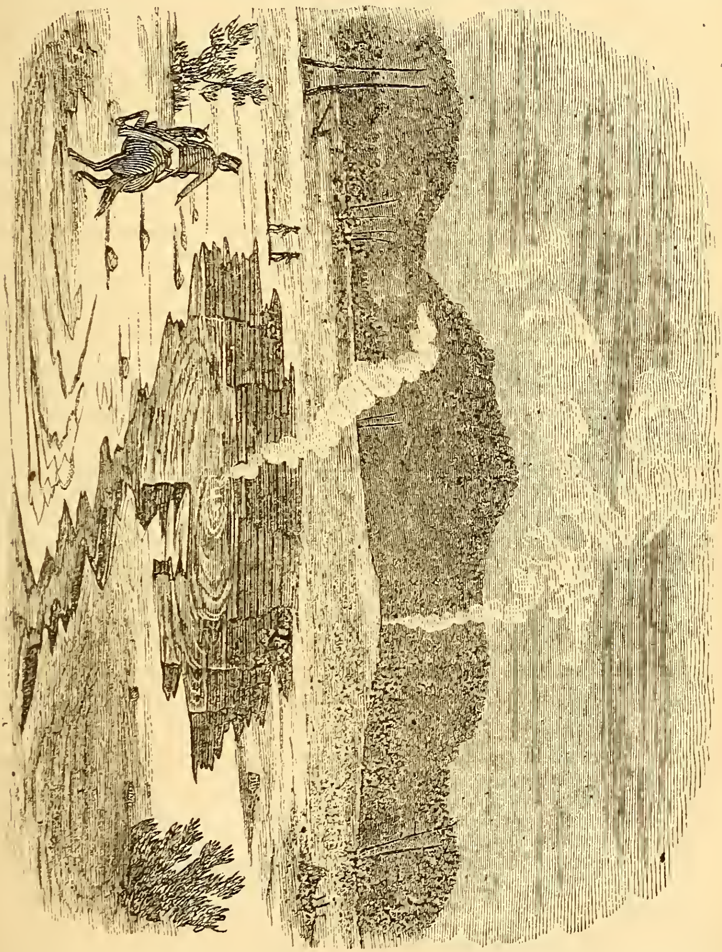


Fig. 36 a.

HALF-WAY SPRINGS, FIRE HOLE RIVER.

At the lower end of the basin the Fire-Hole River is joined by Fairy Fall Creek, at the head of which there is a beautiful fall called the Fairy Fall. This fall is 250 feet high, and the water falls into a beautiful basin at the foot of a cliff. From the mouth of this creek to the mouth of Iron Spring Creek, at the lower end of the upper geyser-basin, the distance is five and a half miles in a bee-line. Between the two there is a large group of springs that can be included in neither, and to which we gave the name of the Half-Way Springs; their general elevation is 7,296 feet. These springs were described at length in the report for 1871. The illustration (Fig. 36*a*) by Mr. Elliot shows one of the principal springs in the group. The peculiar lamination of the deposit at the edges is well shown. The elevation at the lower end of the upper basin is 7,321 feet, and at Old Faithful, at the upper end, 7,397 feet.

On the morning of August 17 all the specimens were sent to Virginia City by pack-train, and in the afternoon, in company with Messrs. Brown, Sloane, and Bingham, I proceeded to the upper basin to make observations on its principal geysers. These are named as follows: Old Faithful, Bee-Hive, Giantess, Castle, Grand, Turban, Saw-Mill, Giant, Grotto, the Riverside, the Fan, and the Soda Geyser. All of these, save the Giant and the Fan, were seen in action this year. Our stay being but three days in length necessarily renders the observations somewhat incomplete. There is but little doubt that a longer stay would develop many new geysers. We spent one day at Old Faithful, as it spouts more frequently than any of the others, and is also at the head of the valley, making a good starting-point. I will refer to them all separately below.

Old Faithful.—The mouth of this geyser slopes inward, measuring outside 8 feet by 4 feet and inside 6 feet by 2 feet. It is in a mound of geyserite that rises 11 feet 11 inches above the surrounding level, and measures at the base 145 feet by 215 feet and at the top 54 feet by 20 feet. The mound is arranged in a series of small basins, rising one above the other, in which the water, beautifully clear, stands after the eruptions. The edges of these basins, as well as the throat of the geyser-tube, are ornamented with bead-like silica. We tried to sound the depth of the geyser-tube, and after letting out the entire length of rope, 360 feet, and withdrawing it, we found the end completely tangled, which was the case in every attempt. It was impossible to get the temperature of the water, for immediately after the eruption the water sank out of sight, and at other times there was so much steam escaping that we could not even look into the tube. There are four conical mounds about Old Faithful that were probably geysers at some time in the past. The eruptions of the geyser commence with a few abortive attempts, followed by a rapid succession of jets, which soon reach the maximum, and then gradually subside and are followed by a slight escape of steam. We measured a base-line of 100 feet, and Mr. Brown was able to get the heights of five eruptions, although there were altogether seventeen witnessed during our stay, as follows:

No. of eruption.	Date.	Eruption began.	Eruption ended.	Time of maximum height.	Maximum height.	Average height.	Length of eruptions.	Intervals between eruptions.	Interval between commencement and maximum.
		h. m. s.	h. m. s.	h. m. s.	Feet.	Feet.	m.	h. m. s.	s.
1	Aug. 17	3 22 00 p. m.	3 27 00 p. m.	....	....	....	5		
2	Aug. 18	7 27 30 a. m.	7 32 30 a. m.	....	....	....	5		
3	Aug. 18	8 35 30 a. m.	8 40 30 a. m.	....	....	....	5	1 03 00	
4	Aug. 18	9 40 30 a. m.	9 46 30 a. m.	....	....	....	6	1 00 00	
5	Aug. 18	10 46 26 a. m.	10 51 13 a. m.	10 46 27 a. m.	106	49.4	4.47	59 56	1
6	Aug. 18	11 54 31 a. m.	11 59 10 a. m.	12 55 00 a. m.	130.3	45.0	4.39	1 03 18	29
7	Aug. 18	1 05 05 p. m.	1 09 46 p. m.	1 5 20 a. m.	125.5	52.2	4.41	1 05 55	15
8	Aug. 18	2 15 25 p. m.	2 20 15 p. m.	2 15 46 a. m.	125.5	49.9	4.50	1 05 39	21
9	Aug. 18	3 23 51 p. m.	3 28 22 p. m.	3 24 10 a. m.	120.8	31.9	4.31	1 03 36	19
10	Aug. 18	4 33 22 p. m.	4 38 22 p. m.	....	....	....	5	1 05 00	
11	Aug 18	5 41 00 p. m.	5 46 00 p. m.	....	....	....	5	1 02 38	
12	Aug. 18	6 42 30 p. m.	....	....	....	....	4.45		
13	Aug. 18	7 44 30 p. m.	....	....	....	....	4.50		
14	Aug. 18	8 51 00 p. m.	....	....	....	....	4.20		
15	Aug. 19	10 7 00 a. m.	10 11 45 a. m.	....	....	....	....		
16	Aug. 19	11 12 30 a. m.	11 17 20 a. m.	....	....	....	....	1 00 45	
17	Aug. 20	11 54 00 a. m.	11 58 20 a. m.	....	....	....	....		

The Bee Hive is on the opposite side of the river from Old Faithful, and about 300 yards distant in a northwesterly direction. It is on the bank of the river and recognizable at once by its cone, which is 3 feet in height and almost circular, measuring 3 feet by 4 feet at the top and 20 feet in circumference at the base. It is coated with beautifully beaded formations which, in some places, have a pearly aspect. The orifice at the top of the cone measures 3 feet by 2 feet, and the line dropped into the tube reaches a depth of 21 feet. The eruptions are very fine, and peculiar to this geyser. The water and steam escape from the orifice with great force in a steady stream. The average of the height of the column, which is fan-shaped, is very high, and, what is the curious, no water falls from it, but it seems to be entirely resolved into spray, which evaporates as soon as formed. Three eruptions were witnessed, but all from a distance, and we were able to get the height of but one, which was over 100 feet.

The following table gives the eruptions we saw:

No.	Date.	Eruption began.	Eruption ended.	Length of eruption.	Interval.
		h. m.	*h. m. s.*	*m. s.*	*h. m.*
1	August 18	1 39 p. m.	1 44 00 p. m.	5 00	....
2	August 19	3 2 p. m.	3 17 00 p. m.	15 00	25 18
3	August 20	12 34 p. m.	12 38 30 p. m.	4 30	21 17

The duration and interval are both seen to vary, although a greater number of observations are necessary to deduce any conclusions, as there may be as it were a sort of regular irregularity.

Giantess.—This geyser is on the same side of the river as the Bee-Hive and only 200 yards from it. It has a large basin, measuring 23½ feet by 32½ feet, in which the water is 63 feet deep and appears of a green color. When I took its temperature, two days after the eruption, the water was level with the rim and perfectly quiet, the mercury recording 192° F.; air, 56° F., at 11.50 a. m. The only time we observed it in action was on the evening of August 18. The eruption commenced at 6.56.30 p. m., and lasted 17 minutes, starting again at 7.43.30 p. m. This lasted about the same length of time; at 8.48.30 p. m. it was followed by a third. The maximum height of the water was 39 feet; average, 30 feet; the steam reaching a height of 69 feet. The angles for height were taken from the end of a base-line 200 feet in length. There was an immense mass of water thrown up which surged and splashed in all directions, with seventy-three pulsations per minute. After the eruption the water sank 20 feet in the basin.

Around the Bee-Hive and Giantess there is a group of springs in which I took ten temperatures, ranging from 118° F. to 196° F., the average being 173°.6 F. Among them are a number of cones, which are probably geysers spouting at long intervals, although none of them were seen in action. On one of these I saw the bodies of about a dozen mice, that had the appearance of having been scalded to death.

Castle Geyser is farther down the river, 430 yards from the Giantess, on the opposite side. It has one of the most noticeable craters that is found in the basin. The cone is on a platform measuring 75 by 100 feet and 3 feet in height. Above this platform it rises 11 feet 11 inches. It is 120 feet in circumference at the base and 20 feet diameter on top. The orifice of the geyser-tube is circular and 3 feet in diameter, and its throat is lined with large globular masses, of an orange-color, and beautifully beaded, as is seen so universally throughout both geyser-basins. An eruption is as follows: It commences with a succession of jets of water, in number about twenty per minute, which rise to various heights. These last about fifteen minutes and are succeeded by steam, mingled with spray, which escapes with a sort of pulsating movement. This soon changes to a steady escape. It seems as though the water were exhausted and the steam was being forced out as rapidly as possible. This again changes, and the steam escapes in cloud-like masses with a roaring sound, like the escape of steam from some vast escape-pipe, which in reality it is. This gradually dies away and the eruption is ended, having lasted about an hour and twenty minutes. We witnessed one full eruption and parts of two others, as follows:

First eruption, August 18.—Maximum height, 34 feet; mean height, 21 feet.

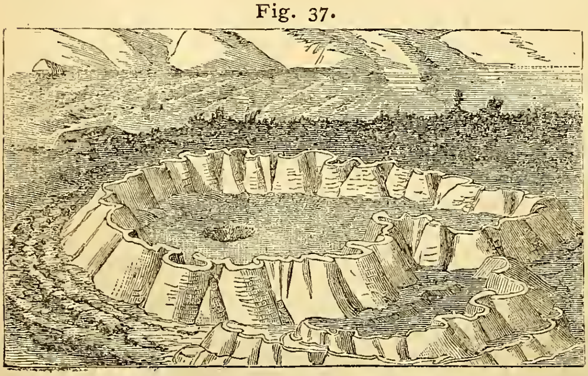
Second eruption, August 19.—10.3.0 a. m., commencement; 10.6.40 a. m., maximum of water-period, height 93 feet; 10.18 a. m., maximum of steam, height 115 feet; 11.25 a. m., end of eruption.

Mean height of water, 57 feet; of steam, 81 feet.

Third eruption, August 20.—7.24 a. m., eruption began; 7.40.20 a. m., eruption ended.

We did not see the beginning of the first eruption, and did not, therefore, wait until it was over. The angles for height were taken from the end of a base-line of 100 feet, measured from the center of the orifice, and the heights are above the end of the base-line. The third was witnessed from a distance, and the height was not ascertained. At the base of the Castle there is a spring, measuring 12 feet by 7 feet, which bubbles intermittently. The water was at the boiling-point, (199°;) air, 64° F., at 11.35 a. m. Twelve feet from this there is a second spring of the same character, measuring 6 feet by 3 feet and having a temperature of 192° F. The bed of the stream flowing from these springs is coated with bright-red oxide of iron. The water in these springs rose and fell repeatedly during the eruption of the Castle. While steam mingled with spray escaped from the Castle the water was out of sight in these springs, and when steam alone escaped they were active, spurting to the height of 3 feet. The principal spring near the Castle is a large blue spring, almost circular in shape, measuring 19 by 21 feet. It has a most regular and beautiful scalloped edge, and looks as though it were lined with white marble. This white basin slopes to a large funnel-shaped orifice, which is on the side next the Castle. This is 40 feet deep. The surface of the water is placid and appears of a most intense blue, especially over the orifice. The temperature of the water was 180° F.; air, 58° F., at 9.08 a. m. Fig. 37 is an illustration of one of the springs near the Castle, showing the ap-

Fig. 37.



RIM ABOUT A GEYSER-TUBE, UPPER FIRE-HOLE.

pearance of the crater when the water has receded into the tube. A few hundred yards south of the Castle, separated from it by a small belt of timber, there is a group of quiet springs, ranging in temperature from 100° F. to 196° F., the average being 171°.3 F. A number of them are mud-springs, and it is the only place in the upper basin where I noticed any sulphur. The analysis of a specimen of blue clay from one of these springs, by Dr. Endlich, gives the following result:

	Per cent.
Loss by ignition	15.15
Silica	50.70
Alumina	20.27
Ferric oxide	3.25
Magnesia	11.55
Lime	Trace.
Sulphuric acid	Trace.
Chlorine	Trace.
	100.92

Grand Geyser is 460 yards from the Castle, across the river. It is situated at the base of a small hill, and, unlike the majority of the geysers, has no raised cone, but only a basin sunk below the general level. One would scarcely take it to be an important geyser, unless he witnessed one of its eruptions. The basin is 52 feet in diameter and 1 foot in depth. In the center is the mouth of the geyser-tube, measuring 4 feet by 2 feet. The depth was not ascertained. All the eruptions we saw took place early in the morning, and we were unable to get the height of but one, and in order to do this we camped immediately in front of it and kept guard by turns through the night. It did not spout, however, until daylight, but we succeeded in ascertaining the exact height of the column. The eruptions are as follows:

First eruption, August 18.—5.20 a. m., eruption began; 5.35 a. m., eruption ended.

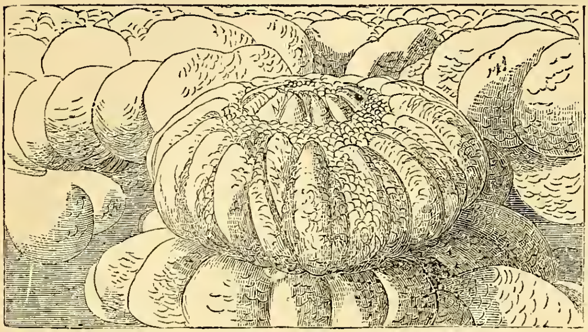
Second eruption, August 19.—3.35 a. m., eruption began; 4.12 a. m., eruption ended.

Third eruption, August 20.—6.33 a. m., eruption began; 6.36 a. m., eruption suspended; maximum height, 122 feet; mean, 79 feet. 6.42 a. m., eruption began again; 6.46 a. m., eruption suspended; maximum height, 173 feet; mean, 149 feet. 6.56 a. m., action recommenced. 7.5 a. m., eruption ended; maximum height, 84 feet; mean, 53 feet.

As is shown above the eruption consists of three distinct periods of action, after each one of which the water sank completely out of sight, and water overflowed from the Turban, which is in close proximity, into the tube of the Grand. The water during the eruption is carried up in a succession of jets, the main mass of water being large. Through this a column will shoot at intervals to the greatest height. The shape of the entire column is, therefore, pyramidal, broad at the base and tapering to a point. Immense clouds of steam accompany the water, and the latter in falling back shakes the ground. The third eruption was not as high as some that were not measured. The height must sometimes exceed 200 feet. The interval between the first and second eruptions was 22 hours, and between the second and third 26 hours and 21 minutes. During the third eruption there were at first 73 pulsations per minute, which afterward were reduced to 71.

Turban Geyser.—Although this is one of the minor geysers of the upper basin, it has, perhaps, one of the most uniquely beautiful craters. It spouts very frequently, but as all our time was occupied with the more important ones, we ascertained the height of but one eruption and obtained no data as to the interval. The crater is only a few feet from the Grand Geyser, above which it rises about 3 feet. It is 23 feet long and 11 feet wide and 6 feet in depth. The sides and bottom of this large basin are covered with globular masses that look like large squashes or pumpkins. (Fig. 38.) This resemblance is increased by their yellow color. We thought of naming it the Pumpkin Geyser, but, as the name Turban is perhaps more euphonious and some of the masses are turban-shaped, we called it the Turban Geyser.

Fig. 38.



GLOBULAR MASSES IN THE CRATER OF THE TURBAN GEYSER.

The orifice through which the water rises is situated at one end of the basin and is irregular in shape, measuring 4 feet by 3 feet. After the eruptions the water sinks into the tube very rapidly, leaving the entire basin empty. Preceding the eruption the basin fills, and the mass of water is so great that it cannot be projected to any great height. It is violently agitated and the escaping steam splashes it about in all directions.

The following is the eruption we witnessed:

August 20.—7.5.30 a. m. eruption began; 7.5.45 a. m. eruption ended. Maximum height, 25 feet; mean height, 19 feet.

Saw-Mill Geyser.—This also is one of the smaller geysers as well as one of the prettiest in the basin. The mass of water thrown up is not very great in quantity and is so broken into spray that it presents a most delicate fountain-like stream. I saw but one eruption closely, and before I had time to ascertain the height of the column, the Grand Geyser, which is quite near, began to spout, and I was obliged to leave the Saw-Mill. During its eruption there are noticed four distinct periods of action per minute, each one made up of fifteen impulses. The main body of water is carried up about 5 feet and then at intervals a stream is suddenly shot through this mass to the height of about 15 or 20 feet. I stood between the geyser and the sun, and on one side of the column there was the half-arch of a rainbow.

Giant Geyser.—This geyser was not seen in action by any member of the expedition this year, although last year it was one of the most active in the group. It is 500 yards northwest from the Grand Geyser, on the opposite side of the river, near the water's edge. It has a rough cone-like crater, 10 feet in height, measuring 24 by 25 feet at the base. The top is about 8 feet in diameter, the orifice from which the water is projected being about 5 feet in diameter. This cone is situated on a platform of geyserite, which rises 4 feet above the surrounding level and has a circumference of 342 yards. The sounding-line reached a depth of 25 feet in this cone. On the same platform there is a second cone, or rather a mound, 232 feet in diameter and 6 feet high, which has two orifices from which water spouts to the height of 12 to 15 feet at irregular intervals. The first orifice measures 6 feet by 2½ feet, and at the bottom there are two holes from which the water is projected simultaneously. The greatest depth which the line reaches here is 17½ feet.

Orifice No. 2 is 3 feet above the first. It is 1 foot in diameter and 12 feet deep. Besides these principal openings there is a large number of smaller orifices and springs scattered over the platform, some of which are quiet and some of which spout. Some of the temperatures are as follows: 194° F., 188° F., 182° F., 198° F., 196° F., 194° F., 186° F., 196° F., 194° F.; air, 68° F.; time, 4.25 p. m. The water in the Giant seemed to be considerably agitated, but never reached a greater height than about 3 feet above the top of the cone. The platform is made up of successive layers of geyserite, and on the side next the river the water has so cut into it that the layers are well exposed. They are very irregular in composition, but as a rule the lower we go the harder we find them. In one of the layers I obtained pieces that bore a remarkable resemblance to true opal, the color and specific gravity being that of semi-opal rather than geyserite. The colors are white, red, and green. Two of these specimens were submitted to Dr. F. Endlich, of the Smithsonian Institution, who has sent me the following communication in regard to them.

WASHINGTON, D. C.

DEAR SIR: I have examined the specimens from the Giant Geyser that you have kindly submitted to me, and give you herewith the results. From their position at the crater of the geyser, it may be deduced that they are older than the geyserite at the surface. The minerals form plates of about ½ to 1 inch in thickness, lying horizontal when in position, and are also distributed in irregular nodules, bordered on all sides by geyserite. For particulars in regard to locality I refer to your report. The varieties obtained are two, as follows:

No. 1.—Structure, amorphous; hardness, 6–6.5; specific gravity, 2.4903; color, milky white; fracture, sub-conchoidal; luster, dull.

Analysis.

	Per cent.
Loss by ignition	1.50
Silica	95.84
Ferric oxide	2.68
Soda*	Trace.
Lithium*	Trace.
Calcium*	Trace.
Alumina	Trace.
Total	100.02

No. 2.—Structure, amorphous; hardness, 6–6.5; specific gravity, 2.0816; color, light-greenish brown; fracture, conchoidal; luster, vitreous. Water, 6.3 per cent.

Comparing with quartz, opal, and geyserite, we find the position of this mineral as follows:

	Hardness.	Specific gravity.	Percentage of silica.	Percentage of water.
Quartz	7.0	2.5–2.8	99	0.3
Specimen No. 1	6.0–6.5	2.4	95	1.5
Specimen No. 2	6.0–6.5	2.08	....	6.3
Opal	5.5–6.5	1.9–2.3	93	7.00
Geyserite	5.0	1.8–2.0	87	10.00

We therefore have a mineral resembling in some points semi-opal; in this case, however, having but little water, a comparatively high specific gravity, and an entirely new process of formation for any mineral, occupying, as it does, an intermediate position between quartz and opal. As the characteristic feature of opal is the presence of

* By spectroscopic examination.

water, it must, in a chemical system, be referred to that species; but, taking into consideration the specific gravity, the small percentage of water, and the circumstances under which the mineral is formed, I wish to distinguish it as a well-defined sub-species of opal, and propose to name it "*Pealite*," as you were the first to find and collect the mineral.

Very respectfully,

FREDERIC M. ENDLICH.

Dr. A. C. PEALE.

The following are analyses by Dr. Endlich of specimens from the same locality. The first is from the top of one of the cones, and is a typical specimen of geyserite. It is one of the latest formed and is covered with beautiful bead-like processes, having a pearly luster. The second specimen is also from the Giant Geyser, but is from one of the lower layers and is much older. It is opaloid and in layers some of which are white and others red. The latter have a flesh-color, like raw-beef.

Analysis of specimen No. 1.

	Per cent.
Loss on ignition	13.42
Silica	79.56
Lime	1.54
Alumina	.046
Magnesia	1.78
Iron	Trace.
Chlorine	Trace.
Soda*	Trace.
Total	97.76

Analysis of specimen No. 2.

	Per cent.
Loss by ignition	6.25
Silica	92.64
Lime	1.03
Ferric oxide	0.60
Alumina	Trace.
Magnesia	Trace.
Soda*	Trace.
Strontia*	Trace.
Total	100.52

Fig. 39 is an illustration of one of the minor geysers of the Upper Basin.

The *Grotto Geyser* is 400 feet northwest from the Giant, and separated from it by a line of trees. There are two cones which spout alternately during the eruption. The larger one, which we will call No. 1, is very irregular and is 8 feet in height. The tube from which the water is projected measures 6 feet by 2 feet and is 19 feet deep. The other cone, No. 2, is 19 feet in diameter at the base and 14 on top. It is 4 feet high, and the orifice on top is quadrangular in shape, measuring 5 feet by 3 feet. When not in action the water is from 10 to 15 feet below the top. The basin is 16 feet deep. The entire length, including both cones, is 53 feet and width 26 feet, the centers of the two being 30 feet apart. The plan shown in Fig. 40 gives the relation of the two. Between them there are two small geyser-tubes which spout whenever the main cones are in action. The eruptions consist of a series of jets averaging about 20 per minute.

* Spectroscopic examination.

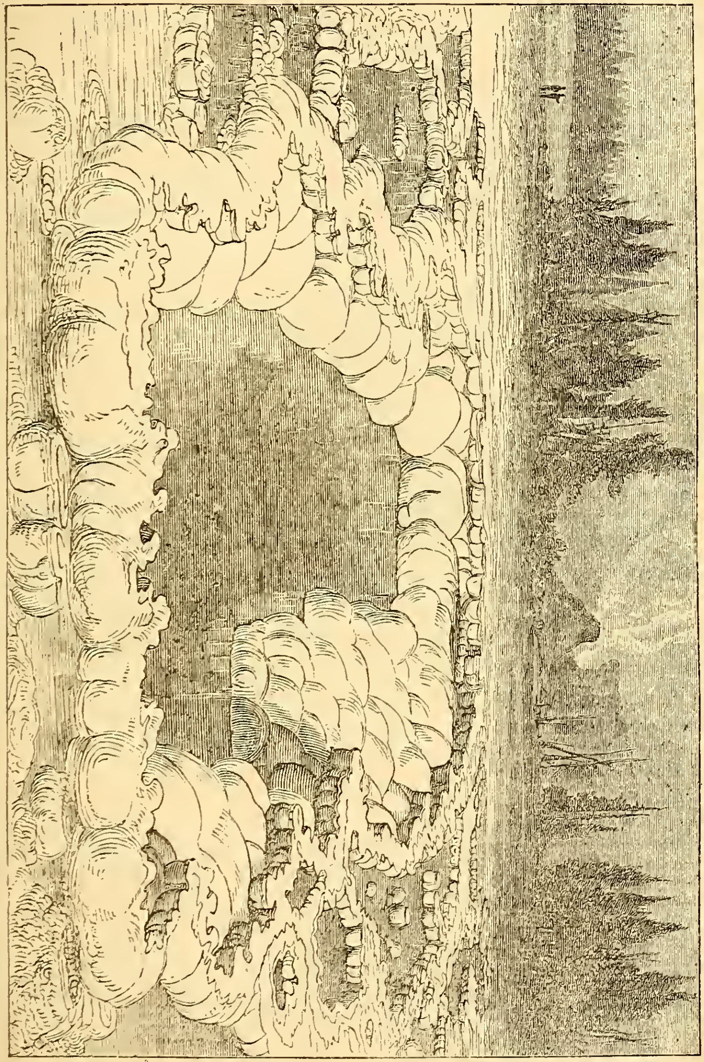
First eruption, August 16.—2.45 p. m., eruption began; 3.23 p. m., eruption ended.

Cone No. 1. Maximum height, 32 feet; mean height, 13 feet.

Cone No. 2. Maximum height, 24 feet; mean height, 8 feet.

Second eruption, August 19.—1.27 p. m., eruption began; 2.40.30 p. m., maximum of No. 1, 31 feet; 2.42.30 p. m., maximum of No. 2, 41 feet; 4.0.0. p. m., eruption ended.

Fig. 39.



OBLONG GEYSER NEAR THE GIANT, UPPER BASIN, SHOWING THE ORNAMENTAL CHARACTER OF THE BORDERS OF THE SPRINGS.

Mean height of No. 1, 16 feet; of No. 2, 13 feet.

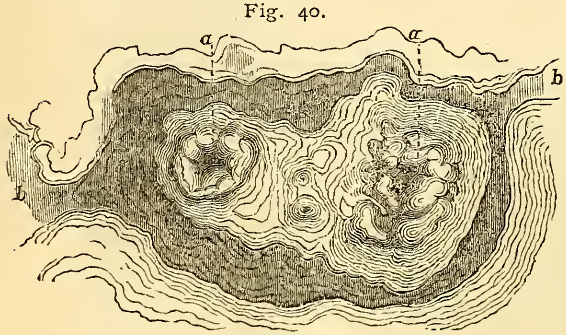
After the eruption the water sank rapidly to about 20 feet in No. 2 and 15 feet in No. 1.

The following table will present the results of the observations on the various geysers as made by myself. Other points of interest will be found in the various reports:

Name.	No of eruptions observed.	Average length of eruptions.	Average interval between eruptions.	Maximum height.	Elevation of geyser above sea-level.
		m. s.	*h. m. s.*	*Feet.*	*Feet.*
Old Faithful	17	4 53.07	1 2 45	130	7,397
Bee-Hive	3	8 10	23 17 30		7,402
Giantess	1	7 13		39	7,408
Castle	3	15 30		93	7,387
Grand	3	28 00	24 10 30	173	7,387
Turban	1	15 00		25	7,387
Grotto	2	125 30		41	7,324

As we go from the Grotto Geyser down the river on the oppsite side, we pass through the timber at the foot of a hill. Emerging from the trees the first spring we meet with is situated at the top of the hill some distance above the level of the river. This spring is bordered by cauliflower-like forms of geyserite, which have a greenish tinge. The water flows from the spring in several small streams, the bed of each one being a bright orange color. The water flowing down the hill becomes cool long before it reaches the river. An analysis of a specimen from the edge of this spring is as follows:

Fig. 40.



PLAN OF GROTTO GEYSER.

a a, Orifices of cones; *b b*, Outlets for water.

Color, greenish-gray; fracture, conchoidal; luster, dull; hardness outside 3, inside 6.

Analysis.

	Per cent.
Loss at 110° C	2.00
Loss on ignition	10.20
Silica	86.10
Alumina	1.96
Iron	.717
Lime	.28
Magnesia	Trace.
Soda	Trace.
Potassa	Trace.
Lithia	Trace.
	101.257

Thinking that the hot springs would have considerable influence on the temperature of the water in the river, I took the following temperatures in the Fire-Hole and Madison Rivers:

Position.	Time.	Temperature of air.	Temperature of river.
		°F.	°F.
Above Old Faithful	12.00 m	56	53
Below Old Faithful, opposite Bee-Hive	12.05 p.m.	58	56
Opposite Grand Geyser	12.30 p.m.	56	60
Above Giant	1.50 p.m.	58	60
Below Grotto	1.55 p.m.	58	60
East Fork of Fire-Hole River above its junction with the main river, but below springs	7.30 a.m.	44	56
Madison River, just below the junction of east fork of Fire-Hole River with the Fire-Hole River	7.40 a.m.	45	55
Madison River about twenty miles, below the junction of east fork of Fire-Hole River.	6.00 p.m.	66	60.4
	6.00 a.m.	28	56
Madison River just after its junction with the Jefferson River, near Gallatin City, Montana Territory	7.30 a.m.	45	52
Gallatin River just above the junction with the Missouri River, near Gallatin City, Montana Territory	7.30 a.m.	45	50.5

These observations were all made in August, with the exception of the last two, which were made September 10, 1872.

The following analyses are of specimens collected by the Snake River division of the expedition:

No. 1.—Geyserite ball from geysers of Shoshone Lake. Composition, irregular; luster, dull; structure, amorphous; hardness, 5.5; color, grayish white.

Analysis.

	Per cent.
Loss at 110° C	5.75
Loss on ignition	6.25
Silica	85.75
Alumina and iron	2.20
Lime	85
Magnesia	Trace.
Soda*	Trace.
Potassa*	Trace.
Lithia*	Trace.
	100.80

No. 2.—Bluish-gray geyserite from geysers of Shoshone Lake. Amorphous; laminated; luster, dull; hardness, 5.

Analysis.

	Per cent.
Loss at 110° C	5.00
Loss on ignition	8.00
Silica	76.80
Alumina	9.46
Iron	Tracc.
Lime	1.80
Magnesia	Trace.
Soda*	Trace.
	101.06

* By spectroscopic examination.

The following table gives the principal analyses of geyserite from all parts of the world.

Locality.	Analyst.	Year of analyses.	Specific gravity.	Si.	H.	Al.	Fe.	Ca.	Na.	K.	Mg.	S.	Li.	Cl.	Sr.	Mn.	Total.
Iceland	Damour			87.67	10.40	0.71 (Al. + Fe.)		0.40	0.82	Trace							100.00
Do	do			92.59	7.41												100.00
Do	do			91.23	8.97												100.00
Do	Klaproth			98.00		1.50	0.50										100.00
Do	Kersten			94.01	4.10	1.70											99.81
Do	Forchhammer			84.43	7.88	3.07	1.91	0.70	0.92 (Na. + K.)		1.06						99.97
Do	Bickel			88.26	4.79	0.69	3.26	0.29	0.11	0.11		2.49					100.00
Do	do			91.56	5.76	1.04	0.18	0.33	0.16	0.19	0.47	0.31					100.00
New Zealand	Pattison	1844	1.968	77.35	7.66	9.70	3.72	1.74									100.17
Do	Mallet	1844	2.031	94.20	3.06	1.58	0.17	Trace	*0.85								99.86
Do	Mayer			86.03	11.52	1.21 (Al. + Fe.)		0.45	0.38 (Na. + K.)		0.40						99.99
Do	do			84.78	12.86	1.27 (Al. + Fe.)			1.09 (Na. + K.)								100.09
Do	do			79.34	14.59	3.87	1.34	0.27	0.42 (Na. + K.)		0.26						100.09
Do	do			88.02	7.99	2.99 (Al. + Fe.)		1.04 (Ca. + Na. + K. + Mg.)									100.04
Do	do			86.80	11.61	Trace	Trace	Trace	Trace	Trace	Trace						98.41
Yellowstone National Park, lower geyser-basin.	Peale	1872	1.866	83.83	11.02				*4.00								98.85
Do	Hitchcock	1872		87.56	9.30	1.05 (Al. + Fe.)		0.55	0.48 (Na. + K.)		0.46						100.00
Do	Austen	1872	1.97	87.14	9.79	1.67 (Al. + Fe.)		0.49	0.68 (Na. + K.)		0.23						100.00
Yellowstone National Park, Giant Geyser.	Endlich	1873		92.64	6.25	Trace	0.60	1.03	Trace		Trace				Trace		100.52
Do	do	1873	2.4903	95.84	1.50	Trace	2.68	Trace	Trace				Trace				100.02
Do	do	1873		79.56	13.42	0.46	Trace	1.54	Trace		1.78			Trace			97.76
Yellowstone National Park, lower end of upper geyser-basin.	Peale	1873		86.10	12.20	1.96	0.71	0.28	Trace	Trace	Trace		Trace				101.25
Yellowstone National Park, lower geyser-basin, near Mud Puffs.	do	1873		88.48	10.40	0.88	Trace	0.18	Trace	Trace	Trace		Trace				99.94
Yellowstone National Park, round ball from Great Fountain, lower geyser-basin.	do	1873		88.60	9.00	1.60 (Al. + Fe.)		0.95	Trace	Trace	Trace		Trace				100.15
Yellowstone National Park, brown specimen from back of Twin Buttes, lower geyser-basin.	do	1873		85.85	9.75	1.94 (Al. + Fe.)		1.85	Trace	Trace	0.30		Trace				99.69
Yellowstone National Park, black specimen from ravine back of Great Fountain, lower geyser-basin.	do	1873		82.80	8.99	5.64	1.49	2.13	Trace	Trace	Trace					Trace	101.05
Shoshone Lake geyser-basin, white irregular ball.	do	1873		85.75	12.00	2.20 (Al. + Fe.)		0.85	Trace	Trace	Trace		Trace				100.80
Shoshone Lake geyser-basin, bluish specimen.	do	1873		76.80	13.00	9.46	Trace	1.80	Trace		Trace						101.06

* Na, cl.

CHAPTER V.

MADISON VALLEY GEYSER-BASINS TO GALLATIN CITY, CHERRY CREEK MINES.

Late in the afternoon of August 20 we left the upper geyser-basin and proceeded to the lower, where we found Captain Stevenson's party still encamped, Dr. Hayden having moved down the river. As it was too late to follow we waited until morning, when we started at daylight, and joined the party just as they were about leaving camp on Gibbon's Fork, a branch of the Madison, which joins it five miles below the junction of the east fork. The rocks between these two points are all volcanic, trachyte-porphyries, resembling those we saw at the Grand Cañon of the Yellowstone. In one place I noticed the same round geodic masses that I saw there, only here they were much larger, measuring as much as 6 inches in diameter.

Some of the trachytes are laminated, and seem to have been twisted after having been deposited. On the left bank of the river there is a high bluff-wall extending from below the east fork of the Fire Hole to Gibbon's Fork of the Madison. About three miles above Gibbon's Fork, in a gloomy gorge, is a very fine fall of about 40 feet in height. On reaching Gibbon's Fork I followed it up a few miles, to visit some hot springs which Dr. Hayden reported to me. These springs are on the right side of the river, in a valley about a mile in length and half a mile in width. The springs are situated at the foot of a ridge rising about 1,000 feet above them. This ridge is cut by numerous ravines, the divides between being rounded, thus giving to the top of the ridge the appearance of a range of conical peaks. On the opposite side of the Madison there are vertical walls of trachyte 1,500 feet in height. The springs are seven in number. The largest one is in reality a small lake, in which the water has a temperature of 140° F. It is supplied by two small streams, which have their origin each in two small springs a few feet above. One of these is a pulsating spring, the water rising about a foot above the basin. The temperatures are 135° F. to 150° F. A short distance to the east of this lake there are two other springs, having respectively the temperatures of 100° F. and 122° F. The temperature of the air during these observations was 61° F. About the center of the valley there is an old spring-basin composed of three terraces, rising about 18 inches one above the other, in much the same manner as the terraces of the Gardiner's River springs. Here the springs are extinct and the terraces are overgrown with grass. There is considerable lime, and a coating of iron lines all the channels of the streams, carrying away the overflow of these springs. They have all doubtless passed their most active period.

Messrs. Jackson and Coulter, with some other members of the survey who followed Gibbon's Fork some ten miles above its mouth, have given me the following notes in regard to a fall which they discovered:

About eight or nine miles above the mouth of Gibbon's Fork the valley gradually narrows into a deep cañon, the walls of rock rising with a steep slope on both sides from near the water's edge, leaving scarcely room enough for a rough trail. After following this cañon for about a mile, the slopes becoming steeper and the trail narrower, the river seems to issue from a perpendicular wall standing directly across the head of the cañon. On reaching this precipice, however, we found that the river makes a sharp bend to the right, forming nearly a right angle with its former course, and just at the bend makes a beautiful fall of nearly 100 feet in height. This fall is very similar to the upper fall of the Yellowstone. The stream does not leap sheer over the precipice in one unbroken fall, but after a few feet of perpendicular descent strikes upon a sloping ledge of rock and is shot out at an angle of about 45°. The scene is the more impressive from the fact that it bursts upon the view so unexpectedly. and without the least warning, the noise of the fall being shut off both by the intervening wall of rock and the rapids, into which the river is broken below. Above the fall the river runs with a smooth, slow current, no rapids breaking up its course until it reaches the very brink of the precipice, over which it plunges into the narrow gorge below.

Leaving Gibbon's Fork we find ourselves almost immediately in the upper cañon of the Madison, which averages about half a mile in width and is eight miles in length. The hills on either side rise from 1,200 to 1,500 feet above the river, those on the left side being almost vertical. The valley is partially timbered, and the hills also, wherever the trees can find a foot-hold. Near the lower end of the cañon there is a fine exposure of columns high up on the right-hand side. The rock is mostly a rough, purplish trachyte, with sanidine crystals. Emerging from the cañon we find ourselves in a wide valley, through which the east fork of the Madison flows to join the main river. Both cut their channels in serpentine manner through the modern beds, which are made up of Pliocene sands, containing a considerable amount of obsidian, which gives them a dark color. The valley is partially timbered, and must be nearly fifty miles in width. On the 22d we encamped near the junction of the east fork, just above the middle cañon, where we spent two days waiting for Dr. Hayden to join us from a side-trip through Taghee Pass to Henry's Lake. I made a trip up the valley of the east fork and ascended one of the hills bordering it on the north. The view from this point was one of the fairest that I have ever gazed upon. It seemed to unite all the elements of beauty—hill, grassy plains, and winding streams. Both forks of the Madison wind through the valley in a series of graceful curves. The rocks were not well exposed on this hill, but as far as I could judge the dip seems to be northeast at an angle of about 75° to 80°. Proceeding toward the river I came across limestones, the upper layers of which I take to be Carboniferous, although I could find no fossils to prove it. The lower layers are probably Silurian, and rest on chlorite-schists, which pass into mica-schists and gneisses. The angle of the dip of these limestones is still very great. At the head of the valley of the east fork there is a range of mountains that appear to be volcanic, and is probably part of the same range that I noticed from near the hot springs on Gardiner's River, which I referred to in a previous chapter. On one of the branches of the east fork I found on top of the modern beds layers of trachyte, which seem to have had their origin in these mountains.

On the 25th we moved camp down the river and camped in the midst of the middle cañon. In one of the gullies at the upper end of the cañon I found grains of glauconite in a quartzite-rock. The western side of the cañon seems to be composed entirely of metamorphic rocks, while the eastern side has outcrops of Silurian and Carboniferous limestones, which at the upper end incline northeast at a high angle.

On the 26th I visited a small side cañon on the eastern side of the river, through which a small creek flows to join the Madison, a short distance above camp. It was so narrow and rocky that we were obliged to leave our horses at the mouth. The first rocks we encountered were quartz-schists, followed by chlorite-schists, the strike seemingly at right angles to the course of the stream, the dip being southwest. The next rocks were very compact limestones, dipping underneath the chlorite-schists. The lines of junction could not be seen, but they seemed to be conformable. The angle of inclination was about 60°.

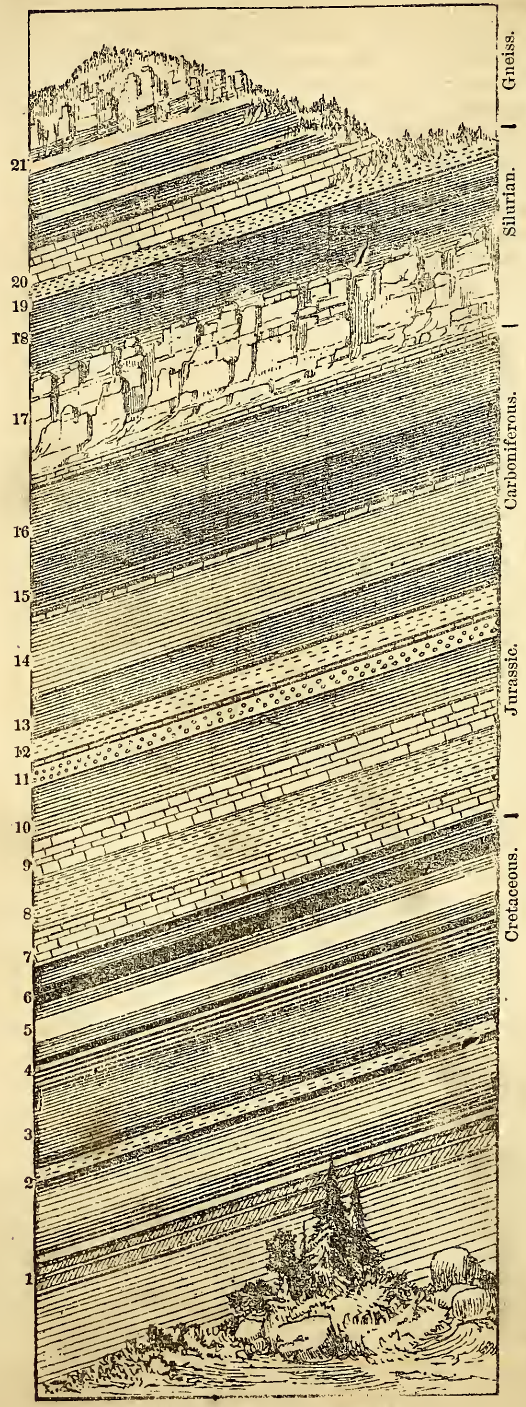
These beds I took to be Silurian, although I could find no fossils. They were followed by Carboniferous limestones, dipping unconformably beneath them at an angle of 50°. This unconformability was caused, most likely, by the force of upheaval. There appears to be a complete inversion of the strata, which a few miles farther up the river we saw almost vertical, but dipping northeast. On the opposite side of the river I found quartz-schists, but they were so covered by detritus and the timber that very little could be determined in regard to them. I will refer again to the inversion of the strata further on.

The middle cañon is seventeen miles long, and its direction from the upper end to the creek, where I found the inverted strata, is northwest. Here, however, it takes an abrupt turn toward the west, almost at right angles to its former direction, and is cut through chloritic and gneissic rocks.

On the 27th we camped just outside the cañon, and from this point, in company with Messrs. Gannett, Holmes, and Savage, I made a trip through Raynold's Pass to Henry's Lake, and thence across the divide, again to the valley of Red Rock Lake. The metamorphic strata still continued dipping southwest. At Taghee Pass, east of Henry's Lake, I believe they are capped with Carboniferous limestone. Raynold's Pass is low, only 6,911 feet in height. The ascent is very gradual, and it is difficult to determine exactly where the stream running into the Madison ends and that running into Henry's Lake begins. To the southwest of Henry's Lake I noticed in the distance a volcanic range. This section of country, however, will probably be fully treated of by Professor Bradley, and I therefore pass it. The divide between Henry's Lake and Red Rock Lake is 7,271 feet high, the distance between the lakes being about eight miles. On the Red Rock side of the divide I found in the valley of a small stream an excellent exposure of reddish quartz schists, the thickness of which I estimated at about 2,000 feet. I am of the opinion that they rest immediately on the granites. They dip southwest at an angle of 20°. Viewed from a short distance the out-crop has the appearance of a huge staircase. Between Red Rock Lake and the Madison Valley the formations are mostly modern, mingled with igneous rocks, the exact relations of which I had not time to determine carefully.

After leaving the middle cañon, the Madison River makes another turn of nearly 90° toward the north, and when we reach the point a short distance below, near Indian Creek, we find the limestones which we saw in the middle cañon again making their appearance. I made several trips into the Madison Range, one above Indian Creek, one at Bear Creek, and a third up Jackass Creek, at the lower end of the valley. Above Indian Creek I found the ridges and peaks made up of mica-schists, which were so covered with detritus that little could be determined in regard to them. We had a great deal of bad weather about this time, which also interfered much with my work. Among the specimens I obtained are aplite, micaceous gneiss, and quartz. Bear Creek is a small stream, joining the Madison on the right side, about forty-eight miles below the cañon. The rocks at the mouth are hard blue and yellow limestones, containing fragments of corals and crinoids. These I take to be either Upper Silurian or Devonian. The layers are very much contorted, but the dip is about west, or, perhaps, a little north of west; angle, 20° to 30°. These beds are followed by dark-blue Carboniferous limestones, containing *Strophomena*, *Spirifer*, *Productus*, and *Orthis*.

Fig. 41.



INVERTED BEDS OF JACKASS CREEK.

The entire exposure of limestones is about 800 feet in thickness. The upper, or rather lower, layers—for they are inverted as I found them in the middle cañon—are magnesian, and contain in places bladed crystals of tremolite. The limestones are followed by 430 feet of massive quartzites, which are at first white and then dark from the presence of iron. Beneath the quartzites, and dipping in the same direction at an angle of 20°, are alternate layers of sandy and calcareous shales, with interlaminated bands of coal-like slates, which break readily at right angles to the plane of deposition. They are followed by greenish-gray calcareous sandstones, breaking into lamina from ½ inch to 2 or 3 inches in thickness. These contain *Trigonia*, *Modiola*, and other fossils, proving their undoubted Jurassic age. All of these rocks are conformable to each other.

Jackass Creek joins the Madison at the lower end of the valley, just above the lower cañon. This creek, like the others, cuts deeply into the range, affording an excellent chance to get at its structure. The range, however, is so long and so rugged, capped with so many sharp peaks, that to determine its geology with precision will require the work of several seasons, and I will be able, therefore, to give only a general idea of it. Still I think future research will modify but little my idea and only fill in the details that are wanting. There is no doubt but that it presents one of the most interesting fields of study to be found in the West. Jackass Creek emerges from the mountains through a cañon, the mouth of which is very narrow and bordered by gneisses, which are very micaceous and of a black color. As we proceed up the stream they become lighter. The exposure on the right bank is very fine, the bedding being conspicuous, dipping northwest at an angle of 20° to 30°. About a mile inside the cañon we meet first with the limestones, which seem to dip underneath the gneissic rocks. On the left-hand side of the cañon, as we go up stream, there are two hills, on one of which the out-crop is gneissic and on the other limestone. Between is a deep gully, in which the line of junction is so obscured that even with the most careful investigation it could not be determined. Just above the limestones we find shales and quartzites, which probably represent the Potsdam group. Between there is a very compact porphyritic rock, which I take to be an old intrusion of igneous material. The limestones are very compact and brittle, and in layers of about 6 inches in thickness, dipping northwest at an angle of 30°, seemingly conformable with the gneisses. They are probably Silurian, and we found in them the fragment of a tribolite and lingulepis. Still farther up the cañon we find Carboniferous limestones, containing well-defined Carboniferous fossils, dipping northwest, conformably, with the Silurian beds. These layers above weather a blue color, those below yellow, and between them red. Then follows a porphyritic layer, resembling the one seen above the Silurian rocks. It is followed by what I take to be Jurassic beds. Although I found no fossils here, the rocks are precisely of the same character as those I found in Bear Creek, which contained *Trigonia*, &c. Then followed more modern beds, made up of soft, gray calcareous sandstones and clay-slates. The lowest layer observed was igneous material. The accompanying illustration, Fig. 41, corresponds with the following section:

1. Igneous rock.
2. Clay-slates.
3. Soft, gray sandstone. Containing fragments of leaves.
4. Green and black shales.
5. Gray shales.
6. Green and black shales.
7. Quartzite.
8. Shales.
9. Quartzite.
10. Limestone.
11. Conglomerate.
12. Porphyritic, igneous rock.
13. Dark-blue limestone.
14. Reddish limestone. } *Spirifer*, *Productus*, and *Zaphreretis*.
15. Yellowish limestone. }
16. Bluish limestone. }
17. Silurian limestones.—*Trilobite* and *Lingulepis*.
18. Shaly sandstones.
19. Porphyritic, igneous rock.
20. Quartzite.
21. Gneiss.

Toward the north the strike of these rocks seems to bend more and more toward the east, and probably extend across to the Gallatin, where I shall refer to them again further on.

The valley of the Madison from the middle cañon to the lower cañon is fifty miles long and averages six miles in width. It once formed the bed of a lake, which was probably one arm of the lake to which I have referred before as covering the country about the Three Forks of the Missouri, and extending also into the valleys of the Gallatin and Jefferson Rivers. Since the subsidence of the waters the gradual elevation of the country at the head of the river has caused it to carve out of these deposits a beautiful set of terraces, the most perfect I have ever seen. At the head of the valley there are four of them, all well defined. Some are capped with basalt and trachyte, which is columnar above and laminated below. Opposite Virginia City there are two, the first of which, on the west side of the river, is 53 feet in height and on the eastern side is wanting. The top of the second terrace is 243.5 feet above the level of the river on the western side and 149 feet on the eastern side. These terraces are but the remnants of what once filled up the entire valley, and are composed above of very soft sandstones, containing fine grains of mica. These sandstones pass down into conglomerates. The beds are all calcareous and nearly horizontal in position. On the western side of the Madison Valley we find granites outcropping, upon which are limestones probably from the Silurian upward. The Carboniferous beds, at any rate, are present in considerable thickness. The underlying rocks in the valley, upon which the lake-deposits rest, I take to be granites. The accompanying illustration (Fig. 42) will show what I conceive to be the structure of the country. It represents a section across the country in a westerly direction from the east side of the Gallatin River to the west side of the Madison. The dotted lines represent the relation of the inverted beds, extending along the entire Madison Range to the beds resting on the granites on the west side of the Madison. The force which inverted the beds of the Madison range was probably oblique in its direction. The amount of erosion since the upheaval must have been enormous. I shall refer to this section again when speaking of the Gallatin Cañon.

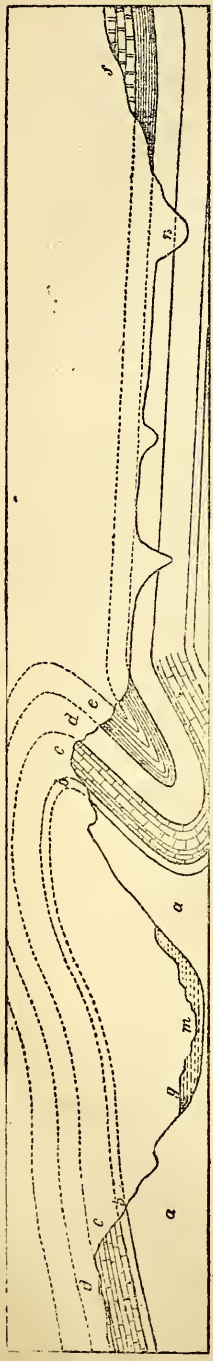


Fig. 42.

SECTION FROM GALLATIN RIVER TO MADISON RIVER, M. T.

M, Madison River; N, Gallatin River; A, Granite; B, Silurian; C, Carboniferous; D, Jurassic; E, Cretaceous; F, Volcanic; G, Terraces Tertiary.

When I visited Jackass Creek with Mr. Holmes and one of our packers, we left the main party on the west side of the river, on which side they intended to proceed down stream some distance before crossing, while we were to go down on the east side skirting the lower cañon as closely as possible, and after visiting the Cherry Creek mines to join them as soon as we could overtake them. We left Jackass Creek on the morning of the 8th and proceeded to the river, which we followed until we reached the point where it enters the middle cañon. We then struck up on to the hills, which we found to be composed of granitoid rocks, mostly gneisses. We were unable to get very near the cañon, on account of the ruggedness of the country. We spent the day descending into deep ravines and crossing high ridges. The country is very rough and we had no trail to follow. Several times we thought we might be obliged to turn back. The highest point we reached had an elevation of 8,000 feet. This was on the divide between the Gallatin and the Madison, and we had a good view of the valleys of the Gallatin, Madison, and Jefferson, which lay spread out before us, the relations to each other of the different patches of lake-deposits between the rivers being beautifully shown. In the gneisses over which we were passing, which dip northwest, there are numerous veins of white quartz. In one place I noticed immense masses of it containing a green mica, *fuchsite* which was so abundant that it gave a green color to the entire mass. We camped late in the evening at the head of Pole Creek, which we mistook for Cherry Creek. In the morning we proceeded down stream, hoping to reach the mines. We found that the gneissic rocks continued for some distance and were succeeded by beds of massive quartzite resting conformably on them. These quartzites are succeeded by sandstones, shales, and shaly limestones, above which, we find a bed of jasper and flint containing a beautiful variety of specimens. Above this is a bed of limestone. All of these beds are probably Lower Silurian. Reaching the mouth of Pole Creek we found that it was a branch of Cherry Creek, and we were four miles below the mines. We then turned our horses' heads up stream and reached the mines about noon. We spent two hours examining them, during which time I obtained the following information: The mines are situated in gneissic rocks of distinct bedding, dipping northeast. All the openings have been made on the side of the hill, which faces toward the south. The first discovery was made at the Havana lode, near the Madison River, some four miles northwest of the present camp, in May, 1872. Next, the Devil's Gate lode was discovered, 3,000 feet southeast of the Havana. In June the discovery was made at the present camp. There has really very little been done, as yet, beyond the staking of claims and the beginning of shafts into them. I will give the names of the various lodes that I visited, with various points of interest concerning them:

Eberhardt lode.—This lode was discovered on the 5th of June, 1872. It is three feet in width and strikes north 75° west, dipping north 15° east; angle, 40°. The walls are gneissic. The gangue is quartz and jasper containing native silver. The assays of the ore are said to average $600 per ton. There are two claims on the lode, one called the Eberhardt Discovery and the other the Eberhardt Extension. A shaft has been sunk in each to the depth of 15 feet. Not more than four or five tons of ore have been taken from these shafts. Several sales in this lode have been made since its discovery, averaging about $150 per 100 feet.

The Heintzleman lode was also discovered on the 5th of June, 1872. It is above and parallel with the Eberhardt. The strike is north 80° west; dip, north 10° east; angle, 40°; width, 3 feet. The walls are gneissic; the gangue is the same as in the Eberhardt, containing native silver and pyrites. There are two claims, and two tunnels are being driven into it. One has reached a depth of 25 feet and the other 30 feet. The ore is said to average $900 to the ton, none of the assays ever having been less than $300; the greatest (a picked specimen) gave a result of $5,670 to the ton. One hundred and fifty feet of this lode were sold for $3,500, with the agreement that a shaft was to be sunk to the depth of 100 feet.

Clarke lode.—This lode was discovered June 11, 1872. The strike is northwest; dip, northeast; angle, 50°; width, 2½ feet.

Alabama lode.—This lode is below the others. Strike, north 70° west; dip, northeast; angle, 60°. It is only a few inches in width, and at present there is only a small opening into it.

Pennsylvania lode was discovered June 11, 1872. This is also quite narrow, not exceeding a foot in width. The strike is north 30° west; dip, northeast; angle, 65°. Assays are said to yield $54 in gold and $22.75 in silver.

G. W. Rea lode is 3½ inches in width. The ore has never been assayed.

Valentine lode is supposed to be an extention of the Eberhardt. Very little work has been done on it yet.

Z. Daniel's lode.—This lode was discovered June 7, 1872. It has a shaft 10 feet in depth. The crevice is 2 feet in width. The strike is northwest; dip, northeast; angle, 50°.

Home lode.—This lode was discovered June 9, 1872, and is one of the richest in the district, the ore being said to have assayed $3,200 per ton. The strike is north 30° west; dip, northeast; angle, 48°. The width is 3 feet. There have been two shafts sunk on it, one reaching 10 feet in depth, the other 15 feet. The strike seems to turn to the southwest, and the angle decreases to 45°. A three-fourths interest in this lode (1,125 feet) has been sold at $900.

Parasol lode is above the Heintzleman, and parallel with it. It dips northeast at an angle of 60°. It is 4 feet in width, and has a shaft 10 feet in depth.

Emma lode is above the Parasol, and parallel with it. It is 2 feet in width.

New Haven lode is on top of the ridge above the Emma, and is 18 inches in width. Other lodes in this district are the *Claggett*, *Yankee Doodle*, *Merrimac*, *Davis*, *Silver Crown*, and *Monarch*.

The Harper lode is opposite the Cherry Creek district, on the opposite side of Cherry Creek, and is in limestones instead of gneisses. It is 25 feet wide, and the strike is nearly east and west; dip, south. It was discovered July 12, 1872. The ore is said to assay $37 in gold and $7 in silver per ton.

When I visited them there were fifty men working at the Cherry Creek mines, their wages being $4 per day, or $75 per month with board. This is the first important discovery of silver in the Territory, and there are no mills for the reduction of the ore at present. Whether the ore is in ore-beds or bedded veins cannot be determined without further investigation. Some of the lodes have been traced from the Madison River a distance of more than four miles. The country-rock is all gneissic, and the lodes are parallel with each other. It will be noticed that they are all narrow, but it is claimed that they widen as we descend. The metallic silver is very apparent in the ore, having the form of arborescent crystals.

On the opposite side of the Madison we find the *Silver Shower district*, containing silver mines, which were discovered about the 28th of June, 1872. It is probable that they are merely extensions of the ledges we have described on the east side of the Madison, as the ore is said to be much the same and occurring in the same manner in gneissic rocks. The principal lodes in the Silver Shower district are the *Silver Shower*, the *Pilgrim*, the *Stonewall Jackson*, the *Chloride*, and the *Cross-Key*. The assays are said to vary from $650 to $900 per ton. Native silver is not seen so abundantly as in the specimens from Cherry Creek. Specimens from the Stonewall Jackson lode contain galena, which is not seen at Cherry Creek.

Leaving Cherry Creek we crossed the hills to Elk Creek, which runs almost parallel to Cherry Creek. On the way we passed, on top of the ridge, several openings, none of which were developed to any great extent. Reaching Elk Creek we followed it to the Madison, where we learned at a ranch that the party had passed down the river the day previous. We camped for the night a few miles below the mouth of Elk Creek, and the next morning started down the Madison. The bluffs on either side of the river are made up of Pliocene marls and sandstones, the remnants of the lake-deposits. In some of the ravines, cut in these bluffs by the little streams, we find beautiful specimens of silicified wood. We reached Gallatin City at the Three Forks of the Missouri about noon, and learned that the party had camped there the night before and had left early in the morning on their way up the Gallatin River. We followed and joined them at night-fall. Above Gallatin City, on the north side of the river, there are several fine exposures of Carboniferous and Silurian rocks, the consideration of which I reserve for the next chapter. About four miles above Gallatin City, on the right-hand side of the stage-road leading to Bozeman, I noticed bowlders of brown, flinty rock, resembling those I saw on Pole Creek, but was unable to determine whence they came. The following day, September 11, we reached Fort Ellis, and camped on our old camp-grounds, from which we had been absent almost two months.

CHAPTER VI.

GALLATIN VALLEY, BOZEMAN CREEK, MIDDLE CREEK, MOUNT BLACKMORE, AND WEST GALLATIN RIVER.

On the 14th of September, in company with Messrs. Gannett and Holmes, I left Fort Ellis to ascend Mount Blackmore and investigate the geology of the country south of the Gallatin Valley. The range in which the peak is situated gives origin to the branches of the East Gallatin, and once formed a portion of the southern shore-line of the lake which extended over the country about the Three Forks. Although the peak stands up prominently, and is in plain sight from Fort Ellis and Bozeman, it was difficult to determine exactly which stream would lead us to its base. We selected Bozeman Creek as the one to follow, hoping that if it did not lead us to the right point we would be able to cross the ridges and thus accomplish our purpose. We camped in the evening, just inside the mountains, in the cañon of Bozeman Creek, and the next day pushed on up stream. The timber along the creek was so thick that we ascended the hills, hoping to find traveling less difficult. We were obliged, however, to return to the bottom of the cañon. From the mouth of the cañon for about five miles the granites are the only rocks exposed. Succeeding them are the limestones to which I referred in the second chapter when speaking of Mystic Lake. The hills come down so abruptly to the edge of the creek and the cañon is so densely timbered that, in order to make any progress at all, we were often obliged to wade in the bed of the stream. On reaching Mystic Lake we found that it would be impossible to take our animals across the ridges which separated us from Mount Blackmore, and that our best plan would be to try the next creek to the westward. So, joined by Mr. Jackson and his party, who had been at Mystic Lake several days photographing its fine scenery, we returned to the plain of the Gallatin Valley, and the next morning, skirting the edge of the mountains until we reached Middle Creek, we entered its cañon. We found the lower part of the cañon quite open and had very easy traveling for about two miles, when it began to narrow, and the granite rocks towered high above us on both sides of the stream, which here rushes furiously over its rocky bed. Immense slides of rock extend from the cliffs above to the water's edge, and, with the dense pine-forest through which we were obliged to cut our way with the ax, rendered our progress slow and difficult. The rocks are mostly gneissic, dipping northeast at an angle of about 70°. After five miles of this rough traveling we came out into a small open valley or park, bounded on either side by rather low rounded hills covered with sage-brush; here we camped. Shortly after getting out of the cañon we find limestones crossing the creek, the strike being almost at right angles to its course. On the left bank of the creek there is a bluff showing a fine exposure of the layers, which I take to be Silurian, although no fossils could be found. They dip south of east 45° to 50°. They are, probably, a prolongation of the layers below Mystic Lake. Between the two points there must be a rather abrupt turn in the strike. When at Mystic Lake, however, I noticed that the layers began to turn more and more toward the west as we followed them below the lake. A little farther up the valley of Middle Creek we found true Carboniferous beds containing *Orthis*, *Spirifer*, *Strophomena*, *Atrypa*, and other Carboniferous fossils. Still farther up the valley we find that the dip is reversed, and we have crossed a synclinal which is at right angles to the course of the stream. The occurrence of volcanic outbursts at the head of the stream has thrown the sedimentary beds into some confusion, so it is difficult to reduce them to any system. On the 17th we camped in one of the most picturesque valleys or parks that I have ever seen. It is about a quarter of a mile in length and almost oval in shape, bordered by a line of grand old pines. Through the center of the park Middle Creek flows. Back of the trees on the east side of the park, rising to the height of over 3,000 feet above the bed of the creek, is an almost bluff wall of volcanic rock, the prevailing color of which is black, relieved here and there by streaks of red and green, as though it had been painted. This wall is surmounted by dome and spire like points of rock, in whose crevices lay deep snow-banks. At some points on the wall we could distinguish groups of stunted pines. On the opposite side of the park is a similar wall, which has been more affected by the processes of weathering and presents many curious architectural forms. It does not require a very vivid imagination to trace on its front the forms of castles and fortress-walls. At the head of the park the wall makes a slight turn to the east, and here there are three monument-like piles of rock, dome-shaped masses surmounting perpendicular walls, on which we could see numerous waterfalls, looking like silver threads against the black background. To the most prominent of the three we gave the name of Palace Butte and the other two we called the Twin Buttes. The park in which we were camped we called Palace Park. From this point we concluded to strike out for the ascent of Mount Blackmore, which, although not in sight, we knew to be to the westward of us and not far off. The following morning we started, and, reaching the summit of the first ridge, saw the peak immediately before us and separated from us by a deep ravine which we were obliged to cross. On this first ridge we passed over the upturned edges of limestones, dipping about northeast, and on the opposite side of the ravine, on the side of the ridge which culminates in Mount Blackmore, there is also an exposure of limestone, dipping in the same direction. The upper layers have an inclination of about 30°, while the lower ones incline only 10°. These limestones are capped with volcanic material, which seems at first to have tipped them up and afterward crushed them. Mount Blackmore itself is a volcanic peak, and the nearness of the sedimentary rocks to the center of volcanic action, which lies to the south or southeast, has affected them to a great extent and thrown them into great confusion. Taking our horses to the timber-line (9,550 feet) we finished the ascent on foot with comparative ease. The rock of which the peak is composed is basaltic in its character, of black and red colors. On the summit it is very compact and massive, while below we find it laminated and somewhat porphyritic. On the way up I found excellent specimens of *Hyalite* in globular concretions, as clear as glass, coating the rocks and making them look as though coated with ice. I also found *Chalcedony* and a yellow variety of opal resembling somewhat fire-opal. It varies in color from a honey-yellow with a greenish tinge to a brownish red. It is opaque; luster vitreous; hardness, 5; specific gravity, 2.172. Considering its physical properties it might be distinguished as a variety of opal between fire-opal and the ordinary semi-opal. I propose for it the name of *Blackmorite,* from its locality, Mount Blackmore. An analysis of it is as follows:

Analysis.

	Per cent.
Loss at 110° C	7.40
Loss on ignition	2.40
Silica	85.20
Iron oxide	2.68
Lime	1.48
Magnesia	0.37
Soda *	Trace.
	99.53

The view from the summit of Mount Blackmore is grand in the extreme. When we turn to the south we overlook an intensely rugged country, studded with numerous sharp volcanic peaks. Quite near the peak there is one point which looks as though it were once the center of volcanic action, the sloping sides bearing a striking resemblance to the sides of an old crater. To the north the field of vision is immense. The valley of the Gallatin, from its sources at our feet to the Three Forks, lies spread out before us, and beyond we could distinguish in the dim distance even the Missouri. Here we could trace the layers of limestone from Mystic Lake to Middle Creek, thence across the Cottonwood, the next stream to the west, and thence across to the West Gallatin. All these streams have cut their way directly across the strata at right angles to the strike. To the west we could see the Madison Range, and on the east the snowy range of the Yellowstone. The elevation of the peak above sea-level is 10,134 feet. The following morning we followed Middle Creek to its sources, and found that the valley abounded in most magnificent scenery, foliage, rocks, and numerous water-falls and cascades combining to form the most beautiful pic-

* By spectroscopic examination.

tures, and Mr. Jackson concluded to remain several days in the valley. We continued on our way, hoping to be able to cross the range and descend to the West Gallatin, where we expected to join the main party the next day. We reached an elevation of 9,000 feet, and found ourselves surrounded by a semicircular wall, which rose 600 feet in perpendicular height above us. At the base lay immense banks of snow. To cross was impossible, so we retraced our steps, and on reaching the first open space above the cañon where we had encamped three days before, we crossed the ridge to Cottonwood Creek, which we followed to the plain. We then proceeded along the edge of the mountains until we reached the mouth of the West Gallatin Cañon, and, striking the trail of the main party, we pushed up stream as rapidly as possible. The rocks at the mouth of the cañon are gneisses, which dip northwest at an angle of about 75°. They are followed by immense beds of limestone, which at first, I think, dip in a southerly direction, but soon change to the northeast. The angle varies from 20° to 30°. They are the direct prolongation of the layers which we observed on Middle and Cottonwood Creeks, and which we also noticed on Pole and Cherry Creeks when we were on our way down the Madison. The limestones are again succeeded by gneisses, probably the continuation of those through which the Madison cuts the Lower Cañon. Then follow limestones dipping southwest. These I believe to be the continuation of the layers in the Madison Range, which I referred to as making a turn toward the east near Jackass Creek. To the east of the Gallatin River it is difficult to trace them, for we find ourselves immediately in a volcanic region. That there is some connection between this ridge and the layers outcropping on Cinnabar Mountain is highly probable. Just above this last ridge of limestone we found the main party encamped. On the opposite side of the river there was a high bluff wall made up of Cretaceous and Jurassic rocks. Our camp on the western side was upon Jurassic rocks. These seem to continue to the westward in a gentle slope from the Gallatin to the Madison Range. The weather became so snowy and unfavorable for work that I was not able to follow the beds to the westward, as I desired, but the section shown in Fig. 42 which I referred to in the preceding chapter, will show what I believe to be the relation of the beds exposed on the Gallatin, opposite our camp, to those of the Madison Range. To definitely settle their relation, however, the western side of the Madison Range will have to be worked out in more detail than it has been up to the present time. The cañon of the West Gallatin is so fully treated of in other portions of the report that I have thought it best merely to refer to it. Leaving the Gallatin River we crossed the divide to the Yellowstone River. On the very summit I obtained specimens of silicified wood embedded in basaltic rock, which is here mingled with Tertiary sandstones, which have here been very much metamorphosed. The elevation of the divide at the point we crossed it is 9,317 feet. We struck the Yellowstone just below the second cañon, and followed it down to Bottler's ranch. While at this point I crossed the Yellowstone River and went up Emigrant Gulch, one of the regions in which gold-mining has been carried on to a somewhat limited extent. The gulch cuts into the mountain-range for some distance in a general southeasterly direction. The rocks near the mouth of the gulch are chlorite schists, which dip in a northerly direction, or perhaps a little west of north, at an angle of 40° to 45°. These chloritic rocks extend for about two miles and a half, and are followed by gneisses, which dip underneath them. These gneisses are probably a continuation of those exposed in the second cañon of the Yellowstone.

They extend for a short distance, when we find igneous rocks resting upon their upturned edges. These igneous rocks rise to a great height on either side of the gulch, and in fact form the crest of the entire range, as I noticed when on the summit of Emigrant Peak last year. The stream descends very rapidly as it flows down the gulch, and there are numerous cascades and waterfalls in its course. At the mouth of the gulch there was formerly quite a large settlement, but at present nothing remains save the stone chimneys of Yellowstone City. As we ascend the creek the gulch narrows very rapidly. There are two mining-camps, one at the head of the stream, the other at the mouth of the gulch. The mines are all placer-diggings, and at present there are only twenty or thirty men working here. The highest yield is $15 per day, the average being about $5 per day to each man. There are four claims worked at the lower camp and three at the upper, and since the discovery, in 1864, it is estimated that the gulch has yielded over $100,000.

The chloritic rocks, which are exposed in Emigrant Gulch, extend along the range as far north as the Lower Cañon of the Yellowstone. Near the latter, in one of the smaller gulches, I obtained specimens of *Itacolumite* in lamina about an inch in thickness and having a greenish color. None of the specimens were flexible. Our next camp, after leaving Bottler's, was just above the Lower Cañon of the Yellowstone. Here the limestones extend across the river, which cuts through them almost at right angles to the strike. The dip of the beds is east of north. They are probably the continuation of one branch of the anticlinal, which we have referred to before in Spring Cañon. On the north side of the cañon we find Jurassic layers resting immediately on thick beds of quartzite, which lie between them and the Carboniferous limestones. The inclination of the beds is about 25°. The Jurassic beds consist of alternate layers of calcareous clay shales, which weather blue, and hard, yellow limestone. They contain great quantities of fossil, among which are *Trigonia*, *Ammonites*, *Ostrea*, and *Pinna*. These are succeeded by Cretaceous sandstones, which are in turn followed by Tertiary strata, which are from 1,500 to 2,000 feet in thickness. After passing through the Lower Cañon, we turned to the left and proceeded up Divide Creek, a small stream flowing into the Yellowstone from the western side. Its valley, for the most part, is a monoclinal valley, between Cretaceous and Tertiary strata. The Tertiary beds are composed of sandstones, which are generally quite soft and of a gray color. The lower layers are often quite hard, and of a somber brown color, seeming to have been somewhat changed. At several points I noticed the occurrence of dikes, to which this change may be attributed. The general dip is in a northerly or northeasterly direction, and the angle about 35° to 40°.

Reaching the head of the stream, we crossed the divide, and found ourselves at the head of the creek which flows through Spring Cañon. Here we turned toward the right and crossed to Bridger Creek, which we followed up around the eastern side of the Bridger Range to Flat-Head Pass, through which we went to the Gallatin Valley. The rocks on the eastern side of the range at Flat-Head Pass are Cretaceous sandstones, dipping a little north of east, angle, 30° to 50°, succeeded by Jurassic layers, which are for the most part covered with grass, concealing them. The center of the range is made up of Carboniferous limestones, which are almost vertical. As we pass toward the westward, however, they begin to dip in a westerly direction. They are followed by Silurian beds, which also dip in the same direction. The Silurian layers are composed of slaty limestones, pebbly conglomerate limestones, and compact brittle limestones, containing fragments of trilobites.

They are followed by very hard, compact, micaceous sandstones. During the upheaval of this range, the line of force seems at first to have been vertical, and tipped up the layers as we see them on the eastern side. Then the force seems to have acted in a line oblique to its former direction, and, breaking through the Silurian and partialy through the Carboniferous layers, carried their lower edges to the westward; so that, while the Cretaceous, Jurassic, and a portion of the Carboniferous layers dip in an easterly direction, the remainder of the Carboniferous and all of the Silurian beds dip toward the west. This remarkable occurrence is fully treated of in Dr. Hayden's report, in which there is also a section showing the various beds.

From Flat-Head Pass we crossed the country in a northwesterly direction to the Missouri River, striking it at Horse-Shoe Bend, below the Three Forks. Between these two points there are a number of local synclinals and anticlinals. From Horse-Shoe Bend, we proceeded up the Missouri River to the junction of the Gallatin. About four miles above Gallatin City there is a magnificent exposure of strata on the east side of the river. The following section is in ascending order from the lowest exposure to the Jurassic beds.

	Feet.
1. Micaceous sandstones, interlaminated with blue, shaly limestones, weathering brownish, in bands, varying from a few inches to a foot or more in thickness. The upper layers of the sandstone are of a steel-gray color, breaking into cubical blocks, that give it the appearance, from a distance, of basalt. The general color of the sandstones is an olive-green. They contain fine grains of mica and small pebbles of quartz, mixed with a few opaque crystals of white feldspar. The rock is very hard, and has been little affected by the weather. It extends in high bluffs for considerable distance along the river. Some of the limestones contain flat, rounded concretions of about 6 inches in diameter and 3 inches in thickness. The sandstones vary in thickness from 2 to 4 feet. The general dip is northwest, inclination being 25° to 30°. The thickness of these beds is about	1,600
2. Pink sandstones, above which are heavy beds of quartzite. The general dip is about 30° northwest. Thickness, estimated at	100
3. Green and blackish shales, breaking into lamina of a few inches thickness. Low down we find layers that are of a deep-purplish, red color. Short distance above these latter, we find a very hard calcareous sandstone, containing grains of a mineral resembling *glauconite*. In them we find also the remains of trilobites. A short distance above this layer we find sandstones of about 3 inches thickness, interlaminated with green argillaceous shales, containing trilobites, *Lingulepis*, *Conocoryphe*, &c. The estimated thickness of these beds is	300
4. Layers of very hard limestone, breaking into lamina of an inch or more in thickness and containing immense quantities of trilobites. Thickness	40
5. Black, shaly limestones, containing a small *Lingula*, *Acrovleta*, and *Obolella*, followed by rather thin layers of very compact, blue limestone. Thickness	50
6. Pebbly beds of limestone, containing trilobites, and *Lingulepis*. Thickness	60

	Feet.
7. Reddish and greenish calcareous shales, with interlaminated limestones, containing trilobites. Thickness	50
8. Limestones, weathering to a brownish color, shaly in many places	200
9. Alternate beds of pebbly and compact limestones	200

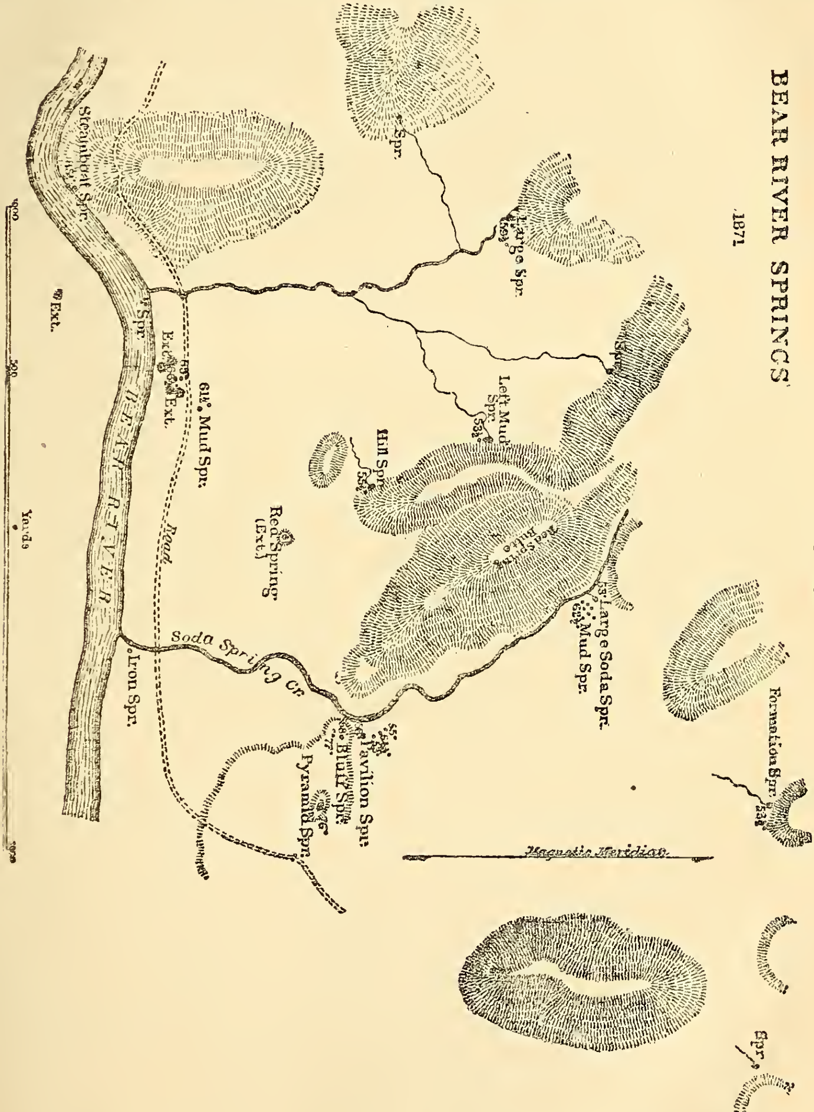


Fig. 43.

10. Thick beds of limestone in which were found *Spirifer*, *Productus*, *Chonetes*, *Zaphrentis*. The lower layers weather yellow. The layer in which the fossils occur is of a blue color, and very compact. Thickness, estimated at 1,000
11. White quartzite.
12. Jurassic beds.

For a complete list of the fossils found at this locality I refer to Professor Meek's report.

Layers 10 and 11 probably represent the entire extent of the Carboniferous beds. No. 1 should probably be referred to the Huronian series, while No. 2, I believe, represents the Potsdam group, or at least a portion of it. From No. 3 to No. 9 includes the remainder of the Silurian beds. The section given above was made with all the care possible in the limited time afforded. More extended observation will no doubt result in the discovery of new organic forms and the more accurate determination of the age of the various beds. We followed up the East Gallatin River, reaching Bozeman on the 15th of October, when the expedition disbanded for the season.

Fig. 43 shows the relations of the various springs on Bear River, which were described in the report of 1871. These springs were described by Frémont in 1843, and called the Beer Springs, from the agreeable taste of the water.

No. 1.—CATALOGUE OF THERMAL SPRINGS.

Locality.	Number of springs.	Position.	Elevation above sea-level.	Time of observation.	Gases evolved.	Principal constituents.	Temperatures Fahrenheit. Highest.	Lowest.	Average.	Of air.	Boiling-point.	Date of observation.
			Feet.				°	°	°	°	°	
Near Colorado Springs on the Fontaine qui Bouille, Colorado Territory.	5	Granites	6,529	Afternoon	Carbonic acid	Carbonates of lime, soda, potassa, magnesia.	60	48.5	54.06	70	201	May —, 1872
Do	2	...do		12 m	...do		67	63	65	68		*July 13, 1820
Do	2	...do		11 a. m	...do		69	60.5		73		†July 18, 1843
Do	2	...do		Sunset	...do		61	58		66		†July 18, 1843
Do	2	...do		Sunrise	...do		57.8	54.3		57.5		†July 19, 1843
Mouth of Ogden Cañon, near Ogden City, Utah Territory	1	Syenites	5,000	4 p. m	...do	Iron and carbonates	121			73	204	May 30, 1872
Ten miles above Ogden City, Utah Territory, 4 miles from Salt Lake.	10	Quartzites	4,517	Evening	...do	Chloride of sodium, iron, lime, and magnesia carbonates.	136	109	129	83	‖204	June 11, 1871
Do	12	...do		4 p. m			135		129			May 29, 1872
Do	2						136	132½				‡Sept. 5, 1843
Twelve miles north of Brigham City, Utah Territory.	3	Limestones, probably.		4 p. m	Carbonic acid	Chloride of sodium and carbonates.	128	68	72.33	78		June 25, 1872
Do	5	...do		9 a. m	...do	...do	132	60	102.08	36		Nov. 10, 1872
Do	1	...do			...do	Chloride of sodium, iron, carbonate of lime.	134					§Sept. 13, 1843
Lincoln Valley, near Fort Hall, Idaho Territory.	5	Limestones	4,720	Morning		Alumina, lime, carbonic acid.	87	69	75.68	80	‖204	June 22, 1871
Hot Spring district, Madison County, Montana Territory.	3	Syenites	4,804	...do		Carbonates	76	64	70	48	‖204	July 8, 1871
Do	3	...do	4,804	...do		...do	124	110	117	50	‖204	July 8, 1871
Gardiner's River, Mammoth Hot Springs. First group level of river.	7	Limestones and igneous rocks.	5,750	8 35 a. m	Sulphureted hydrogen.	Lime, iron, alumina, magnesia, silica, carbonic acid.	132	94	110.02	70		July 29, 1872
Second group, between river and main springs.	2	...do	5,980	8 a. m	...do	...do	140			65		July 29, 1872
Third group, 1st terrace	4	...do	6,278	8.40 a. m	...do	...do	160	150	155	70		July 28, 1872
Fourth group, 2d terrace	3	...do	6,304	9 a. m	...do	...do	162	144	156	69		July 28, 1872
Fifth group, 4th terrace	1	...do	6,412	9.25 a. m	...do	...do	152			72		July 28, 1872

* Long's expedition to the Rocky Mountains in 1819-'20, vol. 2, page 24. † Frémont's exploring expedition, 1842-'43-'44, page 118. ‡ Frémont, page 150. § Frémont, page 159.
‖ Approximate.

Locality.	Number of springs.	Position.	Elevation above sea-level.	Time of observation.	Gases evolved.	Principal constituents.	Temperatures, Fahrenheit. Highest.	Lowest.	Average.	Of air.	Boiling-point.	Date of observation.
			Feet.				°	°	°	°	°	
Gardiner's River, sixth group, fifth terrace.	1	Limestones and igneous rocks.	6,465	9.30 a. m.	Sulphureted hydrogen.	Lime, iron, alumina, magnesia, silica, carbonic acid.	152	......	......	74	......	July 28, 1872
Seventh group, 6th terrace	8	....do	6,491	12.30 p. m.	......do	......do	152	148	149	80.5	......	July 28, 1872
Eighth group, 7th terrace	2	....do	6,551	10 a. m.	Sulphureted hydrogen and carbonic acid.	......do	154	150	152	72	......	July 28, 1872
Ninth group, 8th terrace	1	....do	6,556	9.45 a. m.	Sulphureted hydrogen.	......do	122	......	......	72	......	July 28, 1872
Tenth group, 9th terrace	6	....do	6,591	10.14 a. m.	......do	......do	162	157	151.17	74	......	July 28, 1872
Eleventh group, 10th terrace.	2	....do	6,596	10.30 a. m.	......do	......do	162	129	141	74	......	July 28, 1872
Twelfth group, 11th terrace	3	....do	6,603	10.35 a. m.	......do	......do	154	148	150.66	74.5	......	July 28, 1872
Eighteenth group, 12th terrace	8	....do	6,681	12.20 p. m.	......do	......do	162	160	160.75	78.5	......	July 28, 1872
Fourteenth group, 13th ter	14	....do	6,758	11.12 a. m.	......do	......do	148	108	138.43	78	......	July 28, 1872
Fifteenth group, 14th terrace.	14	....do	6,779	11–11.50 a. m.	Sulphureted hydrogen and carbonic acid.	......do	145	92	107.29	74	......	July 28, 1872
Near Lower Falls of Yellowstone River, Yellowstone National Park.	1	Trachytes	6,188	Morning	Sulphureted hydrogen & carbureted hydrogen.	Iron, alumina, lime, magnesia, sulphuric acid.	127	......	......	70	......	Aug. —, 1871
South of Mount Washburne, near its base, 1st group.	8	Igneous rocks	8,117	7.30 a. m.	Sulphureted hydrogen.	Sulphur, alumina, iron, silica.	190	52	116.5	76	198.3	Aug. 5, 1872
South of Mount Washburne, near its base, 2d group.	4	Igneous rocks and clay.	......	9 a. m.	......do	Sulphur, lime, iron, alumina, magnesia, sulphuric acid.	194	140	177	78	198	Aug. 5, 1872
South of Mount Washburne, near its base, 3d group.	3	....do	......	9.30 a. m.	......do	......do	190	185	188.33	79	197.6	Aug. 5, 1872
East side of Yellowstone River, near lower falls.	33	....do	8,000	......	......do	......do	190	88	134.5	......	......	Aug. 20, 1871
Crater Hills, Yellowstone Valley, 1st group.	3	Igneous rocks.	7,828	......	......do	Sulphur, silica, magnesia, iron, sulphuric acid.	183.5	130	151.2	77.5	198.2	July 27, 1871
First group	2	....do	......	10 a. m.	......do	......do	178	164	171	58	198.2	Aug. 11, 1872
Second group	2	Igneous rocks and clay.	......	......	......do	Sulphur, silica, magnesia, lime, iron, alumina, sulphuric acid.	188.5	163	175.5	77.5	198.27	July 28, 1871

Second group	49	....do	....	10 a. m.–12.00 m.	......do	......do	188	80	157.62	59	....	Aug. 11, 1872
Violet Creek, Yellowstone Valley, near Crater Hills.	11	....do	....	Morning	Carbonic acid and sulphureted hydrogen.	......do	198	120	166.27	70	198.3	Aug. 10, 1872
Head of Violet Creek, Yellowstone Valley.	12	....do	8,059	12.30 p. m.	......do	......do	194	140	175.66	72	198.1	Aug. 10, 1872
Branch of Violet Creek, Yellowstone Valley.	9	....do	7,873	2 p. m.	......do	......do	194	160	181	68	198.5	Aug. 10, 1872
Mud Volcanoes, Yellowstone Valley.	19	Igneous rocks and clay.	7,756	....	Sulphureted hydrogen.	Sulphur, iron, alumina, silica.	190	88	147.8	48.58	198.5	Aug. 1872
Shore of southwest arm of Yellowstone Lake.	40	Shore of lake	....	....	....	Silica, iron, alumina	191	115	166.5	64	....	Aug. 8, 1871
East Fork of Madison or Fire-Hole River, near head.	9	Igneous rocks	7,098	Morning	....	Sulphur, silica	199	128	179.2	70	....	Aug. 1, 1871
East Fork of Fire-Hole River, above geyser-basin.	4	... do	....	8 a. m.	....	Silica	180	164	....	64	....	Aug. 14, 1872
Lower geyser-basin, 1st group on East Fork of Fire-Hole River.	67	....do	....	Morning	....	......do	198	106	158	50	....	Aug. 2, 1871
Second group, Thud Springs, &c.	17	....do	7,162	....do	....	......do	195	171	185.35	*63.33	199.3	Aug. 15, 1872
Third group, near Mud Puffs.	8	Igneous rocks and clay.	7,357	....	....	Silica, alumina, iron, magnesia.	196	140	175.13	55	....	Aug. 3, 1871
Fourth group, ravine east of 3d group.	20	Igneous rocks	....	....	....	Silica	196	130	158.2	60	....	Aug. 3, 1871
Fifth group, ravine, south of 4th group.	42	....do	....	....	....	......do	198	112	178	60	....	Aug. 3, 1871
Sixth group, on Fire-Hole River.	95	....do	....	....	....	......do	196	112	172.5	70	....	Aug. 4, 1871
Seventh group, on Fairy Fall Creek.	34	....do	....	....	....	......do	198	106	184	70	....	Aug. 4, 1871
Lower geyser-basin, 8th group, back of Twin Buttes.	7	....do	....	....	....	......do	198	187	194.14	....	....	Aug. 15, 1872
Half-way Springs, between lower and upper geyser-basins.	20	....do	7,296	....	....	Silica, iron	196	132	184	74	....	Aug. 4, 1871
Upper geyser-basin, 1st group, near Bee-Hive and Giantess.	10	....do	7,402	Afternoon	....	Silica, iron, magnesia.	196	118	173.6	*67	199	Aug. 5, 1871
Second group, near Castle Geyser.	11	....do	7,387	Morning	....	......do	199	130	172.82	58	....	Aug. 19, 1872
Third group, back of Castle.	23	....do	7,387	4 p. m.	Sulphureted hydrogen feebly.	Silica, alumina, iron, sulphur.	196	100	171.3	68	....	Aug. 18, 1872
Fourth group, on northern side of river about Grand Geyser.	23	....do	7,387	....	....	Silica, alumina, iron, magnesia.	196	118	175.13	*67	....	Aug. 5, 1871
Fifth group, from above Giant and Pyramid to below Grotto.	20	....do	7,324	....	....	......do	192	150	167.1	*67	....	Aug. 5, 1871
Sixth group, about Soda Geyser.	4	....do	7,321	....	....	......do	184	140	167	*67	....	Aug. 5, 1871

* Average.

Locality.	Number of springs.	Position.	Elevation above sea-level.	Time of observation.	Gases evolved.	Principal constituents.	Temperatures, Fahrenheit. Highest.	Lowest.	Average.	Of air.	Boiling-point.	Date of observation.
			Feet.				°	°	°	°	°	
Seventh group, opposite Soda Geyser, extending up the river.	19	....do	7,331			......do	196	134	175	*67	....	Aug. 5, 1871
Eighth group, Iron Spring Creek.	4	....do	....	Morning		......do	184	152	172.25	*67	....	Aug. 5, 1871
Third Geyser Basin of Fire-Hill River.	5	....do	7,772			Silica	192	185	188	....	198.5	Aug. —, 1872
Shoshone Lake geyser-basin, 1st group, agitated springs.	9	....do	7,870	Middle of day.		Silica, iron, alumina	198	160	187.44	....	198.6	Sept. 5 & 7, '72
Shoshone Lake geyser-basin, 2d group, quiet springs.	7	....do	....	....do		......do	196	156	175	....	198.6	Sept. 5 & 7, '72
Third group, geysers	4	....do	....	....do		Silica, sulphur, iron	198	190	192.5	....	....	Sept. 5 & 7, '72
Lewis's Lake, 1st group	10	....do	7,828	....do		......do	148	112	130.8	....	198.6	Sept. 1872
Lewis's Lake, 2d group	6	....do	....	....do		......do	176	140	168.33	....	....	Sept. 1872
Near mouth of Union River	....	....do	....	5 p. m.		Silica	158	102	130	....	....	Sept. 16, 1872
Cañon of Snake River	2	Limestones	....	3 p. m.	Sulphureted hydrogen.	Lime and other carbonates.	194	117	....	*58	....	Oct. 3, 1872
Below cañon of Snake River	6	....do	5,050	11 a. m.		......do	144	88	124.33	....	....	Oct. 6, 1872

*Average.

The boiling point at the Gardiner River Springs varies from 200.9 to 199.5.

No. 2.—CATALOGUE OF MINERALS.

Agate. (See *Quartz.*)
Amethyst. (See *Quartz.*)
Azurite, (blue carbonate of copper.) In Ogden Cañon, Utah Territory; near the head of Clarke's Fork of the Yellowstone River, Montana Territory; Little Cottonwood Cañon, Utah Territory; near Virginia City, Montana Territory.
Amphibole. *Tremolite* in Bear Creek Cañon, in Madison Range, Montana Territory. *Asbestus*, near Henry's Lake, Idaho Territory. *Hornblende* in syenites, near Ogden, Utah Territory; on the east side of the Madison River, in Middle Cañon, Montana Territory; in rocks of the Téton Range, Idaho Territory; on the east side of Henry's Lake, Idaho Territory; in slates, near Virginia City, Montana Territory; in gneissic rocks, in second cañon of Yellowstone, above Boteler's; in basaltic rocks, near Boteler's, in Yellowstone Valley; in acicular crystals, in rocks on the summit of Mount Washburne, Yellowstone National Park.
Asbestus. (See *Amphibole.*)
Aurichalcite. Little Cottonwood Cañon, Utah Territory.
Biotite, (black mica.) Granites of Little Cottonwood Cañon; in basalts of Emigrant Gulch, Montana Territory.
Calamine, (silicate of zinc.) Head of Little Cottonwood Cañon, Utah Territory.
Calcite, (carbonate of lime.) *Rhomb-spar* in blue limestones, near Ogden, Utah Territory; in sandstones, near Fort Ellis, Montana Territory; at Cinnabar Mountain and other points of the Yellowstone Valley, associated with agate and quartz in geodes; in geodes of agate from the East Fork of Yellowstone River; east side of Madison River, in the Middle Cañon, Montana Territory; bluff, opposite the Hot Springs, on Gardiner's River; cañon of Jackass Creek, in Madison Range, Montana Territory. *Crystals*, yellow, from Colorado Springs, Colorado Territory; Spring Cañon, near Fort Ellis, Montana Territory; Bridger's Peak, near Fort Ellis, Montana Territory; east side of Madison River, in Middle Cañon, Montana Territory; Sawtelle's Peak, Idaho Territory. *Stalactites*, from cañon on east side of Middle Cañon of Madison River, Montana Territory; from cave at Gardiner's River, Hot Springs, Yellowstone National Park.
Cerrussite, (carbonate of lead.) From head of Little Cottonwood Cañon, Utah Territory.
Cervantite, (oxide of antimony.) From head of Little Cottonwood Cañon, Utah Territory.
Chalcedony. (See *Quartz.*)
Chalcopyrite (copper pyrites.) Near Virginia City, Montana Territory; Clarke's Fork of Yellowstone River, Montana Territory.
Chlorite. (See *Ripidolite.*)
Chrysoprase. (See *Quartz.*)
Coal, (Tertiary.) Near Spring Cañon, Fort Ellis, Montana Territory; six miles above Spring Cañon, in hills head of Trail Creek, Montana Territory; (Cretaceous,) near Cinnabar Mountain, Montana Territory; poor quality opposite Gardiner's River Springs; on Hunter's River, near Mount Hancock, Yellowstone National Park.
Copper, (native.) Near Virginia City, Montana Territory.
Cuprite, (red oxide of copper.) Near Virginia City, Montana Territory.
Epidote. In crystals from the Téton Range, Idaho Territory.

Feldspar, (*Orthoclase.*) In syenites at Ogden, Utah Territory; in granites at Colorado Springs, Colorado Territory, in red masses; in granites throughout Idaho and Montana Territories. *Sanidine*, in trachytes, throughout the Yellowstone National Park and Montana and Idaho Territories. *Amazon stone*, near Colorado City, Colorado Territory.

Flint. (See *Quartz.*)

Garnets. In gneissic rocks near Golden City, Colorado Territory; in gneiss near Ogden, Utah Territory; in second cañon of the Yellowstone, above Boteler's, Montana Territory; in Emigrant Gulch, Montana Territory; in micaceous gneiss, on Black-Tail Deer Creek, near Gardiner's River; Hot Springs, near lower cañon of Madison River, in gneiss; in gneiss on Cherry Creek, Montana Territory; near Henry's Lake, Idaho Territory; in rocks of the Téton Range, Idaho Territory.

Galenite, (sulphide of lead,) (argentiferous.) Little Cottonwood Cañon, Utah Territory; Central City, Colorado Territory; Emigrant Gulch, Montana Territory; Clarke's Fork of the Yellowstone River; Yellowstone National Park; Hot Springs district, Silver Shower district, and other mining districts in Montana Territory.

Geyserite. (See *Opal.*)

Glauconite. East side of Madison River, in Middle Cañon, Montana Territory; near Gallatin City, Montana Territory; Téton Mountains, Idaho Territory.

Gold. Central City, Colorado Territory; Emigrant Gulch, Yellowstone Valley, Montana Territory; near Virginia City, Montana Territory; Hot Springs district, Madison County, Montana Territory; Upper waters of Snake River, Idaho Territory; near Taylor's Bridge, Idaho Territory.

Graphite. Twelve miles north of Ogden, Utah Territory.

Gypsum, (sulphate of lime.) Colorado Springs, Colorado Territory. *Selenite*, Colorado Springs, Colorado Territory; opposite Hot Springs, at Gardiner's River, Yellowstone National Park; in old hot-spring deposits, opposite Tower Creek, on Yellowstone River; Yellowstone National Park; in Grand Cañon of Snake River, Idaho Territory. *Satin-spar*, Colorado Springs, Colorado Territory.

Halite, (common salt.) In springs on Turbid Lake, near Yellowstone Lake, Yellowstone National Park; Great Salt Lake, Utah, in fine crystals coating wood; in springs in Idaho Territory; springs above Ogden, Utah Territory.

Hematite, (oxide of iron,) (micaceous.) Near Ogden, Utah Territory; near Brigham City, Utah Territory; near Madison Cañon, Montana Territory. *Iron-stone*, Emigrant Gulch, Montana Territory.

Hornblende. (See *Amphibole.*)

Jasper. (See *Quartz.*)

Limonite, (sesquioxide of iron.) Little Cottonwood Cañon, Utah Territory; near Fort Ellis, Montana Territory.

Lithomarge. Little Cottonwood Cañon, Utah Territory.

Magnetite, (magnetic-iron ore.) In gneissic rock, near Golden City, Colorado Territory; in gneisses near Ogden, Utah Territory.

Malachite, (green carbonate of copper.) Upper end of Ogden Cañon, near Ogden City, Utah Territory; near Virginia City, Montana Territory; Clarke's Fork of Yellowstone River, Montana Territory.

Massicot (lead-ocher.) Little Cottonwood Cañon, Utah Territory

Muscovite, (common mica.) Near second cañon of Yellowstone; near Black-Tail Deer Creek, Montana Territory; Téton Mountains, Idaho Territory; (var., Fuchsite,) from east side of Madison Cañon, Montana Territory.

Nephelite. In trachytes in Grand Cañon of Snake River, Idaho Territory.

Obsidian, (volcanic glass.) On Trail Creek, near Yellowstone Valley; in chips throughout the Yellowstone Valley, from the lower cañon to Yellowstone Lake. *Spherulitic*, from Grand Cañon of Yellowstone River. *Porphyritic*, from Grand Cañon of the Yellowstone; divide between Yellowstone and Madison Rivers; Yellowstone National Park; east side of Snake River, Idaho Territory; in basin of Henry's Lake, Idaho Territory; head of Falls River, Idaho Territory; Lewis's Lake, Wyoming Territory; valley of Madison River, Montana Territory; West Gallatin Cañon, Montana Territory; near Missouri River, below Horseshoe Bend, Montana Territory.

Olivine. In basalts in Yellowstone Valley, opposite Boteler's Ranch, Montana Territory; in basalts on Snake River and Henry's Fork, Idaho Territory.

Opal. East Fork of Yellowstone River, Grand Cañon of Yellowstone; summit of Mount Blackmore, Montana Territory; Colorado Springs, Colorado Territory. *Hydrophane*, Grand Cañon of Yellowstone. *Wood-opal*, East Fork of Yellowstone River, near Gallatin City, Montana Territory; Jefferson County, Montana Territory. *Dendritie*, Hot Springs district, Montana Territory. *Hyalite*, Grand Cañon of Yellowstone River. Excellent specimens; clear, in colorless globular concretions, from summit of Mount Blackmore, Montana Territory; near Jackson's Lake, Wyoming Territory. *Geyserite*, (siliceous sinter,) geyser-basins of Fire-Hole River, presenting white, gray, greenish, pink, and red varieties, massive, porous, filamentous, compact, cauliflower-like, beaded, or pearly. The specimens vary from translucent to opaque, some being very friable while others are firm, even on drying; Hot Springs, on southwest arm of Yellowstone Lake; geyser-basin of Shoshone Lake, Yellowstone National Park.

Plasma. (See *Quartz.*)

Prase. (See *Quartz.*)

Pummice. Emigrant Gulch, Montana Territory.

Pyrite, (iron pyrites.) With galena, Central City, Colorado Territory; with serpentine and hematite, near Ogden, Utah Territory; in quartzite, in Emigrant Gulch, Montana Territory; Clarke's Fork of Yellowstone River, Montana Territory. *Pentagonal dodecahedral crystals*, from Téton Mountains, Idaho Territory; Little Cottonwood Cañon, Utah Territory.

Quartz. In granites throughout Rocky Mountains. *Rock-crystal*, Ogden, Utah Territory; in geodes, with chalcedony and calcite, from East Fork of Yellowstone River; from Sawtelle's Peak, near Henry's Lake, Idaho Territory; in granites of Téton Mountains, Idaho Territory; divide between Ross Fork and Fort Hall, Idaho Territory. *Amethystine* (*amesthyst,*) from the Colorado divide south of Denver, Colorado Territory; fine crystals in large geodes of chalcedony from East Fork of Yellowstone River, about ten miles above the junction of the Yellowstone. The specimens are found on the summit of a bold hill on the south side of the river. *Blue*, near second cañon of the Yellowstone. *Smoky* (*cairngorm stone,*) Colorado divide, Colorado Territory. *Milky*, near second cañon of Yellowstone; East Fork of Yellowstone River. *Chalcedony*, Spring Cañon, near Fort Ellis, Montana Territory; in chips throughout the Yellowstone Valley; in geodes with calcite and quartz, above second cañon in Yellowstone Valley; associated with jasper from Elk Creek, near Yellowstone River, Montana Territory; forming the outside of geodes from East Fork of Yellowstone River; also associated with calcite at same locality, from Grand Cañon of Yellowstone River; in rounded pebbles on shores of Yellowstone Lake; from summit of

Mount Blackmore, Montana Territory; beautiful blue specimens with jasper, in Hot Spring district, Montana Territory; from Jackson's Lake, Wyoming Territory. *Carnelian*, from Grand Cañon of Yellowstone. *Chrysoprase*, East Fork of Yellowstone River. *Prase*, East Fork of Yellowstone Lake, Montana Territory; Willow Cañon, Utah Territory; near lower cañon of Madison River, Montana Territory. *Agate*, banded, near Fort Ellis, Montana Territory; in Yellowstone Valley, above second cañon; East Fork of Yellowstone River, near Elk Creek, Yellowstone Valley, Colorado Springs, Colorado Territory. *Mochastone* (*moss-agate*,) nearBoteler's ranch, Yellowstone Valley, Montana Territory. *Flint*, (bluish variety,) in valley of Yellowstone; West Gallatin River; (brown variety,) Pole Creek near Madison River, Montana Territory; (black variety,) East Fork of Yellowstone River. *Jasper*, (red variety,) in conglomerates, near Ogden, Utah Territory; near Fort Ellis, Montana Territory; Yellowstone Valley, Montana Territory; back of Boteler's ranch, Montana Territory; East Fork of Yellowstone River; near Elk Creek, Montana Territory; east side of Middle Cañon of Madison River; (yellow variety,) Bridger Peak, near Fort Ellis, Montana Territory; East Fork of Yellowstone River; (gray variety,) East Fork of Yellowstone; (green variety,) East Fork of Yellowstone River; near Horseshoe Bend of Missouri River, below Gallatin City, Montana Territory; on Henry's Fork of Snake River; (black variety,) East Fork of Yellowstone River. *Silicified wood*, abundant throughout the valleys of Yellowstone, Madison, and Gallatin Rivers, and on the Yellowstone National Park. *Itacolumite*, (common inflexible variety,) near Mount Cowan, Yellowstone Valley.

Ripidolite. In metamorphic rocks, near Ogden, Utah Territory; east side of Middle Cañon of Madison River, Montana Territory; near Henry's Lake, Idaho Territory; Téton Mountains, Idaho Territory.

Sanidine. (See *Feldspar*.)

Satin-spar. (See *Gypsum*.)

Selenite. (See *Gypsum*.)

Serpentine. Near Ogden, Utah Territory; in Snowy Range of Yellowstone; divide between Madison and Gallatin Rivers; Alder Gulch, near Virginia City, Montana Territory; Cañon Creek, a branch of Téton River, Idaho Territory.

Silicified wood. (*See Quartz*.)

Silver, (Native.) Cherry Creek mines, Madison County, Montana Territory; in *galena*, from Little Cottonwood Cañon; Clarke's Fork mines.

Sphalerite, (zinc blend.) Little Cottonwood Cañon, Utah Territory.

Strontianite, (carbonate of strontia.) Sawtelle's Peak, near Henry's Lake, Idaho Territory.

Sulphur. *In crystals*, at Gardiner River Hot Springs; on bluffs opposite Tower Falls; in Mud Springs, near Mount Washburne, in small crystals; Crater Hills, Yellowstone Valley; geyser-basin of Fire-Hole River; Shoshone Lake geyser-basin; on divide between Yellowstone and Fire-Hole Rivers.

Talc. Near Ogden, Utah Territory; in Snowy Range of Yellowstone, Montana Territory; near Henry's Lake, Idaho Territory; Téton Mountains, Idaho Territory.

Tremolite. (See *Amphibole*.)

Tufa, (Calcareous.) At Hot Springs, Gardiner's River; Warm Springs, near Fort Hall, Idaho Territory; Grand Cañon of Snake River, Idaho Territory.

Wulfenite. Little Cottonwood Cañon, Utah Territory.

No. 3.—CATALOGUE OF ROCKS.

Catalogue of rocks collected by the Yellowstone division of the expedition, A. C. Peale.

No.	Name.	Locality.
1–7	Red porphyritic granite	Ute Pass, Colorado.
8–11	White gypsum	Near Colorado City, Colorado.
12–14	Pink gypsnm	Do.
15–17	Light-red sandstone	Do.
18–19	Dark-red sandstone	Do.
20–26	Serpentine, with quartz and chlorite	Ogden, Utah.
27	Chlorite-schist	Do.
28	White qnartzite	Do.
29	Quartzite, ferrugineous	Do.
30	Siliceous conglomerate	Do.
31–32	Protoginic gneiss	Do.
33–35	Syenite	Do.
36–42	Quartz, with hematite	Do.
43	Quartz	Do.
44	Jasper-conglomerate	Do.
45	Pink quartzite	Do.
46	White quartzite	Do.
47	Blue limestone	Do.
48	Mica-schist	Do.
49	Syenitic gneiss	Do.
50–51	Aplite	Do.
52	Quartzite	Do.
53	Mica-schist	Do.
54	Syenitic gneiss	Do.
55–56	Protogine	Do.
57	Protogine, with pyrites	Do.
58–59	Syenitic gneiss	Near North Ogden, Utah.
60	Porphyry	Bingham Cañon, Utah.
61	....do	Do.
62	Quartzite, with pyrites	Do.
63	Hematite	Do.
64–66	Granite, (white)	Little Cottonwood Cañon, Utah.
67–68	Mica-schist	Do.
69–70	Quartzite	Do.
71	Crystalline limestone	Do.
72	Magnesinm-limestone	Do.
73–74	Dendritic sandstone	Near Helena, Montana.
75–78	Purple quartzitic sandstone	Spring Cañon, near Ft. Ellis, Mont.
79	White quartzitic sandstone	Do.
80–83	Argillaceous sandstone, (metamorphosed)	Do.
84	Sandstone-conglomerate	Do.
85–88	Brown limestone	Do.
89–91	Calcareous sandstone shale	Do.
92	Gray calcareous sandstone	Do.
93	Coarse reddish sandstone	Do.
94–95	Gray fossiliferous sandstone, (calcareous)	Do.
96	Coarse brown limestone	Do.
97	Compact limestone	Do.
98	White qnartzite	Do.
99	Calcareous sandstone	Do.
100	White qnartzite	Do.
101	Grayish quartzite	Do.
102	Flinty conglomerate	Do.
103	White quartzite	Do.
104	Yellow limestone	Do.
105	White quartzite	Do.
106–07	Yellowish calcareons sandstone	Do.
108	Reddish sandstone	Do.
109	Purple sandstone	Do.
110	Pink sandstone, calcareous	Do.
111	Conglomerate	Do.
112	Purple spotted sandstone	Do.
113–14	Brick-red sandstone, (compact)	Do.
115–16	Purple sandstone, (compact)	Do.
117	Gray quartzite	Do.
118	Purple sandstone	Do.
119	Arenaceous limestone	Do.
120	Carboniferous limestone	Do.
121	Gray sandstone, (Eocene)	Above Spring Cañon.
122	Soft, gray sandstone, (calcareous)	Near Fort Ellis, Montana.
123	Gray sandstone	Do.
124–25	Brown sandstone, (Eocene)	Do.
126	Calcite	Do.
127–29	Sandstone conglomerate, (Pliocene)	Do.
130–37	Volcanic breccia	Mystic Lake, near Fort Ellis, Mont.
138–39	Limestone, (Carboniferous)	Do.
140	White calcareous sandstone	Near Fort Ellis, Montana.
141	Red limestone	Do.

Catalogue of rocks collected, &c.—Continued.

No.	Name.	Locality.
142–46	Gray sandstone, (Cretaceous)	Bridger Peak, near Fort Ellis.
147–48	Hard, greenish sandstone, (Cretaceous)	Do.
149	Hard, gray sandstone	Head of Middle Creek, Montana.
150	Soft, gray sandstone	Do.
151	Basalt	Valley of Yellowstone River.
152	Volcanic breccia	Near Boteler's, Montana.
153–54	Trachyte	Do.
155	Rhyolite	Do.
156–57	Basalt, with olivine	Do.
158	Basalt-tuff	Do.
159	Diabase	Cinnabar Mountain, Montana.
160	Blue slate	Do.
161	Trachyte	Electric Peak, Yellowstone Valley.
162–63	Soft sandstone, (Cretaceous)	Do.
164	Clay slate, (Cretaceous)	Do.
165	Marl	Valley of Yellowstone River, near Boteler's.
166	Sandstone, (Tertiary)	Bluff opposite Gardiner's River.
167	Quartzite, (Cretaceous)	Do.
168	Sandstone, (Cretaceous)	Do.
169	Purple sanidine trachyte	Do.
170	Micaceous gneiss	Mouth of Black-Tail Deer Creek, Montana.
171	Limestone, (Carboniferous)	Near mouth of Black-Tail Deer Creek, Montana.
172	Brown sandstone metamorphosed, (Tertiary)	Near Elk Creek, Montana.
173–74	Trachyte-breccia	Do.
175	Trachyte	Do.
176–77	Gneiss	Do.
178	White rhyolitic	East Fork of Yellowstone River.
179	Volcanic sandstone	Near Tower Creek, Yellowstone Valley, Montana.
180	Gray sandstone	Near junction of East Fork of Yellowstone, Montana.
181	Micaceous gneiss	Do.
182	Quartz	Do.
183	Trachytic sandstone	Near Grand Cañon of Yellowstone.
184	Obsidian porphyry, (black)	Do.
185	Obsidian porphyry, (brown)	Do.
186	Obsidian porphyry, (perlite-like)	Do.
187	Porphyritic obsidian	Do.
188	Spherulitic obsidian	Do.
189	Vesicular trachyte-porphyry	Do.
190	White trachyte-porphyry	Do.
191–92	Rhyolite	Do.
193	Jasper	Do.
194	Perlite-like trachyte-porphyry	Do.
195	Green and brown jasper	Do.
196	Cavernous trachyte-porphyry	Do.
197–98	Common trachyte-porphyry	Do.
199	White trachyte	Do.
200	Vesicular trachyte	Grand Cañon of Yellowstone River.
201	Porphyritic trachyte	Do.
202	Obsidian porphyry	Do.
203	Vesicular trachyte	Do.
204–13	Argillo-trachyte porphyry	Do.
214	Hot-spring deposit	Violet Creek, valley of the Yellowstone.
215	Trachyte-conglomorate	Crater Hills, Yellowstone Valley.
216–18	Trachytic tuff	Do.
219	Vesicular trachyte	Near Mud Volcanoes, Yellowstone Valley.
220	Brown obsidian sandstone	Do.
221	Black obsidian sandstone	Do.
222	Purplish volcanic conglomerate	Do.
223	Red volcanic conglomerate	Do.
224	White trachyte	Do.
225	Trachyte porphyry	Do.
226	Geyserite sandstone	Fire-Hole Basins, Yellowstone National Park.
227	Trachyte porphyry	Upper Cañon of Madison River.
228	Rhyolite	Do.
229	Cavernous trachyte, (porphyritic)	Do.
230	Vesicular trachyte-porphyry	Do.
231	Siliceous limestone	East side of Madison River, near Middle Cañon.
232	Quartzite	Do.
233	Gray calcareous sandstone, (Jurassic)	Do.
234	White arenaceous limestone	Do.
235	Blue limestone, (Carboniferous)	Do.
236	Jaspery limestone-conglomerate	Do.

Catalogue of rocks collected, &c.—Continued.

No.	Name.	Locality.
237	Pebbly limestone, (Silurian)	East side of Madison River, near Middle Cañon.
238	Micaceous gneiss	Do.
239	Chlorite-schist	Do.
240	Gray gneiss	Do.
241	Mica-schist	Do.
242	Limestone, (Quebec)	East side Middle Cañon of Madison.
243	Quartzite	Do.
244	Glauconitic quartzite	Do.
245	Red calcareous sandstone	Do.
246–47	Chlorite-schist	Do.
248	Talcose-schist	Near Red Rock Lake, Montana.
249	Quartz-schist	Do.
250	White quartz	Wedge Peak, east side Madison River.
251	Mica-schist	Do.
252	Gneiss	Do.
253	Micaceous gneiss	Do.
254	Trachyte	Valley of Madison River.
255	Slaty trachyte	Do.
256	Purplish trachyte	Do.
257–58	Gneiss	Madison Range.
259	Red quartzite	Do.
260	Magnesian limestone, (Carboniferous)	Bear Creek, Madison Range.
261	Blue limestone, (Carboniferous)	Do.
262	Calcareous sandstone	Do.
263	Garnetiferous gneiss	West side Lower Cañon of Madison River.
265	Quartz	Do.
266	Fine-grained gneiss	Do.
267	Gray gneiss	Do.
268	Slaty gneiss	Do.
269	Micaceous gneiss	Do.
270	Sandstone	Jackass Creek, Montana.
271	Flint	Pole Creek, Montana.
272	Basalt, (black)	Mount Blackmore, Montana.
273	Basalt, (red)	Do.
275	Gabbro	West Gallatin Cañon, Montana.
276	Diorite	Do.
277	Brown sandstone, (Cretaceous)	Do.
278	Gray sandstone, (Cretaceous)	Do.
279	Blue limestone, (Carboniferous)	Do.
280	Crystalline limestone, (Carboniferous)	Do.
281	Oolitic limestone, (Carboniferous)	Do.
282	Brown fossiliferous limestone, (Jurassic)	Do.
283	Volcanic conglomerate	Divide between West Gallatin and Yellowstone River.
284	Metamorphosed sandstone, (Tertiary)	Do.
285	Amygdaloid	Valley of Yellowstone, above Boteler's.
286–87	Chlorite-schist	Emigrant Gulch, Montana.
288	Gneiss	Do.
289	Dolerite	Do.
290	Basalt	Do.
291–92	Basalt-tuff	Do.
293	Porphyritic basalt	Do.
294	Quartzite, with pyrites	Do.
295	Volcanic tufa	Near Boteler's, Yellowstone Valley.
296	Quartz	Mt. Cowan, Yellowstone Valley.
297	Itacolumite, (common)	Do.
298	Gneiss	Do.
299	Chloritic schist	Do.
300	Brown sandstone, (Tertiary)	Divide Creek, Montana.
301	Blue slaty limestone, (Carboniferous)	Flathead Pass, Montana.
302	Slaty limestone, (Silurian)	Do.
303	Pebbly limestone, (Silurian)	Do.
304	Coarse fossiliferous limestone, (Silurian)	Do.
305–06	Micaceous sandstone	Do.
307	Chlorite-rock	Near Horseshoe Bend, Missouri River, Montana.
308	Basalt	Do.
309–10	Brown-clay slate, (Silurian)	Do.
311	Sandstone	Do.
312–13	Blue argillaceous slate	Do.
314–15	Trap, (from dike in Jurassic)	Missouri River, below Gallatin City, Montana.
316	Trap, (from dike in Carboniferous)	Do.
317	Pebbly limestone, (Silurian)	Near Gallatin River, above Gallatin City, Montana.
318	Glauconitic limestone, (Silurian)	Do.
319	Hard-brown sandstone, (Silurian)	Do.

Catalogue of rocks collected, &c.—Continued.

No.	Name.	Locality.
320	Blue slaty limestone, (Silurian)	Near Gallatin River, above Gallatin City, Montana.
321	Green chloritic slates, (Silurian)	Do.
322	Purple calcareous sandstone	Do.
323	Glauconitic sandstone, (calcareous)	Do.
324	Purplish sandstone	Do.
325	Pink quartzite	Do.
326	Steel-gray quartzite	Do.
327	Red sandstone	Do.
328	Micaceous sandstone, (fine-grained)	Do.
329	Micaceous sandstone, (pebbly)	Do.
330	Blue argillaceous slate, (calcareous)	Do.
331	Brownish argillaceous slato, (calcareous)	Do.
332	Trap-rock, (dike in Jurassic)	Do.

Rocks collected by the Snake River division of the expedition, Professor F. H. Bradley and W. R. Taggart.

No.	Name.	Locality.
1	Hematite	Near Brigham City, Utah.
2	Oolitic limestone, (Tertiary)	Bear River Bridge, Utah.
3–9	Fossiliferous limestone, (Quebec group)	Malade City, Utah.
10	Gray limestono, (Tertiary)	Do.
11	Gray trachyte	Near Fort Hall, Idaho.
12–14	Cellular trachyte	Sand Hill Mountain, Idaho.
15–17	Basalt	Falls River, Idaho.
18	Rose-colored trachytic tufa	Do.
19–20	Basalt	Pierre's River, Idaho.
21–22	Trachytic tufa	Do.
23	Trachyte-porphyry	Do.
24	Serpentine	Do.
25–26	Conglomerate-limestone, (Quebec group)	Téton Cañon, Idaho.
27	Limestone, (Niagara group)	Téton Creek, Idaho.
28	Glauconitic sandstone	Téton Mountains, Idaho.
29	Trap-rock	Do.
30	Slaty trachyte	Bechler's River, Idaho.
31	Granular trachyte	Do.
32	Trachytic tufa	Crater near Henry's Lake, Idaho.
33–35	Basalt	Sawtelle's Peak, Idaho.
36	Micaceous quartzite, (Potsdam)	Tyghee Pass, Idaho.
37–38	Sanidine trachyte	Upper Madison Cañon, Montana.
39	Hot-spring deposit, (calcareous)	Gibbon's Fork of Madison River, Montana.
40	Volcanic sandstone	Lower geyser-basin, Yellowstone National Park.
41–42	Volcanic sandstone, compact, metamorphosed	Shoshone Lake, Yellowstone National Park.
43–44	Volcanic sandstone, conglomerate	Do.
45–46	Brown porphyritic obsidian	Near Shoshone Lake, Yellowstone National Park.
47–48	Volcanic sandstone	Do.
49	Sanidine trachyte	Two miles south of Shoshone Lake, Yellowstone National Park.
50–51	Trachyte	Lewis's Lake, Wyoming.
52–64	Tufaceous geyserite	Do.
65	Tufaceous sandstone	Do.
66	Compact geyserite	Do.
67	Trachyte	Mt. Sheridan.
68–69	Trachyte-porphyry	Do.
70	Compact sandstone, (Tertiary)	Hunter's River, Wyoming.
71–77	Rhyolitic	East side cañon of Union River, Wyoming.
78	White volcanic sandstono	Do.
79	Porphyritic obsidian, (black)	Do.
80–81	Spherulitic obsidian	Do.
82	Rhyolitic	Do.
83	Gray trachyte	West side cañon of Union River, Wyoming.
84	Brown trachyte	Do.
85	Trachyte	Ridge west of Coulter's Creek, Wyoming.
86	Red trachyte	Do.
87	Cellular trachyte	Do.

Rocks collected by the Snake River division of the expedition, &c.—Continued.

No.	Name.	Locality.
88–89	Red sandstone, (Triassic ?)	Third cañon of Snake River, Wyoming.
90	Pink sandstone, (Carboniferous ?)	Opposite mouth of Union River, Wyoming.
91	Sandstone, (Carboniferous ?)	Do.
92	Limestone, (Carboniferous ?)	Do.
93–94	White sandstone	Do.
95	Trachyte	Do.
96–98	Trachyte	Do.
99	Cellular trachyte	Do.
100	Porphyritic trachyte	Head of Fall River, Wyoming.
101	Sandstone, (metamorphosed)	West side outlet of Jackson's Lake, Wyoming.
102	Cavernous trachyte	Do.
103	Gray trachyte	Do.
104–05	Amygdaloidal trachyte	Do.
106	Volcanic tufa	Do.
107	Sandstone	Mouth of Buffalo Fork of Snake River, Wyoming.
108	Limestone, (laminated)	Head of Buffalo Fork of Snake River, Wyoming.
109	Green sandstone, (Pliocene)	Ridge east of Henry's Lake, Idaho.
110	Granite	East side Téton Mountains, Wyoming.
111	Micaceous gneiss	Do.
112	Granitoid gneiss	Do.
113	Quartz	Do.
114	Granite	Do.
115	Chert, (Carboniferous)	North Gros Ventre Butte, Wyoming.
116	Siliceous limestone, (Pliocene)	Do.
117	Calcareous sandstone	Do.
118	Quartzitic sandstone, (Potsdam ?)	Do.
119–21	Slaty trachyte	Do.
122	White sandstone, (Tertiary)	Gros Ventre River, Wyoming.
123	Limestone, (Triassic ?)	Do.
124–26	Red sandstone, (Triassic ?)	Do.
127	Limestone, (Carboniferous)	Do.
128–33	Rhyolite	South Gros Ventre Butte, Wyoming.
134	Slaty trachyte	Do.
135–36	White quartzitic sandstone, (Carboniferous)	West side Téton Pass, Wyoming.
137–39	Red sandstone, (Triassic ?)	Do.
140–41	Pink trachytic tuff	Do.
142–44	Compact basalt	Do.
145–48	Bituminous mud-stone	Snake River Cañon, Wyoming
149–51	Gypsiferous bituminous mud-stone, (fossiliferous)	Do.
152–53	Conglomerate sandstone	Do.
154–56	Fine-grained sandstone	Do.
157–60	Chert, (Carboniferous)	Do.
161	Hot-spring deposit	Do.
162–63	Slaty trachyte	Snake River, below mouth of Salt River, Wyoming.
164–65	Vesicular trachyte	Snake River, head of upper basalt-cañon, Wyoming.
166–68	Porphyritic trachyte	Do.
169–70	Magnesian limestone	Swan Valley, Idaho.
171–72	Quartzitic sandstone	Do.
173	Compact limestone	Do.
174	Brown quartzitic sandstone	Do.
175	Semi-metamorphosed sandstone	Do.
176	Sandstone	Do.
177–78	Pink siliceous limestone	Do.
179	Crinoidal limestone	Do.
180	Compact blue limestone	Do.
181	Fragmental limestone	Do.
182	Chert	Do.
183	Purple trachyte	South side of upper basalt-cañon Idaho.
184	Vesicular trachyte	Do.
185–86	Limestone, (Pliocene)	Near Fort Hall, Idaho.
187–89	Limestone, (Jurassic)	Lincoln Valley, near Fort Hall, Idaho.
191–92	Glauconitic sandstone, (Quebec)	Near Fort Hall, Idaho.
193	Chert, (Carboniferous)	Lincoln Valley, Idaho.
194 } 200 }	Compact limestone, (Pliocene)	Do.

REPORT

OF

FRANK H. BRADLEY,

GEOLOGIST OF THE SNAKE RIVER DIVISION.

REPORT OF FRANK H. BRADLEY, GEOLOGIST.

WASHINGTON, D. C., *April* 5, 1873.

SIR: I hand you herewith my report upon the region examined by me during the past season, while accompanying the Snake River division of your party.

After working for about a month at Ogden, while our outfitting was being completed, we followed well-marked roads to Fort Hall, Idaho, and thence to Market Lake Station. Here we turned off into the almost unbroken wilderness, and spent some time in examining the Téton Mountains, from which region we passed up the valley of Henry's Fork to its head, and crossed by Tyghee Pass to the Upper Madison, which we also followed to its source, in Madison Lake, after stopping by the way to examine the geysers and hot springs of the Fire-Hole Basins. Thence we crossed the divide to Shoshone Lake, examined all the head-waters of the main Snake River, and descended that stream, via Jackson's Lake and the Grand Cañon, to its emergence into the Great Basin, reaching the latter at a point only a few miles from Fort Hall.

From Ogden to Fort Hall, we were able to examine but a narrow strip of country; but, beyond the latter point, frequent side trips enabled us to understand the general features of quite wide areas, though, at several points, we were so much hurried as to neglect certain small spaces, which are now seen to have been essential to absolute certainty regarding the connections of different parts of our work. Upon the whole, however, though much yet remains to be done by subsequent explorers in that region, I am satisfied that they will find but few errors in our results.

I am indebted to Mr. Bechler, our chief topographer, for many distances and bearings, as well as for the very accurate map which he has now nearly completed, and upon which I expect to color the outcrops of the various formations. I am also indebted to Mr. Hering, astronomer and meteorologist, for the determination of most of the levels indicated in this report. Mr. Gannett, of your own party, has also aided me in this matter. As Mr. Nicholson remained at Fort Hall during our absence, taking hourly observations, while previous barometric comparisons of Fort Hall and Ogden had been made by Messrs. Gannett and Hering, I place much reliance on the determinations of elevations throughout the region examined.

The skillful pencil of Mr. Holmes has supplied the sketches which accompany this report, the materials being mostly obtained from the photographs of Mr. Jackson, who accompanied us as far as to the Fire-Hole, and from Mr. Bechler's field-notes.

Mr. Taggart acted as my assistant during most of the trip; and his work was satisfactory.

I have to thank our surgeon, Dr. Curtis, for information on certain microscopical points, as well as for much personal kindness.

Yours, very respectfully,

FRANK H. BRADLEY,
Chief Assistant Geologist.

DR. F. V. HAYDEN,
In charge of the United States Geological Survey of the Territories.

CHAPTER I.

WAHSATCH MOUNTAINS—OGDEN TO FORT HALL.

The first installment of the party reached Ogden, Utah, which had been determined on as our rendezvous, upon the evening of Friday, May 24; and the work of the season was commenced on the following day, by the ascent of a peak of the Wahsatch Range, which stands directly back of the town, and has been called Ogden Peak. This is the culminating point of that block of mountains which is separated from the northerly and southerly continuations of the range by the cañons of Weber and Ogden Rivers. No mercurial barometer was taken to the summit; but its height was twice measured with aneroid barometers, and once, roughly, with a pocket-level. The elevation was thus approximately determined at 5,298 feet above the railroad at Ogden Station, or 9,638 feet above the sea-level.

The mountain was originally pretty well covered with a tolerably thick growth of small-sized pine and spruce, with some cedar along the limestone outcrops, except on the steepest slopes, which, where not entirely bare of soil, had, and still have, very dense, low growths of a form of "Jersey tea," (*Ceanothus velutinus*,) and of small "mountain mahogany," (*Cercocarpus ledifolius*,) mostly so depressed by the winter's snows as to have taken a permanent downward slope, which greatly increases the difficulty of the steep ascent, but often renders the descent altogether too easy. The timber has mostly been cut, except on the highest parts of the mountain; and, along the small cañons and lower slopes, the places of the pine and spruce have been taken by a small growth of scrub-oak (*Quercus alba*) and maples, (*Acer glabrum* and *A. grandidentatum*.) This oak also abounds along most of the small streams which flow from all the cañons, and extends in small groves far out upon the terraces. I think that we may reasonably expect these and other "hard woods" to increase and take the place of the pines which have so nearly disappeared, and which have here but very few descendants.

Upon our first ascent of the mountain, we reached the lower edge of the snow, upon a spur, at about 2,000 feet below the summit, and, on our return, descended to nearly the same level, in a ravine, by "sitting glissades," over the soft surface.

At the time of our arrival, the streams issuing from the cañons were pretty full, though variable, by reason of the daily meltings and nightly freezes; but, before our departure for the northward, the snow drifts were so greatly reduced that their flow had nearly ceased; and the irrigation of the lower ground immediately about the town, until then depending on these streams, was supplied entirely from Ogden River, by a ditch starting at the mouth of Ogden Cañon. This failure during the summer will render the cultivation of the higher terraces impossible, or at least extremely precarious, until ditches are run up the Ogden or the Weber River far enough to take water at quite a high level.

Except along the immediate banks of the streams, these terraces are mostly overgrown with sage-brush, though the scrub-oaks before mentioned also spread out over considerable areas, and there are some patches of almost barren sand and gravel. Along most of the mountain, there are only three prominent terraces, marking old lake-levels, the highest reaching the level of about 876 feet above the railroad, or 966 feet above the present lake-level; but they are much more numerous near the mouths of the streams, where the stream-currents have distributed their sediment, when the lake-waters were at these higher levels. Thirteen of these terraces were observed on a line between the center of the town and the mouth of Ogden Cañon, the highest of which was less than 400 feet above the railroad. Above this point, the foot of the mountain has been swept so bare of rubbish as to show no terrace until we reach the highest, which was slightly outlined on the upper slopes.

Most of the material of these terraces is entirely uncompacted, and the edges expose beds of drifting sand and loose gravel; but, at two or three levels, there are layers, a few feet in thickness, in which a calcareous cement has more or less consolidated the gravel into still rather loose and porous conglomerates.

The *débris* thus deposited along the base of the mountain has so covered the solid strata as to make it difficult to determine their exact positions at this low level; but the upper slopes show so much bare rock as to make the general structure very evident. The beds form, as was stated in last year's report, a huge anticlinal, whose axis makes a small angle with the general trend of the range; but it proves to be much more complicated than was then supposed. While its eastern slope is nearly regular, its western is quite irregular, including at least two subordinate folds, large portions of which have been eroded, so that one must study closely, to be able to supply the missing links.

The accompanying sketch (Fig. 44) shows, in a general way, the actual and theoretical section through the range, at Ogden Peak.

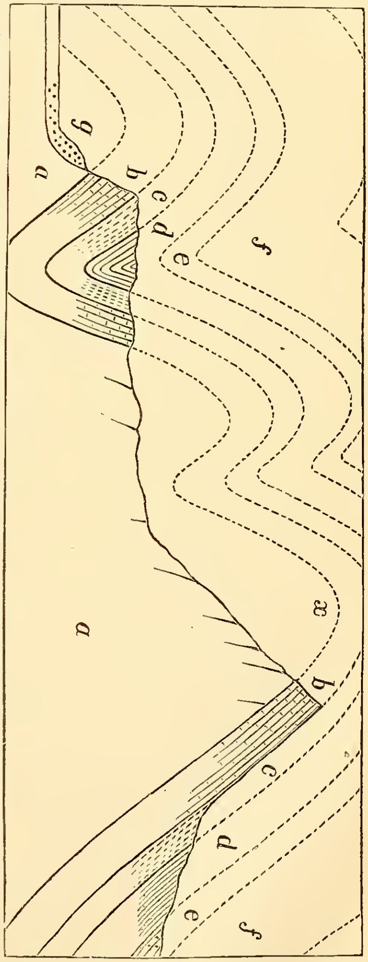


Fig. 44.

a, Metamorphics; *b*, 1st Quartzite; *c*, Shales; *d*, 1st Limestone; *e*, 2d Quartzite; *f*, 2d Limestone; *x*, Axis of main anticlinal; *g*, Terraces.

In the more northern portion of this block of mountain, both of the folds of the western slope make considerable outcrops; but their axes are so much inclined to the horizon that the bottoms of the folds rise rapidly as we go southward, until they pass above the present surface, leaving the western slope here entirely composed of metamorphic rocks, in which no continuation of these particular folds can be traced. The southern portion of the eastern slope was not examined; so that I cannot say just at what point of the eastern base the unmetamorphosed rocks disappear from it; but they certainly show no outcrop in the section displayed along Weber Cañon. At two or three points, the metamorphic rocks show some slight easterly dips; but most of their dips are strong westerly, and the overlying beds are *plainly unconformable.* The metamorphics are mostly hornblendic gneisses, with some granites and occasionally chloritic and talco-mica schists, all more or less penetrated by quartz-veins. One of these veins, near the summit, contains considerable quantities of translucent semi-crystalline masses of hematite. These veins have been opened at various places by prospectors; but nothing of any value has yet been reported. Several of these openings were examined; but a few small scattered crystals of pyrite were the only metallic indications seen. The so-called "tin-mine" was not visited. Samples of its "ore" appeared to be merely massive hornblende, whose high specific gravity, due to the presence of iron, probably originated the idea of its metallic character. A "graphite mine," about twelve miles north of Ogden, near the Hot Springs, was examined, in company with its owners, and found to be a small opening in an irregular quartz-vein which contains a few small flakes of graphite, but gives no indication of the presence of any valuable bodies of that mineral. On the whole, it appears probable that no valuable mines will be found in the metamorphic rocks of this neighborhood.

Immediately upon the metamorphics we find about 1,500 feet of heavy-bedded quartzite, partly white, but mostly quite ferruginous. Its lowest layers consist of a coarse conglomerate of large, red, gray, and white quartz, and jasper pebbles. The upper portions are mostly finer grained, with occasional streaks of very small pebbles. The lines of false bedding are rather irregular, but mostly face the west or southwest, indicating open sea in that direction at the time of their deposition. The only fossils found in these beds are indistinct fucoidal markings, resembling in general appearance the *Arthrophycus Harlani* of the Medina sandstone, but plainly not identical with it. From the character of the overlying strata, I am inclined to refer this bed to the age of the Potsdam sandstone. It forms the grand arch figured in the report for 1871. Just to the south of this arch, the horizontal edges of its outcrop, in the continuation of the axis of the arch, form a high cliff, over which the waters of one of the small mountain-streams falls, first in a steep cascade 52 feet, and then in one leap 263—in all, 315 feet—to the bottom of a narrow ravine. The tumbling rocks under the spray of the fall were covered with numerous snails, (*Helix.* sp.)

These quartzites are overlaid by something over 1,000 feet of gray calcareous shales, without fossils so far as seen, and these by nearly 2,000 feet of compact blue and gray dolomitic limestone, partly oolitic in structure, partly silicious and even cherty, partly filled with irregular streaks and patches of ferruginous clay. In this immediate neighborhood, this bed of limestone is exposed only where the strata have been much disturbed, and it has consequently been mostly thoroughly shivered in every direction, though afterward recemented by the thin sheets of calcite which fill all the crevices. No fossils were found in it hereabout, but a single specimen of *Halysites catenulata*, the characteristic coral of the Niagara group, was obtained by the survey, in 1871, from the upper part of what was supposed to be this bed, in Box-Elder Cañon, some twenty-five miles north of Ogden. From the character of the rock, however, I judge that at least the larger part of the bed, together with the underlying calcareous shale, belongs to the Quebec Group of the Lower Silurian age, which is so largely developed along the Malade Valley farther north. It is not impossible that here, as in the neighborhood of the Téton Mountains, nearly two hundred miles farther north, the deposition of limestone might have been continuous from the Quebec epoch onward to the Niagara epoch or even later.

This limestone is followed by a second heavy bed of quartzite, mostly ferruginous, from 2,000 to 2,500 feet in thickness. No fossils were seen in it, and I know of nothing which would give any grounds for judging as to its age.

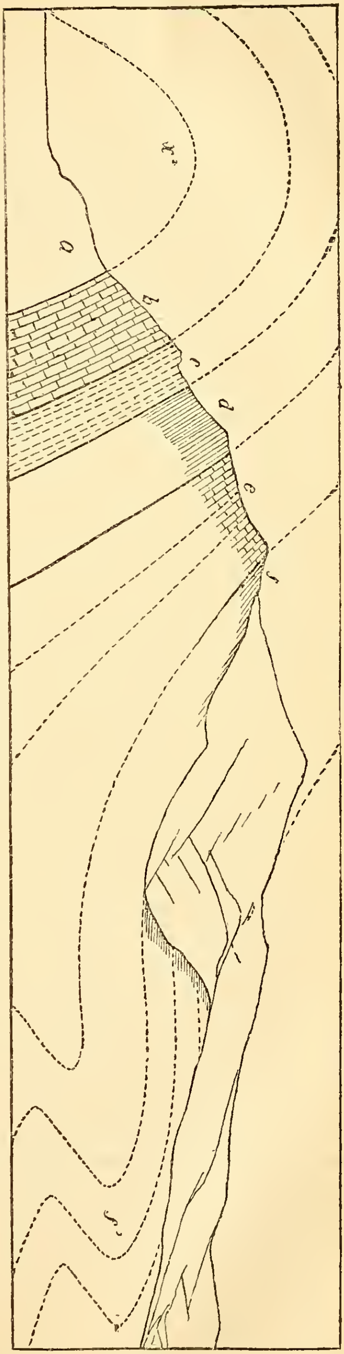


Fig. 45.

SECTION, OGDEN CAÑON.

a, Metamorphics; *b*, 1st Quartzite; *c*, Shales; *d*, 1st Limestone; *e*, 2d Quartzite; *f*, 2d Limestone; *x*, Axis of main anticlinal.

This is followed by probably 3,000 feet of quite compact, mostly thin-bedded gray and drab limestone, largely silicious, the lower part even cherty and somewhat geodiferous. These beds contain a few fossils, *Zaphrentis*, &c., which are plainly of Carboniferous age.

These higher beds make no appearance upon the western slope of this mountain-block, except in the immediate neighborhood of Ogden Cañon. The crest of the mountain consists of the lower quartzites, as shown in the section previously given. The upper of the two subordinate folds on the western slope has its eastern side much steeper than its western, and at some points almost pinched out. The lower and more westerly one has both sides quite steep, and the two edges of the thin plate of limestone which forms its central portion are folded so closely together as to appear, at first sight, when seen from below, near the limekiln, like a single outcrop; higher on the spur, where they perhaps spread a little more than they do below, the eastern edge has a dip of only from 50° to 53°, and the western one of 75°.

The following is a section of the strata as they are exposed in Ogden Cañon. (Fig. 45.) The two subordinate folds of the western slope of the anticlinal, having more westerly trends than the mountain-range itself, pass under the valley before reaching Ogden Cañon, and, accordingly, are not seen in this section.

In ascending the stream the first grand fold of the upper limestone is so much concealed by the *débris* as to be unnoticed until we pass the second bridge and come to the "wedge" figured in the report of 1871, and even then it is difficult to trace the outlines of the fold on the upper slopes. The second fold, however, is very prominent, forming an immense tilted "Z" upon the mountain-side, a half mile long and at least 1,000 feet high. The upper bar of the "Z" dips 16° and the lower one 11° to the eastward, while the connecting stroke has a dip of 49° in the opposite direction. The angles are very sharp, and the rocks, correspondingly, so much broken that they have yielded readily to water-action on the south side of the cañon, known as Walker's Cañon, which gives passage to a large stream supplied by the melting snows of the great hollows on the northeast side of Ogden Peak. Small cold springs, depositing calcareous tufa, were noticed along the rocky sides of this cañon. At Dr. Cannon's, half way down Ogden Cañon, a strong sulphur spring flows from the second quartzite on the north side of the river. The foot-bridge, which generally makes this accessible, had recently been washed away, and this stream was not fordable at the time of our visit, so that we could not measure its temperature. The water was said to be warm but drinkable. The escape of gas was strong enough to be noticeable as we passed along the road on the opposite side of the stream. Near the mouth of the cañon there are two small clusters of hot springs, both of which are saline and ferruginous. The upper cluster, just below the lower bridge, and within the mouth of the cañon, flow from the granites, make but little deposit, and have a temperature of 136°. The lower ones, just outside the mouth of the cañon, have formed a considerable mound of calcareous tufa, and, for that reason, are supposed to come up through the lower limestones, one of the folds of which should be in place beneath the terrace about at this point. The thermometer used here was too short, and simply indicated a temperature of 125° or *higher*.

The lower part of the cañon through all its length, but especially near its mouth, is more or less lined with heavy beds of coarse gravel, thoroughly consolidated by a ferruginous cement. In some places, this forms the bed as well as the banks of the stream; but, at others, it is cut through, and the original well-worn rock-bottom of the old channel is exposed beneath the gravel by the side of the road. It is evident that, when this cañon was originally excavated, the Great Salt Lake was not far, if at all, above its present level; so that the rushing torrent which wore out this old rounded bottom met no check until it had passed entirely beyond the mouth of the cañon. There followed a time when the lake filled nearly or quite to its highest terrace; and, meanwhile, the Ogden River continued to bring down the sand and pebbles which it had before been accustomed to sweep out upon the lower terrace, but now, checked by the rising lake, deposited them in the lower parts of its old channel, until they accumulated to a very high level, not yet accurately located. Again, the lake retired, and the stream again cut down its channel, sometimes reaching its old level and sometimes not. It is evident that there were some pretty good sized cascades, at least, if not large falls, in the old river where it passed over the more solid limestones and quartzites, and wore away the softer underlying shales and schists. The conglomerated gravel has worn more evenly, though it is far from homogeneous.

The lower bed of limestone was formerly burned in small kilns, about a mile above the mouth of the cañon; but the local supply of wood is now nearly exhausted, and the kilns are deserted. The same bed is used in a kiln at the mouth of Taylor's Cañon, just back of Ogden, where it is burned with coal from Evanston, which is delivered at the Ogden station for $5 per ton. Hauling to the kiln, on the return trips of teams which haul down the lime, costs $2.66 per ton. Three tons burn 100 bushels of lime, which sells readily at 50 cents per bushel, delivered in Ogden. The kiln burns about 60 bushels per day.

In order to examine briefly the southern continuation of this range, and to get some idea as to the uniformity of character of its formations, I accompanied Messrs. Jackson (our photographer) and Peale (mineralogist) to Salt Lake City and Little Cottonwood Cañon, the latter being about fifty miles south of Ogden. At that time, June 20, immense snow-drifts still remained in all the upper parts of the cañon, and made it impossible to obtain more than a very general idea of the section. The outer (western) part of the cañon is walled solely by the almost white granite, which is extensively quarried, near its mouth, for the Mormon temple, as well as for other uses about Salt Lake City. This is entirely different from anything seen near Ogden. From the strike of the bedding, it is evident that the line of outcrop would pass considerably to the eastward of the crest of the mountain, in making only a few miles of northing. The dip is westward, as is the case with most of the metamorphic rocks near Ogden. Several of the large faces of granite exposed in the quarry showed angular and rounded patches of darker material, which were evidently sections of what had been more or less rounded pebbles in the conglomerated mass, before its metamorphism. Unconformably upon this granite lies a heavy mass of ferruginous quartzites, whose northern continuation forms the Twin Peaks, said to be the highest points of the range. Upon this, apparently conformably, lies a series of limestones, the lower part rather thin bedded, the upper part in heavier layers. The lowest beds could not conveniently be visited. A short distance south of the Flagstaff mine, a small mass of rock was found to be full of small fossils, including some characteristic forms of the Sub carboniferous. A few others were found scattered about in such condition as to satisfy me that the whole cluster of mines surrounding the Emma and the Flagstaff is in Carboniferous and Sub carboniferous rocks, so far as yet developed. While the age of the lower part of the series was not determined, yet it was evident that there is nothing in the character of these beds which should cause us to anticipate any considerable decrease in the metallic deposits before reaching the underlying quartzites. At that level, however, they are likely to be greatly diminished, if not entirely wanting.*

Even on the comparatively moderate slopes of the head of the valley, climbing is very wearisome; and the lower part of the cañon is hemmed in by immense nearly vertical walls of granite, standing up out of steepest slopes of *débris*. From these bare walls and steep slopes descend, in winter, the avalanches which have buried so many teamsters and others, and which will continue to thus destroy life and property until the mining companies shall unite in constructing either a covered or an elevated road for the transmission of ore and supplies as well as of passengers. The inexhaustible supply of granite, already broken by nature to manageable size, would seem to make the construction of a covered way extremely feasible.

The limestones which form the base of the high-terrace shoulder of the mountain, at the Warm Springs, just north of Salt Lake City, show at one point a dip of 25° S. 38° E. They apparently belong to a subordinate fold of the western slope of the main anticlinal, similar to those already described.

On June 24 we started from Ogden on our northward journey, and camped at the Hot Springs, about ten miles from that city. After crossing Ogden River, about two miles below the mouth of its cañon,

* As this report is passing through the press, I find that, in the Engineering and Mining Journal of March 11, 1873, Mr. Henry Engelman states that a second quartzite is in place in the Cottonwood section. The lower limestones must therefore be referred to the Silurian age, as at Ogden.

we saw the village of North Ogden, some four or five miles to the right of our route, at the foot of the mountain, in an angle of the lower terrace, at the mouth of the pass which afforded communication with Ogden Hole before the construction of the road through the previously impassable cañon. The mountain between this pass and the cañon has a base of metamorphics, a precipitous face of the lower quartzite, an upper moderate slope of the calcareous shales and lower limestone, and a crest of the upper quartzite. In the portion trending back toward the pass, the shales and limestones descend somewhat, and have been weathered out into an immense amphitheater, reported as being very grand by Dr. Peale, who examined it.

The hot springs are located immediately at the foot of a high shoulder of the mountain, consisting of the upper terrace, preserved from wear and upheld by a mass of quartzites, shales, and limestones, which form the continuation of the uppermost of the subordinate folds on the west flank of Ogden Peak. Though the connecting portion is gone, so far as can be seen, yet some portions of these beds are doubtless in place beneath the plain which stretches past North Ogden to near the mouth of Ogden Cañon. The terrace at the hot springs exposes both sides of the fold very plainly; and here we find, as on Ogden Peak, that the eastern side of the fold is much the steepest, and has been pinched out, so as to show but a thin outcrop. The portion of the terrace next to the mountain consists of metamorphic rocks, as does also far the larger part of the mountain-face. The rocks are mainly hornblendic gneiss and syenite, with quartz-veins. The crest of the mountain here consists of the second quartzite, and reaches an elevation so nearly identical with that of Ogden Peak that I am in doubt which is the higher.

The hot springs flow from the quartzites of the west side of the fold at the end of the terrace, practically on the same line of crack as those just outside the mouth of Ogden Cañon.

Just beyond the springs, several of the high spurs of the mountain form very prominent pinnacles, being capped with masses of the first quartzite, from above which the overlying calcareous shales, by reason of their softness and the easterly dip, have been readily eroded. This structure, as well as the general bedding before described, can be plainly seen by those who may pass on the cars between Ogden and Corinne. A fine fall leaps over this quartzite in Willow Creek Cañon, opposite Willard City.

As we pass northward, the mountain bears farther to the east, the axis of upheaval passes out under the plain, and the quartzites and limestones decline from high dips to nearly level positions, the second quartzite passing from the very crest to the very bottom of the mountain just north of Box Elder Cañon, back of Brigham City, and about twelve miles from the hot springs. The high monoclinal dips seen by Dr. Hayden along this cañon in 1871 probably represent the continuation of the axis of either the "wedge" or the "Z" of the upper limestones in Ogden Cañon, but show greater disturbance than was there experienced. For about six miles north of Brigham City, the upper quartzite forms the base of the mountain, but then disappears, and the upper limestone alone outcrops, though a thin local bed of quartzite appears about the middle of its section for a short distance. At Mr. Barnard's place, about five miles above Brigham City, I was shown a fragment of galena in calcite, with some green carbonate of copper, from an opening in the limestone about a thousand feet up the mountain. The lode was said to be about four feet thick. The ore is reported to be rich in silver, and arrangements have since been made for working it.

Some of the limestone along here is quite compact and furnishes good building-stone, which dresses well, and has been extensively used in this neighborhood for houses and barns, the supply being mostly obtained from the piles of large masses swept down along the channels of the small but rapid mountain-streams. While passing down this road, upon my return in November, I saw a dozen or more medium-sized two-story stone dwellings in process of building or just completed, in as many miles, evincing a much higher degree of general prosperity and thrift than one would have expected from a view of the small adobe cottages previously occupied. The soil is evidently fertile, wherever irrigated. Stacks of wheat and corn and huge piles of pumpkins were constant features along this road at the close of the season.

About twelve miles north of Brigham City we came to another small cluster of hot springs, of temperatures varying from 121° to 128°. These are strongly chalybeate and saline. By the side of them is another cluster of springs only feebly saline, free from iron, and of much lower temperature, mostly about 68°. Upon my return in November these reached 72°, but had a much smaller supply of water. The hot springs were also weaker, and reached 132°. Frémont reports them at 134° in 1843. The water of these springs supplies a long narrow pond, hemmed in by portions of the lower terrace upon which the road runs at this point. Cool springs are said to break out along this pond; but we did not succeed in finding them, and so made our camp on the bank of Bear River, about two miles farther on. This stream is here sluggish, having nearly reached the level of the lake, though yet some miles distant from it.

Passing up the road about seven miles farther, we approached Hampton's Bridge, where the stream is much more rapid. The channel of the river here makes a sharp turn to the eastward, passing through the front range of the Wahsatch Mountains on our right, while the northern continuation of the valley in front of the range is occupied by a tributary now known only by the name of Malade River, though sometimes referred to in old publications as Roseaux or Red Creek.

The immediate channel of Bear River, where it breaks through the mountain, at the point known as "The Gates," is narrow, with high precipitous walls of light-drab, compact limestone, partly siliceous, from which I could obtain no fossils; but, from its position, it must be Carboniferous. The strata show a westerly dip of about 25°, and evidently belong to the west side of the anticlinal upheaval, whose southern continuation has been mentioned as crossing Box Elder and Ogden Cañons. The cliffs of this narrow channel reach nearly to the level of the top of the second principal terrace. On the north side of "The Gates," a short distance back from the edge of this channel, there is another considerable break in the upper terrace, showing a second channel to have existed when the stream was at this level; and, as seen from this north side, the appearance of the surface on the south side indicated the probable existence of still a third old channel, along the line now occupied by the Utah Northern Railroad, (narrow gauge,) which there crosses the range into Cache Valley. At the level of the upper terrace, the old valley of Bear River spreads out to a width of about five miles. The upper terrace itself consists almost entirely of a grayish-white limestone, partly fine grained and compact, partly coarse and porous, and mostly pebbly. All of it is more or less oolitic. The compact layers are entirely destitute of fossils; but the more pebbly portions contain very numerous individuals of a few species of fresh-water shells, which are sufficient to mark the bed as of late Tertiary (Pliocene?) age. (Dr. Curtis, of our party, afterward obtained from the shore at the southern end of Salt Lake specimens of oolitic sand, which show that this kind of calcareous deposit is still forming abundantly in this basin.) The beds exposed are about 200 feet thick. They show, at this point, a dip of about 25° south, 68° west. As no corresponding disturbance of the surface of the terraces is apparent, it is evident that the upheaval antedates the Terrace epoch. The lower terraces show extensive deposits of coarse gravel, which is well exposed in the cuts of the Utah Northern Railroad, and supplies that road with an abundance of superior ballast.

After crossing Bear River, the Tertiary limestones are found covering the entire foot of the mountain, for two or three miles, though the mountain itself is still plainly composed of the older limestone, which appears on its summit. Then the Tertiary disappears altogether, and the upper quartzite rises so as to form the face of the ridge, for four or five miles. Then the Tertiary comes in again, in a heavy body of compact flinty limestones and siliceous shales, running to the very tops of the hills, which are here much depressed. The strata are mainly nearly level, only the portion nearest the valley having a westerly dip, which at some points reaches 40°. About nineteen miles above Hampton's Bridge, the mountain rises again, and the Tertiaries disappear again, exposing the face of the lower limestone, which has now risen so as to form the entire mass of the mountain. At the junction of the two series of strata, it is evident that the Tertiaries lie unconformably upon the older limestones, many layers of which are here crowded with fragments of trilobites and other fossils, which are plainly of the age of the Quebec group. Among the specimens from this locality which have already been worked up, there are at least fifteen trilobites of the genera *Conocoryphe*, *Bathyurus*, *Dicellocephalus*, *Agnostus*, &c., five brachiopods, two gasteropods, and one pteropod. As we approach Malade City the mountain becomes higher and more precipitous, a point about three miles south of that place being found to be about 2,500 feet above the river. Of this total, about 2,000 feet are exposed in the face of the mountain, the terraces being mostly washed away. All the strata exposed belong to the Quebec Group, and consist mainly of limestones, though including perhaps 200 feet in all of sandstones, partly shaly, but mostly thick-bedded and quartzitic, as well as an indeterminate amount of interlaminated greenish calcareous shales. The uppermost limestones are compact and full of nodules and layers of chert; the lower ones vary greatly, from pure compact to coarsely fragmentary, to fine-grained silicious, and to oolitic and coarsely concretionary forms. The colors vary from drab to blue, gray, buff, flesh-color, and pale red, sometimes uniform, sometimes mottled and streaked. Some of the beds, of both the limestones and the sandstones, would make good building-stone; but these are rather too high in the section to be conveniently quarried on the face of the mountain; though they could probably be easily reached by ascending some of the numerous cañons which break through the range in this neighborhood. The fossils occur at various levels, from bottom to to of the section, though some portions of considerable thickness are entirely barren. They can be most easlly obtained from the tumbled masses of the different beds which lie numerously along the foot of the mountain. As Malade City is only one day's ride, by stage, from Corinne, the locality can easily be visited by collectors who may be passing over the Central Pacific Railroad. The section should be more carefully examined, so as to determine the positions of any special horizons which may be marked by special groups of fossils. Time did not permit me to make so thorough examinations of the different beds as such determinations would require.

The finding of distinctively Quebec Group fossils, in such abundance and through so great a thickness of strata, was a matter of considerable interest, since this was, I believe, the first identification of this horizon on the western side of the Rocky Mountain divide; and, indeed, but few specimens from that or any other part of the Silurian, had ever been obtained from any part of the country west of Minnesota, Missouri, and Texas. As no fossils were found in the lower limestones at Ogden, the age of those beds was in doubt until the identity of stratigraphical position and of lithological character showed that they must be of the same age. The first examination of these Malade rocks was made at a point where the section terminated below in a very quartzitic sandstone, which occupied the relative position of the Potsdam, and was accordingly referred with doubt to that group in a letter-extract which was published in the August number of the American Journal of Science. Later examinations have shown that this was really a part of the true Quebec, whose base is not here exposed.

The valley of the Malade is broad and flat; the stream itself is sluggish and mostly deep, with steep banks and muddy bed. At a few points there is rock or gravel bottom, but crossings are few. The bordering flats are rich, and considerable portions are well cultivated, producing heavy crops of wheat and some corn. They are well watered by numerous large springs, which burst up at various points, doubtless being supplied by subterranean streams flowing through and escaping from the limestones of the mountain. These are mostly pure and cold springs; but at one point near the stage-road, about a mile south of Malade City, there is a low mound of calcareous tufa, surrounding a small spring which is rather warm, but still drinkable. Only a small amount of land has yet been irrigated about here. The ridge which forms the western boundary of the valley is lower and more rounded in outline than that upon the east. It was not visited, but the apparent structure and color of its bare slopes render it probable that it also consists of Quebec Group rocks.

The old route across the divide, to the Snake River Valley, passed on to the head of the Malade, and thence to the left and down Bannock Creek. The stage-route now turns a little to the right at Malade City, and crosses to Marsh Creek. Following it, we camped at Keeney's Station, four miles above Malade City, and stopped over one day, June 28, to examine the neighborhood. The side valley, which the road follows, makes a broad break through the eastern mountain, up which the terraces extend, and connects with a narrower valley lying between this and the next range. Messrs. Taggart and Coulter accompanied Mr. Jackson to the summit of the mountain north of the gap, found it to be the regular continuation of that to the southward, and brought in a few characteristic fossils. Mr. Adams accompanied me to the southward, where we found the back-slopes of the mountain covered with Tertiary beds, consisting mostly of thin-bedded, light-drab, clinking limestones, partly pure, partly earthy, with some silicious shales. Some of these beds would probably make good hydraulic cement. A few minute ostracoids and small, indistinct fresh-water gasteropods were the only fossils found. From the summit of the mountain, it became evident that these Tertiary beds extend up this back valley to that of Bear River, and that this crest formed two long, narrow islands in the old Tertiary lake. The beds have a slight easterly dip.

The next range east was also examined in a hasty reconnaissance up New Cañon, which opens into the valley about four miles east of Keeney's Station. The lower portion of the cañon is walled with heavy beds of ferruginous quartzite, belonging with the lower beds at Ogden, and, like them, referred with little doubt to the Potsdam. Some small excavations have been made by mining prospectors in some of the more thinly-bedded portions, but without any success. Their rubbish gave no indication of anything which should have encouraged such excavations. Above the quartzite lie heavy-bedded, dark-blue and ferruginous, impure limestones, which belong to the Quebec group; but no fossils were found. The dips are all easterly and reach 50°. The upper part of the cañon is heavily timbered with pine and spruce; and residents of Malade City have combined to make a good wagon-road up it, for the purpose of more readily obtaining a supply of timber for building purposes and for fuel. The sharp dips of the cañon are much flattened, a little farther south, so that in the course of a few miles the quartzite and the lower portion of the limestone disappear beneath the upper edge of the abutting Tertiaries of the valley. A cañon on the east side of the mountain north of Keeney's Station has yielded a considerable amount of maple-timber, a foot or more through at the butt, and 30 to 40 feet long.

The small stream-valley which the stage-road follows runs over to the east side of the main valley between the ridges, and leaves the Tertiaries exposed in white banks upon the slopes of the western ridge. Mr. Stevenson reported having examined these for fossils without success.

About eight miles from Malade City, we reached the divide between the waters of the Great Basin and those of the Columbia. The upper lake-terrace, which has been a marked feature of the country thus far upon our journey, with small exceptions, here becomes a little irregular and much washed, but apparently reaches to the very summit, as if this might have been a point of dribbling outflow for the waters of the great lake when at its highest level. This is also true of the point in the upper course of Bear River, where the Port Neuf most nearly approaches that stream in the same broad valley, with only remnants of the old terraces forming the divide between them. The level of the divide between the head of Marsh Creek and the Bear River drainage, at Red Rock Pass, as ascertained by the party of 1871, indicates that this was probably another point of outflow; and the divide between the head of the Malade and Bannock Creek may very probably have been a fourth, since Captain Mullan reports that as "prairie-surface of clear gravel formation." (See Wagon-road Report, 1863, p. 76.) Time forbade our working out the details of these points by the way, and I can, therefore, only offer these suggestions as to points worthy of more deliberate examination. Without any very accurate determinations of levels, I am yet inclined to believe that the terrace-levels rise somewhat as we pass to this northern rim of the basin, implying a moderate upheaval of the whole country in that region, which may have taken place while the lake was yet full, and so have been the first means of separating the Great Basin from the Columbia drainage. I agree, however, with those who hold that the decline of the lake from these old terrace-levels has been due mainly to a climatal change, which decreased precipitation, but either left the evaporation constant or increased it. These variations in the lake-level are still going on, as is shown in the recorded rise of the surface for about twelve years, until, two years ago, it began to decline again. I have questioned, in my own mind, whether this latter decline does not really represent the result of diminished rain-fall theoretically consequent upon the largely-increased consumption of timber in the building and since the completion of the Pacific Railroad. On the other hand, upon the same theory, we may refer the previous rise to the results of cultivation of land and planting of trees, and may expect that, as these increase, the lake will again begin to rise and to spread over larger areas.

As we pass down from the Malade divide into Marsh Valley, the Quebec Group limestone and underlying (Potsdam ?) quartzite outcrop on our right, until the valley spreads, and they disappear beneath the level of the lower terrace. These terraces are very strongly marked through the whole length of this valley; and an upper one is readily identified, though not so prominent, at the level of about 1,000 feet above the stream. They are on too large a scale, and the valley is too wide, to have resulted from merely the drainage of the small area of mountains about the head of the stream; and I am strongly of the opinion that this must have been at one time the channel for a large outflow from the Great Basin.

Rain caused us a day's delay at Watson's ranch, (formerly Carpenter's,) but on the next day (July 1) we moved onward, though showers still continued. At Watson's, a road turns off to the upper cañon of the Port Neuf,* through which it passes to the head-waters of that stream, where it meets the Soda Springs road, and then crosses the divide to Fort Hall. We had proposed to follow this, but found that the river was still high and the fords bad, so that we decided to continue on the stage-road. The distances by the two routes are almost identical.

The face of the high terrace at Watson's consists of Quebec Group limestone, partly quite cherty, with abundant characteristic fossils, though mostly in fragmentary condition. This is overlaid by heavy beds of white quartzite, followed by Carboniferous limestones. The dips are all easterly, varying from 20° to 40°.

A short distance above the junction of Marsh Creek with the Port Neuf, we met with the first appearance of the basalt-rock which fills the Great Snake River Basin. It makes its first appearance as a narrow stream, which forms the floor of the upper cañon of the Port Neuf through its whole length, having had its source in one of the old craters still standing near Soda Springs, though their fires have long been extinct. A short distance up the stream from the point where the stage-road strikes it, we found the lowest of a long series of calcareous spring-deposits, which form a prominent feature of the cañon for several miles, damming the stream at numerous points, so as to make small but pretty waterfalls. This lower dam is about 20 feet high, but with a perpendicular fall of only about 12 feet. In the cañon, the river is sometimes one side of the basalt and sometimes on the other. Where it strikes the wider level of the continuation of Marsh Valley, it has basalt on both sides at first, but soon passes to the right, where it has dug out a channel in the upturned edges of the bordering limestones, leaving the basalt as a perpendicular barrier on the left, which rapidly increases in height as the stream descends. The surface of the basalt has, of course, some slope, corresponding with that of the valley at the time of the volcanic outflow; but it is here much more moderate than that of the present stream, which rushes along rapidly, with occasional leaps of a few feet. The foot and face of the hill on the east side of the valley consist of mostly thin-bedded limestones of the Quebec Group, dipping

* So named after an old French-Canadian trapper.

about 20° N. 51° E., and containing a few fossils. These beds are overlaid by the quartzites before mentioned, which here form a lofty mountain-crest running northward for many miles. As they show here great thickness and only moderate disturbance, I consider this a very favorable locality at which to examine them for fossil remains; but none were found, and the precise age of the formation is uncertain. At the angle of the cañon, a large knob of the limestones, perhaps 500 feet in height, gives a fine view of the whole cañon. From this point, the basalt appears as a high flat-topped ridge, occupying the center of the valley, on the west side of which the narrow valley of Goose Creek has been hollowed out of the edges of the lower quartzites. A small stream also comes in from the right, and has changed its channel once or twice, so that a considerable knob of limestone and some small ones of basalt stand out in the valley; but the streams finally cross to the left side of the valley, leaving the basalt entirely on the right. The road crosses this for some distance, passing among walls and piles of the columnar rock, and then descends to the lower level near Black Rock Station, where the basalt abruptly terminates.

At the angle of the cañon, we had turned sharply to the west, so that, instead of following the strike of the strata, as heretofore, we were now traveling directly across the edges of the outcrops. Soon after we turn, we meet the outcrop of the lower quartzites, upturned at various high angles and strongly metamorphosed. The continuation of this cross-section is confused: one anticlinal is plain and others probably exist; but quartzites, limestones, calcareous schists, all highly metamorphosed, are exposed with various dips; and time and mosquitoes forbade the working out of the details. These, however, though of local interest, have no general importance, since they are not in the direct line of our northern connection.

Though we encountered mosquitoes and gnats in very troublesome quantities at several other points on our trip, yet they nowhere equalled the *mass* which met us between Black Rock Station and the lower angle of the cañon. Hundreds of thousands, at least, perished at our hands, as we hastened through; and such passages are of daily occurrence at this season, but with no perceptible decrease in their numbers. My impression is that this, being a somewhat sheltered point, is a sort of general rendezvous for those of them who are tired of facing the strong winds which so frequently sweep over the unobstructed levels of the broad Snake River plain, into which the cañon now opens, upon turning northward again, after making five or six miles of westing.

Here, again, we encounter basalt; but it seems to belong to a lower layer than that we left at Black Rock. All over the great plain, indeed, we find two or more layers of basalt, separated by greater or less thicknesses of sand and gravel, partly loose, partly consolidated by ferruginous, silicious, or calcareous cement. If two layers should be found superimposed, at any point in the upper part of the cañon, I should believe that they had resulted from two distinct eruptions from the volcanic source before mentioned. As it is, it is not impossible that these layers in the outer plain have been ejected from some central source, have overflowed the plain, and so have run up into the mouths of the valleys opening upon it. It seems hardly possible that, after flowing seventy or eighty miles, the lava should still have retained sufficient fluidity to spread out in a solid layer over the plain. Whatever the source, the material had evidently become quite viscid; for, at some points, where it ran over small inequalities of the surface beneath, it now stands in low mounds, which would not have been the case if it had been very fluid. That these mounds were not all formed by an undermining and sinking of the surrounding mass, to which some of them have very properly been referred, is proved by the tapering shape of the closely-fitting blocks which form the arch. But there is still room for study on all these points.

As the cañon opens toward the plain, white and drab friable sandstones, probably of Pliocene age, make their appearance on the flanks of the bordering hills. As nothing of the kind was apparent within the cañon, it would seem either that the whole width of the cañon has been thoroughly scoured out since the deposition of the Pliocene beds, or else that the stream carried so much and so rapidly-flowing water during the Pliocene epoch as to prevent the deposition of such beds. These sandstones dip about 30° N. 11° W., showing that the disturbances, of which we have such abundant evidence, continued to a very late period. The terraces themselves show no evidence of any local disturbances; their levels were not determined, however, with sufficient accuracy to enable us to judge whether or not any general upheaval, such as has already been suggested, might have affected this region.

Leaving the Snake River plain at Ross's Fork, we followed up the valley of that stream some six or eight miles, and then crossed a dividing ridge to Lincoln Valley and Fort Hall, which post we reached about noon on July 3. Thus far we had followed well-traveled roads, and had transported our baggage and provisions in wagons; but now we were soon to leave roads entirely, and accordingly turned in our wagons and fitted out a train of pack-mules. During the week thus occupied, we were enabled to examine a considerable territory in the neighborhood of the post.

At Ross's Fork we had struck the line of the old emigrant-road across the mountains to Oregon. This road crossed from Green River to the head of Bear River, down that stream to Soda Springs, thence across the head of Port Neuf, and through a low gap to the head of Ross's Fork. Near the mouth of Ross's Fork it crossed Snake River, and thence ran in almost a direct line past the westernmost of the Three Buttes to the foot of the Salmon River Mountains.

Lincoln Valley, as a whole, is broad and flat, with mostly gentle slopes rising to the crests of the bounding ridges. On the wet bottoms, large quantities of a coarse grass are cut for the stables at the post. The slopes are covered with various grasses, sedges, and other forage-plants, which make fine grazing for nearly the whole year. In this excessively dry atmosphere, these plants, which are ripe and have stopped growing by midsummer, lose their moisture so rapidly as to escape the decay common in the damp air of the Eastern States, and so become natural hay while still standing, and mostly retain their nutritious qualities until the melting of the snow and the setting in of the spring-rains, which start the new growth while occasioning the decay of the old. Here in the foot-hills, the snows sometimes lie deep enough to prevent the stock from reaching the standing grass, and so a supply of hay is essential to their wintering. Only a few miles westward, however, the snows are generally so light and melt so rapidly that, in an ordinary winter, no hay is needed; and stock range through the whole winter, never even coming to the ranches of their own accord. This neighborhood was formerly one of the favorite winter-rendezvous of the trappers and fur-traders; and the plains and foot-hills then supported vast herds of buffalo, as well as many antelope, deer, elk, and bears. The region is now so much frequented that none of these animals are often seen, except when the deep snows drive them out of the mountains, and the buffalo is here entirely exterminated.

Hollows on the northern slopes, where the snow lies late in the spring, and so furnishes the requisite moisture, are mostly filled with little copses of scrubby cottonwood. The higher and more rocky parts of the hills bear large numbers of stunted cedars, (*Juniperus occidentalis.*) One of these was seen, a half mile east of the fort, which measured 41 inches in diameter, while only 12 feet high, a form probably resulting from the great dryness of the atmosphere. Large pines are brought from the cañons in the north slopes of Mount Putnam, (formerly known as Sublett's Peak.)

The spur which divides Ross's Fork from Lincoln Valley seems to be the final termination of the limestone ridge which formed the eastern boundary of Marsh Valley and of the upper part of the lower cañon of the Port Neuf, and is mainly a monoclinal ridge with strong easterly dips. Its culminating point is a lofty peak, now called Mount Putnam, standing about twelve miles south of Fort Hall. Its western base was not examined; but it is evident that the lower quartzite forms a large portion of its lower face, followed above by from 200 to 300 feet of drab, thin-bedded limestone, in which no fossils were seen; then, from 100 to 150 feet of compact, coarse, pebbly sandstone, nearly pure white; then several hundred feet of dark drab, pebbly limestone, evidently of Quebec Group age, though only fragmentary fossils could be found, with the exception of a single *Ophileta.* A covered space follows, apparently underlaid by the continuation of the last-named limestone, and then comes an outcrop of about 50 feet of compact, fine-grained, white sandstone, overlaid by from 200 to 300 feet of a light-drab vesicular limestone, much resembling in texture the Niagara limestone of Indiana and Illinois, and probably representing either the Upper Silurian or the Devonian. Neither of these beds showed fossils. Immediately above come heavy beds of Carboniferous limestones, 300 feet or more in thickness. Their lowest layers include some pretty pure limestones, some of which are partly oolitic and contain great numbers of minute fossils, the mass looking much like the layers of the Saint Louis limestone at the famous locality of Spergen Hill, Indiana, except that the color is a dark-bluish drab. From masses collected here, over forty species of brachiopods, conchifers, gasteropods, pentremites, corals, and bryozoans have been separated, of which Mr. Meek has already identified fourteen with well-known Spergen Hill forms. Mr. Meek informs me that these are the first distinctively Spergen Hill forms yet brought from the Rocky Mountains. It will be remembered that a few allied forms from Little Cottonwood Cañon, Utah, have already been mentioned in this report. These beds are followed by several hundred feet of very cherty limestone, rarely containing any fossils, except a large *Zaphrentis* (*Z. Stansburyi,*) which is very abundant in some layers. The upper part of the series consists of mostly pure limestones, from which a few specimens of *Spirifer*, *Productus*, &c., were obtained. The rocks of this series form the upper part of the western face as well as the summit and eastern slope of Mount Putnam.

Passing northward along the line of this ridge we find it much eroded and, in two places, cut entirely through by small tributaries of Ross's Fork. In these gaps, the lower quartzites outcrop clear through the ridge, while the intermediate knobs are capped with the Quebec group limestone. The strike of the beds runs a little to the east of the line of the ridge, so that the Carboniferous limestones pass out from the main spur and form the high knob which stands at the south end of the main part of Lincoln Valley. On the eastern slope of this knob appear the overlying beds, consisting of a few hundred feet of thin-bedded ferruginous sandstone, with few fossils, apparently Carboniferous, with a hundred feet or more of bright-red sandstones, possibly Triassic, followed by brown and drab thin-bedded limestones, crowded with *Pseudomonotis, Lingula, Aviculopecten* (?,) &c., which are evidently of Jurassic age. The dip of these latter beds is here 15°, N. 44° E.; and no unconformability is evident from the very base of the lower quartzite to the top of the exposed beds. At other points in the neighborhood, however, certain distortions and displacements led me to suspect a partial unconformability between the Carboniferous and the Jurassic.

Passing farther out on the main spur, nearly to the road running from Fort Hall to Ross's Fork the, older beds mostly disappear, only a thin outcrop of the shelly Jurassic limestones being located by loose blocks in the soil on the west slopes, while the crest and eastern slopes of the spur consist of white and light-gray Pliocene sandstones and limestones, interlaminated with trachytic porphyries and coarse volcanic sandstones, all dipping about north 54° east, at angles varying from 15° to 30°. These dips, which gave renewed evidence of late disturbance, even later than the commencement of volcanic eruptions in this region, continue with little change to the very extremity of the spur, where the opposite side of the anticlinal fold is also apparent in the basalts, which dip 72°, S. 34° W. The examination was not carried far enough to ascertain certainly whether these tilted basalts are, or are not, continuous with either of the beds which floor the great plain.

On the east side of Lincoln Valley there is either a small fault or a very sharp double fold. About five miles south of the fort, on the east side of the road to Soda Springs, the Jurassic shaly limestones lie at the foot of the ridge, with a dip of about 35°, N. 19° E., while its higher portions include sandstones and interlaminated limestones, probably of Carboniferous age, dipping 65°, N. 45° E. A more eastern portion of this same ridge shows the other side of a synclinal in these same Carboniferous sandstones, dipping 46°, S. 58° W. In the axis of the synclinal the Triassic red sandstone shows a thickness of 100 feet or more, at a point about one and a half miles east of Fort Hall, and visible from that post. The most easterly portion of this ridge, approaching the valley of Blackfoot Fork, exhibits another anticlinal and another synclinal, the eastern edge of the latter culminating in the highest point of the outer end of the spur, which received from our topographers the name of Higham's Peak, in honor of the proprietor of the nearest ranch. From this high point it becomes evident that the valley of Blackfoot Fork occupies, for a considerable distance, the axis of a broad anticlinal; and considerable thicknesses, of Carboniferous limestones are exposed on both sides. The immediate mouth of this valley is rather wide and flat, though the channel of the stream itself is comparatively deep and narrow, but, from a point above five miles up, the stream is for many miles deeply cañoned in basalt which floors the valley as a corresponding stream does that of Port Neuf; and it is probable that, here as there, the valley has given exit to the overflow of some volcano near its head, which is very near to the head of Port Neuf and the Soda Springs. The extremity of the dividing ridge beyond Higham's Peak consists of the Carboniferous sandstones, nearly or quite to the level of the plain. If any volcanic rocks have ever rested upon it, they have been so thoroughly eroded as to leave no trace; but the ridge next east of Blackfoot Fork terminates in a mass of porphyries.

CHAPTER II.

MARKET LAKE—CRATER BUTTES—TÉTON MOUNTAINS—HENRY'S FORK—HENRY'S LAKE—MADISON RIVER—GEYSER BASIN—REUNION.

Having completed our outfit, through the kind assistance of Captain Putnam and his aids, who did all in their power to forward our plans, though at the same time showing such courteous hospitality that we were loth to leave them, we started again, on the 12th of July, and camped at Higham's ranch, on Blackfoot Fork, after a drive of only seven miles. This stream was named after the well-known Indian tribe, whose warriors once infested this region to the great discomfort and danger and frequently loss of the trappers and traders passing through or wintering near here. At present members of the tribe are rarely, if ever, seen on this side of the mountains, and the generally peaceable tribes of Shoshones, Bannocks, and Boisés, whose reservation reaches to the southern bank of the stream, were the only ones seen by our party on the entire trip.

Either westerly winds or the waves of the old lake, which is supposed to have covered this broad plain, have accumulated in this neighborhood considerable bodies of fine sand. As we approach the mouth of Lincoln Valley we encountered broad stretches of this sand, partly covered with a scattered vegetation, partly bare and drifting. On one of these drifting patches lies the bleached trunk of a large cottonwood, though no such trees are now to be found for miles around. Has the gradual drying up of the country only recently permitted the sands to drift and accumulate here? And did its accumulation kill off a formerly extensive growth of trees at this point? Here also appears the first of a long range of sand-knobs, which are seen at short intervals for some miles, until they finally are lost in the irregular sand-plain along the lower course of Sand Creek.

The road we are now following, between Ross's Fork and Taylor's bridge, is much used by drovers and freighters, when they are going south with empty wagons. Being less traveled than the stage-road, which follows directly up the river, the grazing is generally better, while the distance is about the same, and the grades over the ridge west of Fort Hall are not very steep, being only about 88 feet to the mile.

A fine young greyhound had accompanied us from the post, but the march of thirteen miles, from Blackfoot Creek to Sand Creek crossing, under a scorching sun and without water, was too much for her endurance, and she died of thirst, about a mile from our camp on the latter stream. This creek is said to have been entirely dry on June 24, 1871, when crossed by Dr. Hayden's party, and we accordingly attributed its fullness at the time of our arrival solely to the unusually large supply of water furnished by the immense snow-fall of the previous winter; but, upon our return in October, we found its channel still carrying from 12 to 15 feet of water, and were obliged to look to some other source for the change. Our guide, Richard Leigh, generally known as "Beaver Dick," who has long lived in this region, informed us that for many years this channel had carried no water except during rains, when it gathered small amounts from its immediate banks, but that, two or three years since, Willow Creek, which had previously emptied its waters into Snake River by two mouths, one about a half-mile and the other about two miles above Taylor's Bridge, broke over its banks in time of flood and poured part of its surplus into Sand Creek. Since then, the latter stream has, during the spring, carried more or less water, which, however, has all sunk into the sands of the lower part of the channel before reaching Blackfoot, to which it should naturally be tributary, if we may judge by the shape of the country as seen from Higham's Peak. Indeed, from that point, certain water-courses were seen which lead me to suspect that, after once sinking, it again escapes from the sand and renews its individuality, at least for a short space. At present, it is evident that the connecting channel has been so deeply cut that Sand Creek carries far more water than does the original channel of Willow Creek below the separation; and, if this continues to be the case, it is not improbable that it may succeed in clearing away the sand-obstructions from its lower channel and in establishing complete surface-connection with Blackfoot. The tracing of these old channels—and of others which doubtless exist in this broad flat plain—and the determination of the relative dates of their occupation will be of much local interest to geologists who may, in the future, make their homes hereabout. On the upper course of Sand Creek, later in the season, we found many shells in the soil of the banks, giving further proof of the lateral movements of the old channels, while yet the general course of the drainage was unchanged.

Crossing Snake River at Taylor's or Eagle Rock Bridge, we encamped on its west bank, about seven miles above. The stream was very full, carrying an immense body of water, whose surface was constantly broken by the eddying whirls characteristic of irregular bottoms. After a long, hot day, the temperature of the stream, at 6.20 p. m., was 62°, the air being at 78°. At 4.20, on the next morning, with the air at 47°, (the minimum thermometer marking 44°,) the river was still at 62°. Only a very large and much-disturbed flow of water could thus escape all effects of so great an atmospheric change of temperature.

At medium and low stages of water, the river is confined, at the bridge, to a single narrow and deep channel, worn in the basalt; but, in times of flood, it here occupies two bridged channels, and elsewhere spreads considerably upon its banks. On either side there are old channels, more or less plainly marked, which were occupied by the stream at times before it had worn its present channel so deep into the rock. In passing northward, we found many of these, mostly dry, though some of them are occupied, during the rainy season, by the drainage of the neighboring plain and retain some pools through most of the year. The road here follows the bottoms, without anywhere rising to the level of the surrounding plain.

On the morning of July 16, we left the stage-road at Market Lake Station, and turned eastward toward the Tétons, whose highest peak had been visible at intervals, just above the horizon, ever since we crossed the river. The basalt-terrace, which here stands from 50 to 60 feet above the stream, is much broken near its borders, the edge being more or less undermined and sunken. At short distances within the borders are many depressed areas, occupying a few acres each, whose walls appear to have once inclosed small ponds; but these have long since been drained through the underlying sand and gravel, when the river cut its channel to this lower level. Here, again, we see many of the unbroken knolls of basalt, evidently consequent upon the shape of the underlying surface at the time of the overflow.

Since leaving Sand Creek, we had had constantly in view two rounded buttes of moderate elevation, which were now immediately in front of us. As we approached, we found that they stood in the lower angle between retains no wind-marks. At the angle of 38° the sand will rest for an instant, but apparently holds no permanent position when the angle of slope is greater than 33°. The upper and lower edges of the dunes are marked by dense thickets of sage-brush. Above the dunes the base of the mountain shows solid foundations of trachytes, covered with considerable groves of cedar, from 12 to 15 feet high. Then follow covered slopes, thickly beset with Jersey tea (*Ceanothus velutinus*) and sumac, (*Rhus glaber*,) and spotted with blossoms of *Geranium Richardsonii*, and various Compositæ and Umbelliferæ, and, finally, irregular masses of coarsely-porous trachyte cap the crests at the height of about 1,200 feet above the valley. The range is a double one, the southern portion being the longer and larger, which runs about northeast and southwest for perhaps ten miles, with a moderate southern slope, much broken into long spurs, and a steep northern one, descending almost unbroken into a valley perhaps 200 feet above the plain, and about a mile wide, which opens westward, and has thence been filled with the barren drifting sands. These have been blown into drifts reaching to the very crest of the more northern ridge, which attains the same elevation as the other, with generally steep southern slopes, but apparently somewhat spurred on the northern, where it descends to the plain. The range, as a whole, has no apparent connection with any other, the rocks have no definite bedding, and I am inclined to believe that the two main ridges, facing each other with steep slopes, may be fragments of the bounding walls of a huge crater, whose fires were extinguished long before the eruption at the Crater Buttes commenced, and even before the eruption of at least the later of the basalt-layers which floor the plain.

Looking southwestward from these crests, we see the rough, almost impassable, basalt-plain, thickly overgrown with sage-brush, stretching away toward Market Lake. To the west and northwest spread the barren sands of the dunes, which are several miles in width where crossed by the stage-road, near Sand-Holes Station. These also extend northward, and their eastern edge forms a ridge from 100 to 150 feet high, joining the Sand-Hill Mountains to the main divide of the Rocky Mountains near Camas Creek, and forming the western border of the valley of Henry's Fork. These absorbent sands, and the cracked and cavernous basalt with sand and gravel foundations together, may well account for the fact that, from near the head of Henry's Fork to the Malade River, which enters below the Great Shoshone Falls, a distance of fully three hundred miles by the river, no stream joins the Snake by a surface channel, though several good-sized ones reach the plain from the Salmon River Mountains. Along the bank of the Snake, however, at several points, there are large cold springs escaping from the basalt; and, in the lower part of the region named, several large streams are said to leap boldly from the walls of the cañon, thus escaping from the subterranean channels to which they have been confined for many miles.

The low plain bordering Henry's Fork on the west is from two to eight or ten miles in width, partly well grassed, though with many dense patches of sage-brush. About half way between the Sand-Hill Mountains and the river, there is a low hill, in the shape of a horseshoe, opening to the south, which apparently was once a crater; but it has now been so much worn away and covered with soil that no rock is visible.

Nearly opposite the Sand-Hill Mountains we crossed Henry's Fork, at Eagle-Nest Ford. The river is here, perhaps, three hundred yards wide, with from one to three feet of water, with pebbly bottom, a bluff bank on the west side and a low one on the east, which is overflowed during the spring freshets, so as to double the width of the stream. At that then, the latter stream has, during the spring, carried more or less water, which, however, has all sunk into the sands of the lower part of the channel before reaching Blackfoot, to which it should naturally be tributary, if we may judge by the shape of the country as seen from Higham's Peak. Indeed, from that point, certain water-courses were seen which lead me to suspect that, after once sinking, it again escapes from the sand and renews its individuality, at least for a short space. At present, it is evident that the connecting channel has been so deeply cut that Sand Creek carries far more water than does the original channel of Willow Creek below the separation; and, if this continues to be the case, it is not improbable that it may succeed in clearing away the sand-obstructions from its lower channel and in establishing complete surface-connection with Blackfoot. The tracing of these old channels—and of others which doubtless exist in this broad flat plain—and the determination of the relative dates of their occupation will be of much local interest to geologists who may, in the future, make their homes hereabout. On the upper course of Sand Creek, later in the season, we found many shells in the soil of the banks, giving further proof of the lateral movements of the old channels, while yet the general course of the drainage was unchanged.

Crossing Snake River at Taylor's or Eagle Rock Bridge, we encamped on its west bank, about seven miles above. The stream was very full, carrying an immense body of water, whose surface was constantly broken by the eddying whirls characteristic of irregular bottoms. After a long, hot day, the temperature of the stream, at 6.20 p. m., was 62°, the air being at 78°. At 4.20, on the next morning, with the air at 47°, (the minimum thermometer marking 44°,) the river was still at 62°. Only a very large and much-disturbed flow of water could thus escape all effects of so great an atmospheric change of temperature.

At medium and low stages of water, the river is confined, at the bridge, to a single narrow and deep channel, worn in the basalt; but, in times of flood, it here occupies two bridged channels, and elsewhere spreads considerably upon its banks. On either side there are old channels, more or less plainly marked, which were occupied by the stream at times before it had worn its present channel so deep into the rock. In passing northward, we found many of these, mostly dry, though some of them are occupied, during the rainy season, by the drainage of the neighboring plain and retain some pools through most of the year. The road here follows the bottoms, without anywhere rising to the level of the surrounding plain.

On the morning of July 16, we left the stage-road at Market Lake Station, and turned eastward toward the Tétons, whose highest peak had been visible at intervals, just above the horizon, ever since we crossed the river. The basalt-terrace, which here stands from 50 to 60 feet above the stream, is much broken near its borders, the edge being more or less undermined and sunken. At short distances within the borders are many depressed areas, occupying a few acres each, whose walls appear to have once inclosed small ponds; but these have long since been drained through the underlying sand and gravel, when the river cut its channel to this lower level. Here, again, we see many of the unbroken knolls of basalt, evidently consequent upon the shape of the underlying surface at the time of the overflow.

Since leaving Sand Creek, we had had constantly in view two rounded buttes of moderate elevation, which were now immediately in front of us. As we approached, we found that they stood in the lower angle between retains no wind-marks. At the angle of 38° the sand will rest for an instant, but apparently holds no permanent position when the angle of slope is greater than 33°. The upper and lower edges of the dunes are marked by dense thickets of sage-brush. Above the dunes the base of the mountain shows solid foundations of trachytes, covered with considerable groves of cedar, from 12 to 15 feet high. Then follow covered slopes, thickly beset with Jersey tea (*Ceanothus velutinus*) and sumac, (*Rhus glaber*,) and spotted with blossoms of *Geranium Richardsonii*, and various Compositæ and Umbelliferæ, and, finally, irregular masses of coarsely-porous trachyte cap the crests at the height of about 1,200 feet above the valley. The range is a double one, the southern portion being the longer and larger, which runs about northeast and southwest for perhaps ten miles, with a moderate southern slope, much broken into long spurs, and a steep northern one, descending almost unbroken into a valley perhaps 200 feet above the plain, and about a mile wide, which opens westward, and has thence been filled with the barren drifting sands. These have been blown into drifts reaching to the very crest of the more northern ridge, which attains the same elevation as the other, with generally steep southern slopes, but apparently somewhat spurred on the northern, where it descends to the plain. The range, as a whole, has no apparent connection with any other, the rocks have no definite bedding, and I am inclined to believe that the two main ridges, facing each other with steep slopes, may be fragments of the bounding walls of a huge crater, whose fires were extinguished long before the eruption at the Crater Buttes commenced, and even before the eruption of at least the later of the basalt-layers which floor the plain.

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Thus far, we had been accompanied by a large wagon from Fort Hall, which carried some of our heaviest supplies, so that our pack-animals might become accustomed to light loads before receiving heavy ones. Having now reached the limit of convenient wagoning, though it would have been *possible* to take vehicles even to the very base of the Téton range, we sent the wagon back, and spent one day in re-arranging packs and in examining the proposed route up Téton River, or Pierre's River, as it is more properly called, since this latter name was long since commonly applied to it among traders and trappers, as well as upon maps of the region. The trappers of the present day, having little or no knowledge of the names used by their predecessors, have, of course, applied their own terms to the landmarks with which they are familiar; but the adoption of these by geographers would be contrary to all rules.

Upon examining Pierre's River about six miles south of our camp, at a point not far above its junction with Henry's Fork, Mr. Stevenson reported it as occupying a deep though narrow channel, walled on either side by perpendicular cliffs of basalt, 60 feet in height, which frequently come to the water's edge, so as to make travel along the bottoms impossible. Our guide, Beaver Dick, stated that these cliffs increased rapidly to several hundred feet in height, rendering the stream unapproachable by stock for over thirty miles. As we were not in condition, being so heavily loaded, to make so long a march without water, we turned northward for a few miles, to pass up the valley of the next tributary, which Beaver Dick called the middle fork of the Snake. Since neither by position nor by size is this stream entitled to be considered a fork of the main Snake, we have applied to it another name, Falls River, for reasons which will appear later in this report. Camping just above where we struck the stream, we found it about 3 feet deep and from 50 to 60 feet wide. On the opposite bank, a bluff of basalt, about 30 feet high, showed a distinct prismatic structure through the upper 10 feet, while the central portion was amorphous and the lower 5 feet, again prismatic, the whole looking as if the upper and lower portions had been affected by rapid cooling and consequent contraction of the surfaces of the sheet of lava, while the central portion, cooling much more slowly, did not reach the same state of tension. Just above camp, on the south side of the stream, there is a considerable bluff of light-pink porous porphyry, with an indistinct bedding, apparently upturned nearly to verticality, with a nearly north and south strike. The upheaval evidently occurred before the flow of the basalt.

As we leave the valley of Henry's Fork, July 20, the country rises, and becomes more broken and rolling. The abundant growth of grasses, sedges, and other flowering herbs shows plainly that only slight irrigation would be necessary to make this valuable farming-land; and some crops would succeed without that. Most of it would be fine land for stock-raising, the only exceptions being those portions along deeply-cañoned streams, where water is difficult of access. We bore a little to the southward to-day, toward the upper waters of Pierre's River. About eight miles from camp, two rocky knolls, rising about 50 feet above their connecting saddle, and perhaps 350 or 400 feet above the nearest creek, mark two points of the rim of an old, broken-down crater, which faces nearly due east. The lava is a laminated mixture of quartz, obsidian, and feldspar; but no mass seemed to be *in situ*, so that direction of structure could not be determined.

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Where these lower limestones are first encountered, near the mouth of the cañon, they are nearly horizontal; but, as we pass in toward the center of the mountain, we find them rising considerably, until they reach angles of 15°, 20°, and even 30°, dipping westerly and southwesterly, and resting unconformably upon the edges of granites which dip in various directions. At the forks of West Téton Creek, where the granites are first seen, their bedding dips 35° N. 78° E. Up the left-hand fork they rise rapidly, causing beautiful cascades a hundred feet or more in height, and finally occupying the whole upper basin of that stream and reaching the very crest of the ridge. They also occupy the valley of the right-hand fork for a considerable distance, forming smooth, bare cliffs on the left as we ascend, and finally are exposed in broad surfaces on its floor. The right-hand wall of the cañon is abrupt for 1,200 feet or more, reaching well up into the Carboniferous limestones, the upper parts of which form crests here reaching more than 3,000 feet above the cañon and about 10,000 feet above the sea.

The granites, gneisses, and schists, which form the central nucleus of the mountain, vary greatly in character and position. They are partly micaceous, partly hornblendic, and partly talcose and chloritic. No regular succession was ascertained. The granites are mostly white or tinged with pink, and occur in thick, solid beds. The other rocks are much broken up and tilted in various ways, and are crossed in every date, July 17, the pools left by the freshets had not quite disappeared. From a short distance above the ford, the river flows over a basalt-bottom for some miles, occasionally cutting rather deeply and leaping over small falls, but generally having low banks.

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While the beds are generally so much disturbed as to prevent the accurate determination of any regular or prevailing dip, yet the general strike is approximately east and west; and this has determined, to some extent, the structure of the range. The spurs running east and west from each crest-peak are each dotted with three or four subordinate peaks, which would be thought large, if they were not belittled by their larger neighbors. The sharp dips cause the north and south sides to be extremely sharp—even sharper than the natural weathering of the granites, if level, would have made them. The highest of them all are visible from great distances in every direction, both on account of their great elevation and by reason of the sharp depressions on either side of them. From whatever point they may be seen, there is little danger of mistaking their identity, their abrupt, pointed outlines being markedly different from those of any other peaks of the region. From their prominence, affording good landmarks for travelers, they have sometimes been called the Pilot Knobs, (see Irving's Astoria, chap. xxix;) but the name commonly applied, from the earliest times, is that of Tétons, or Paps. As only three of the peaks are usually seen at a distance, they have been called the Three Tétons. There are really ten or more disright, we found ourselves on the divide between the head of the Great Cañon and that of a smaller one, which opened directly out toward Jackson's Hole. In the head of this latter, perhaps 200 feet below us, lay a small ice-covered lake, with no surface-outflow, but probably draining through the slopes of *débris* which hemmed it in on either side. The accompanying outline-sketch of our route beyond this point has been made up by Mr. Holmes from Mr. Jackson's photographs, which were taken from the top of the western wall of the Great Cañon. (Fig. 47.)

In the broad head of the Great Cañon, which we now crossed, there are three or four small and apparently shallow ponds, partly covered with ice, though partly clear. The outflow of one, buried in rubbish for some distance, finally appears on the edge of a cliff and makes a pretty little fall, perhaps 30 feet high, at the head of which, with a favorable wind, one can easily get a spray-bath at short notice. At the head of this pond, a slight depresion of the crest of the spur indicates probably the best point for crossing, though the slopes are of fine sliding rubbish, which makes climbing tedious. Those who preferred climbing over solid rock crossed a little farther out on the spur. Another short half-mile of snow brought us at length to the foot of the central peak. In neither of these two snow-basins was there any apparent consolidation of the snow into glacier-like bodies of ice, though small icy patches were seen, and the compacted snow was occasionally cracked as if by incipient crevasses. Apparently, the melting of the snow is very nearly complete every season, so that no glacier-like masses can be formed. We afterward saw abundant evidence that this valley, like others in the range, was once the scene of intense glacial action.

It is possible to climb directly up the steep slope of bare rock in front of the lowest part of the saddle south of the main peak. Those who prefer gentler slopes of *débris* and snow should pass about two hundred yards farther north, where such a slope reaches to a higher point of the saddle.

Several of the party had already turned back, and Mr. Bechler's injury, previously mentioned, made it imprudent for him to attempt these steeper slopes. Accordingly, he turned off and examined the cañon for a mile or so lower down. Five of us reached the saddle—Messrs. Stevenson, Langford, Hamp and Spencer, and myself. Here I stopped, at 12 o'clock, at the elevation of about 11,400 feet, to wait for a mercurial barometer, which Mr. West had undertaken to deliver to me at that point, so that I might take it to the summit. I afterward learned that he had already turned back from the high spur, without really attempting either to reach the saddle himself or to send forward the barometer by any other person. Meanwhile, I examined the rocks upon and east of the saddle. Climbing is here much hindered by steep slopes of snow, some of which consist wholly of hail-stones from a third to a half inch in diameter. A fierce west wind, blowing forty to fifty miles per hour, was sweeping across the saddle with such force that the loudest shouts were inaudible fifty yards to windward. I experienced no inconvenience from the rarity of the air at this elevation. My highest point was about 12,000 feet, about a half mile east of the main saddle, from which point I had a limited view out to the basin of Jackson's Hole. The mountain descended in bare rock-slopes over 4,000 feet, until, with gentler slopes, there appeared a belt of pines and spruces. In the upper edge of this belt, a small lake, partly iced over, occupied a notch in the base of the mountain immediately beneath me. The timber stretched in a heavy body down along a small stream flowing past the base of the mountain out to its junction with Snake River. In plain direction by innumerable large and small veins, mostly of quartz, but a few granitic. None of these are metalliferous, so far as I could ascertain. At two or three points there are beds of trap-rock from 50 to 70 feet thick, which appeared at first sight to be dikes; but, upon further examination, it became evident that they lay conformably between regularly-bedded members of the granitic series, and it seemed as if they might have been deposited as broad sheets of lava, like those which we have seen flooring the Snake River plain, but deposited ages ago in the bed of the ocean, where were then accumulating the sedimentary sandstones which were metamorphosed into these granites before the Silurian age began. But, again, the trap shows no columnar structure, but is indistinctly laminated parallel to its walling planes; and this would seem to indicate that it might, when quite viscid, have been forced with difficulty between the solid granites after their upheaval, and so have received its laminated structure, while between walls of such slow-conducting power it did not take on the columnar structure. Or it is possible that, having been deposited horizontally among the sediments, as aforesaid, it may have lost a columnar structure, originally possessed, during the metamorphism of the surrounding beds. The trap weathers much more rapidly than the granite; so that its outcrops are plainly marked and readily traced from a distance by a sharp notch on the crests as well as by its *débris* on the slopes of the mountain. One of these beds, which crosses the saddle just south of the Grand Téton, was thus traced across the Great Cañon, and up the side of its perpendicular western wall, where at least 2,000 feet high; and its termination was then capped by the Potsdam quartzite, showing that it is at least older than that rock. Both this trap and its inclosing granites contain much epidote, partly compact, partly crystalline, and some pyrite. Near to this bed of trap are two very noticeable beds of granite, one being of the deepest flesh-red, the other almost pure white; both contain very little mica. The white bed has its constituent minerals much segregated; so that we find in some places large masses of pure feldspar, (orthoclase,) cleaving with broad surfaces, and again fine specimens of graphic granite, (pegmatite.) From a neighboring bed come large masses of mica (muscovite) tolerably well crystallized. A few small garnets were seen, but we found no large or particularly good crystals either of this or of any other mineral.

While the beds are generally so much disturbed as to prevent the accurate determination of any regular or prevailing dip, yet the general strike is approximately east and west; and this has determined, to some extent, the structure of the range. The spurs running east and west from each crest-peak are each dotted with three or four subordinate peaks, which would be thought large, if they were not belittled by their larger neighbors. The sharp dips cause the north and south sides to be extremely sharp—even sharper than the natural weathering of the granites, if level, would have made them. The highest of them all are visible from great distances in every direction, both on account of their great elevation and by reason of the sharp depressions on either side of them. From whatever point they may be seen, there is little danger of mistaking their identity, their abrupt, pointed outlines being markedly different from those of any other peaks of the region. From their prominence, affording good landmarks for travelers, they have sometimes been called the Pilot Knobs, (see Irving's Astoria, chap. xxix;) but the name commonly applied, from the earliest times, is that of Tétons, or Paps. As only three of the peaks are usually seen at a distance, they have been called the Three Tétons. There are really ten or more disright, we found ourselves on the divide between the head of the Great Cañon and that of a smaller one, which opened directly out toward Jackson's Hole. In the head of this latter, perhaps 200 feet below us, lay a small ice-covered lake, with no surface-outflow, but probably draining through the slopes of *débris* which hemmed it in on either side. The accompanying outline-sketch of our route beyond this point has been made up by Mr. Holmes from Mr. Jackson's photographs, which were taken from the top of the western wall of the Great Cañon. (Fig. 47.)

In the broad head of the Great Cañon, which we now crossed, there are three or four small and apparently shallow ponds, partly covered with ice, though partly clear. The outflow of one, buried in rubbish for some distance, finally appears on the edge of a cliff and makes a pretty little fall, perhaps 30 feet high, at the head of which, with a favorable wind, one can easily get a spray-bath at short notice. At the head of this pond, a slight depresion of the crest of the spur indicates probably the best point for crossing, though the slopes are of fine sliding rubbish, which makes climbing tedious. Those who preferred climbing over solid rock crossed a little farther out on the spur. Another short half-mile of snow brought us at length to the foot of the central peak. In neither of these two snow-basins was there any apparent consolidation of the snow into glacier-like bodies of ice, though small icy patches were seen, and the compacted snow was occasionally cracked as if by incipient crevasses. Apparently, the melting of the snow is very nearly complete every season, so that no glacier-like masses can be formed. We afterward saw abundant evidence that this valley, like others in the range, was once the scene of intense glacial action.

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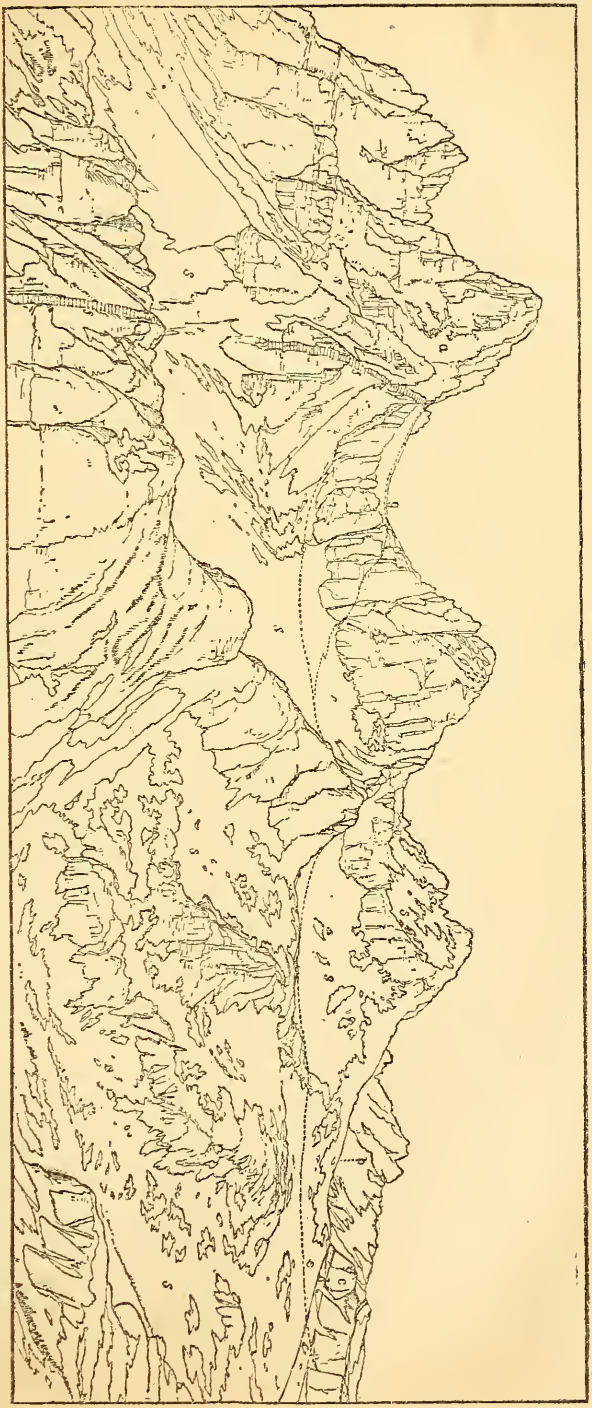
Fig. 47



"THREE TÉTONS," LOOKING EAST.

a, Mount Hayden; *b*, Lake; *c*, Quebec Group limestone; *d*, Quartzite; *e*, Granite; *ff*, Trap dyke; *g*, "Saddle;" *h*, Timber line, 9,000 feet; Dotted line, course of ascent; *ss*, Snow.

valley of that stream running far into the eastern mountains, with large stream, flowing directly from the broad depression north of the Tétons. No sedimentary rocks were seen in this region. Only scattering groves of aspens, pines, and spruces had been seen thus far; but, after crossing, we at once passed into dense bodies of pines and spruces, large areas of which had long since been burned over and were mostly grown up again with dense young pines, from one to six years old, and smaller numbers of quaking aspens. The country is much cut up by precipitous cañons, from 50 to 200 feet deep, with flat bottoms and broad shallow streams, the smaller ones being dammed by the beavers at short intervals. A few purple-nacred unios occur in these streams.

Approaching the Spring Fork of Henry's River, two buttes are prominent, consisting of porphyries and loose-textured volcanic sandstone. Their tops are much cut by ravines, with flat, grassy hollows at their heads, which at first remind one of craters; but closer examination shows that these are not distinct volcanic cones, but are merely fragments of the terrace-like mountain to the northeastward, which have been cut off from it and left behind in the general erosion of the valleys. On the slopes of one of these buttes we found a profusion of large, blue huckleberries, growing on rather small bushes a foot or so high; but these were not again seen on the whole trip. A smaller trailing species, however, forming a perfect carpet in the open groves of pine and spruce, and bearing a very small, deep-crimson berry, with a pleasant acid flavor, now began to appear, and was afterward found abundantly, through all the pine-country, until we reached Jackson's Lake, late in September.

Spring Fork, where we crossed it, is about 100 feet wide, and was then carrying about 150 feet of water. Its banks are very steep, consisting mainly of the drab and pink porphyries so common in this region, which are here well laminated and nearly or quite horizontal. If Raynolds's distances and ours are both correct, our camp must have been about two miles below the immense spring, described by him as leaping over a 30-foot fall into the stream, and furnishing to it fully two-thirds of its water as well as its name. This sudden increase would explain the evident inconsistency between the size of the stream and the apparent extent of its upper basin. We did not at the time understand our relation to Raynolds's route, or we should have tried to reach this spring. Starting from this camp the next morning, August 5, the steep bank proved too exciting for one of the usually most obstreperous of our mules, and, in attempting to kick herself free from her pack, she lost her footing and rolled down hill, turning five complete somersaults before reaching the bottom, where she quietly went to grazing, with only one or two slight scratches. For want of any other name, at the time, we called this, among ourselves, the Mormon Mule's Creek.

Shortly after leaving this stream, we found the soil becoming noticeably thinner, and masses of basalt began to appear upon the surface. The loosely-jointed character of the basalt seems to have given to the soil, as fast as it formed, a ready passage downward with the water of rains and melting snows; so that, in many places, broad surfaces of the rock appear, with barely enough soil upon them to support a few small herbs and grasses. The basalt is doubtless underlaid here, as it is elsewhere, by sands and gravels, which not only readily absorb all waters percolating through the crevices of the basalt, but also furnishes covered passage-ways for the large streams which supply large springs, of which there are many examples in this region besides the one just mentioned. Timber is here more scattered and has suffered less from fire than in the tracts we had recently crossed. The basalt is much bulged up into low domes, like those before encountered and described. Many of these are broken away at the top, and the basins are often occupied by ponds; these being the exact equivalent of the pond-holes already described as having been seen near Market Lake, only these are at a less advanced stage. By the dribbling outlet of one of these ponds, whose water was, during the middle of the day at least, too warm to be agreeable for drinking, we found a small flow of quite cold chalybeate water, of medium strength. By one of these ponds, on the slopes toward Henry's Fork, we camped on the evening of the 5th.

Next morning, a few of us turned southwestward, to try to find the reported falls of Henry's Fork. About two miles from camp we struck the bank of the river, at a point where it was just entering a basalt-cañon. Following down stream for several miles, we found the walls gradually increasing to 50 feet or more in height, but finally turned back without reaching the falls, after having gone nearly twice the reported distance. The falls are said to be below the end of this cañon and about 80 feet in height, the upper 40 feet consisting of rapids and the lower 40 being a clear leap. For about ten miles above the cañon the country is open, with gently-sloping, broad grassy bottoms and scattered groves. At several points, large cold springs break out from beneath the basalt, evidently being the outflow of streams which have been swallowed bodily, higher up, by this cavernous bed. These are full of delicious trout. For the next ten miles, dense timber runs to the river, which is again walled by low outcrops of basalt. At first, fallen timber was very troublesome and delayed the train badly. Since the second day out from our Téton camp, we had been obliged to make our own road, but now, on the banks of Fishing Creek, we found a trail which had, at some recent time, been used by wagons, following our general course, though it led us up Fishing Creek instead of the valley of Henry's Fork, which here makes a large bend to the westward. Before long, the trail became less marked and finally disappeared; but we kept on to the head of the stream, which proved to be one of the large springs so common here, and then bore a little westward to regain the main stream, though guided mainly by the summit of a peak which was said to stand on the south side of Henry's Lake. Here we encountered excessively dense growths of young pine, through which we forced our way with very great difficulty, the packs continually requiring replacement. At length we reached Henry's Fork and a trail almost simultaneously, and soon rejoiced in a good road and a camp. We were now done with bad timber for some time.

The season was now so far advanced that we began to find that mingling of spring and fall flowers which is characteristic of regions where the summers are short. In the same field we often found violets, strawberry blossoms and fruit, monk's-hood, geraniums, everlastings, and fringed gentians, (*G. crinita.*) This last was first seen on August 4. Strawberries were found in considerable numbers as late as September 9.

August 8.—Mr. Bechler examined the stream below our camp, and found that it ran for several miles through a deep basalt cañon. At and above camp, its bottoms are broad and flat, including some beaver-dams, and the valley continues of that general character to the lake, which is only a few miles distant. The groves are somewhat open, yet nearly all the comparatively bare spots are well set with seedling pines, which plainly need only protection from fire to soon make good all previous losses. Passing these, we soon enter the open grassy basin which surrounds Henry's Lake.

This is a broad, shallow sheet of water, said to average not more than

8 feet in depth, which is practically the head of Henry's Fork, though several small streams flow into it from various directions. Though the shore is very winding, and numerous points project into the lake, yet, as a whole, it is a pretty regular body of water, about three miles long by from one and a half to two miles wide. Several small islands are scattered over its surface. From its borders, which are mostly marshy, the plain rises very gradually to the gravelly terrace of an old lake-shore, from 80 to 90 feet above the present water-level. When at that level, the lake would have been some eight or ten miles in diameter. No higher terraces were apparent. The upper level is covered with sage-brush, but the lower flat supports luxuriant growths of grasses, sedges, and other rich forage-plants. Near Sawtelle's ranch, at the head of the lake, large amounts of hay were curing in the hot sun; while a mowing-machine was still in active operation on the meadows. Messrs. Sawtelle and Wurtz here conduct a large trade in fresh fish, caught in the lake and its outlet, which they pack in ice and haul fifty miles to Virginia City. They at first attempted raising stock on these rich meadows; but the immense numbers of horse-flies and gnats which breed in the swampy borders of the lake soon compelled them to abandon that business. They report that game is still abundant in the neighborhood—antelope, deer, elk, moose, bear, and mountain-sheep, as well as smaller animals.

In approaching this basin, the trail passed with the river to the west side of the valley, leaving the main mountain two or three miles to the right. This consists of coarse volcanic sandstone, mostly composed of obsidian. Two or three deep cañons here reach the valley, showing that water once worked powerfully in them, but these are now dry, except where springs burst out of the sandstone at their very mouths, and apparently have carried no water for many years past, except during the times of most rapid melting of the snow in the spring. In examinations made later by Mr. Bechler, when crossing westward from the Fire-Hole Basin, the upper course of these cañons proved to be of the same character; here and there large springs burst out, but soon disappear again in the porous sandstones, which, in that direction, form the surface of the entire mountain. Passing a little to the northward, older rocks appear on the higher slopes of the mountain and soon form its entire face, the volcanic rocks disappearing beneath the valley.

On the opposite side, these appear again in the high mountain lying directly south of Henry's Lake, known to us as Sawtelle's Peak, whose lower spurs run down nearly to the lake-shore. The rugged precipitous sides of the peak, without well-marked stratification, led to the suspicion that it might be of volcanic origin, and it was accordingly visited by Mr. Taggart and myself. It was found to constitute the eastern and north-eastern wall of a great crater, some 1,200 or 1,500 feet deep, whose east and west diameter is about a mile and a half, with a transverse diameter of about a half mile. The sides are much washed down and the bottom filled up; but, from the position of the portions of what was apparently the original wall which are still standing, it is probable that the original crater had very nearly the dimensions above given. The walls consist of ragged, cellular, largely amygdaloidal porhpyry, containing crystals of quartz, calcite, &c., partly weathering with a very rough surface, partly decomposing into a coarse brittle sand, and making very treacherous footing. Lower down, the slopes consist of very dense, nearly black, basalt. The western and northwestern walls were not visited; but their style of weathering indicates much softer material than was found on the part visited. Considerable portions of the crater, as well as the outer slopes of the mountain, were well covered with tall pines and spruces; while the higher portions had only scattered and stunted trees and the crests were entirely bare. though enough dead stems of small pines or cedars were found even there to make a small signal-fire. The small plants of the summit are mostly of Alpine forms. Trails of mountain-sheep were abundant, but the only vertebrate seen was a large gopher, (?) very distinct from any species of which I have been able to find a description, or figure, or mounted skin; unfortunately, he escaped my bullet. The elevation of the peak, as indicated by two readings of my aneroid barometer, is about 10,600 feet.

No lines of outflow were traced down to the plain; but, from the size and position of the crater, and the character of the lava of its lower portion, it is evident that this was a prolific source of the basalt which so many times filled the great plain stretching off to the south and west. The isolated cluster of mountains, about half way between this peak and the Sand-Hill Mountains, has apparently the same structure, and may have been another source of outflow. The lowest gap in the crater-wall of Sawtelle's Peak faces northward; and the principal outflow of lava was probably from that point, escaping thence down the valley of Henry's Fork, though other portions may very probably have escaped through subterranean passages and cracks in other directions, as is frequently the case in those volcanoes whose modern eruptions have given opportunities for the observation of their phenomena. The portions of the lava next to the mountain and out to the center of the valley are all pretty solid basalt, while the farther side of the valley-deposits, and those which form the slopes of the eastern mountain, consist of the older porphyries and volcanic sandstones.

The peaks of the westward continuation of the range of which Sawtelle's Peak forms the eastern termination show such structure, as seen from a distance, as to indicate that they also are of volcanic origin, and may have been other sources of the basaltic outflow. It is not known to any of the present inhabitants of the region that any of these volcanoes have been active in modern times; but Irving, in his Astoria, states that Mr. Robert Stuart, a partner of Mr. Astor in the Pacific Fur Company, when crossing the mountain-range west of Pierre's Hole, in the fall of 1812, "observed to the northwest, between Henry's Fort and the source of the Missouri, several very high peaks covered with snow, from two of which smoke ascended in considerable volumes, apparently from craters in a state of eruption." The location indicated would apply well to peaks of the range now under consideration. It is hardly to be supposed that so experienced a mountaineer should have been deceived by timber-fires, or that such fires should occur near the summits of peaks covered with snow.

The ranges on the north and south sides of Henry's Lake are nearly parallel, while the cross-range west of it is nearly at right angles with them, thus giving a quadrangular form to the plain, which here terminates the broad valley of Henry's Fork. From three points it has easy passages to the neighboring valleys and the region beyond. From our camp on the east side of the valley, Tyghee Pass, named for an old Shoshone chief who was wont to use it, gives a smooth road, with very gentle grades, into the valley of the Upper Madison. From the north end of the lake, a broad, grassy plain, with scarcely a perceptible rise to the divide, about four miles distant, shows a clear road to Virginia City and the Lower Madison. This is called Raynolds's Pass, from having been used by that officer in his expedition of 1859–'60, and described in his report. Tyghee Pass is also mentioned and mapped in that report as having been examined by Dr. Hayden. From the southwest angle of the valley, Red Rock Pass affords a broad, flat, grassy opening to Red Rock Lake, one of the ultimate sources of Beaver-Head Fork of the Jefferson. This was not visited by us, though seen from a distance. It was afterward examined by Messrs. Peale and Holmes, of Dr. Hayden's branch of the expedition. The levels, as decided by the observations of both parties, are as follows: Henry's Lake, 6,492 feet; Tyghee Pass, 7,063 feet; Raynolds's Pass, 6,911 feet; Red Rock Pass, 7,271 feet. The most favorable route for a railroad from Montana to Corinne, which is now talked of, is apparently *via* Raynolds's Pass and the valley of Henry's Fork. Down this valley the grades would be very easy, averaging only about 25 feet per mile from the pass to Taylor's Bridge, on Snake River, and the cost of grading very slight, while the large valleys which open on the east, containing large areas of valuable grazing and farming land, would be opened to settlement, and would very soon furnish considerable local business.

The short range on the west side of Henry's Lake shows at base, near Sawtelle's ranch, a considerable body of dark hornblendic, slaty schist; but the mass of the ridge consists of much-folded metamorphic limestone, which, in its lower portions, shows a considerable thickness of light drab, almost white, rock, which would make very fine building-material. Its higher portions, however, contain very numerous thick and thin bands of white, often transparent, quartz, corresponding, in general appearance and relations, with the bands of chert which accompany certain portions of the Carboniferous limestones in this region. From this character, in the absence of any opportunity to determine its age by tracing the bed to its unmetamorphosed portion, I have referred it, with very little doubt, to the Carboniferous. Upon the crest of the ridge, we found the outcrop of a dike of trap, about 60 feet wide, standing conformably between the layers of the limestone, and therefore supposed to have been deposited in that relative position before the beds were upheaved into their present nearly vertical position. The subsequent metamorphism of the whole series has obliterated any marks of alteration of the adjoining beds of limestone, which we might otherwise have looked for. From the crest of the ridge it was evident that the back spurs were of the same general structure and composition at the main ridge, at least for two or three miles.

On the east side of Raynolds's Pass, metamorphic rocks form the base and lower slopes of the mountain, while quartzites and limestones appear near its summit. This structure continues nearly to Tyghee Pass, where the upper rocks come down to the level of the plain, for two or three miles, and then rise again, exposing the granites, gneisses, hornblende schists, &c., until we reach the outcrop of volcanic sandstone before described. Just west of our camp, at the mouth of Tyghee Pass, the lowest of the quartzites is exposed on the bank of a small creek. The bedding is nearly vertical, with a *strike* trending about N. 53° E. Unconformably upon the edges of this bed lie about 200 feet of a light-drab, impure limestone, of Quebec Group age, from which we obtained with difficulty three fragments of characteristic trilobites. The *dip* is about 45° N. 54° E. As we have elsewhere found quartzites of supposable Potsdam age lying conformably beneath the Quebec Group, we are led to question whether *this* quartzite may not possibly be of still earlier age; but, in the absence of fossils, there are no means of deciding the question. But this may very well be Potsdam, as I presume it really is, without making it necessary that it should everywhere else lie, as here, unconformably beneath the Quebec.

At the quartzite-outcrop, about a fourth of a mile west of our camp on Pass Creek, another small creek comes out of the hills by an entirely distinct cañon. But, on going up the pass about a half mile, the two cañons unite into one valley, with barely enough divide to separate the streams; yet these continue distinct and come from very different directions. At this point, a stream-terrace of about 30 feet elevation is very prominent; but it is not continued out to the main valley. What could have been the conditions under which these two cañons were thus formed? Porphyry appears in place high on the mountain-side at several points, and in the stream-bottoms in this junction-valley, but only in the more eastern cañon, so far as I observed; so that I inferred that the outflow of the porphyry had stopped up the original eastern cañon, and filled up all the upper valley; that, in subsequent erosion, the new cañon had first been worn through the limestones and quartzites to the westward, a terrace-like deposit of sand being meanwhile formed at the head of it by the partially-checked stream; and that afterward, when the new channel had been cut low enough to reach the old-stream gravel, and the porphyry had been eroded from the main valley outside, the percolation of water through the gravel of the old channel undermined the overlying porphyry and opened the cañon anew for the more eastern stream.

The porphyry is now so much worn away from the pass that the outcrops of the older rocks can be traced. Above the Quebec group, as in the cañons of the Téton range, we see the limestones continuous to the highest summits. At one point, the castellated ruins of the Niagara (?) limestone, with their intermediate pine-clad hollows, make a prominent show upon the hill-sides. The Carboniferous limestones, from which a few characteristic fossils were brought by Mr. West, are mainly thin-bedded; but one heavy bed caps some of the highest points. The pass has very little timber and affords a good road. Yet, the largest trees seen during the whole season stood near the summit of the pass. No notes of their size were taken at the time, but I remember them as about four feet through. They all seemed to be dying.

On the Madison side of the range, the porphyry, which appears at intervals all through the pass, is replaced by basalt. The broad bottoms are covered with basaltic sand, bearing a thin growth of pines. The streams have in many places bluff banks from 30 to 40 feet high, of volcanic sand, partially cemented into a loose sandstone. As we pass up the valley the timber becomes more open, and, where not burned over, resembles the artificial grouping of parks, with avenues opening in every direction. There is, however, no turf, the volcanic sand being only sparsely covered with a growth of coarse plants, often including much sage-brush. Through a broad bottom, occupied by numerous beaver-dams, a large stream, carrying perhaps 80 feet of water, comes in from the south, which was afterward traced by Mr. Bechler to its source in the mountains, where it grows rapidly from the large springs characteristic of the porous volcanic sandstone. The Madison itself was carrying possibly 200 feet of water, sometimes thinly spread out in a broad channel, sometimes narrow and deep, with dangerous holes. Trout were shy and appeared to be few. Antelope and black-tailed deer were seen in considerable numbers in this park-like region, which continued up to the mouth of the upper cañon of the Madison.

The cañon is narrow, with lofty cliffs on either hand, running up to 800, 1,000, and 1,200 feet at different points. Passing up the north bank, our trail lay for much of the distance along the edge of the river, on the steep *debris*-slopes of the mountain. The cliffs consist mainly of columnar porphyry, which disintegrates rapidly, forming pretty solid but very porous slopes, and so yield numerous springs and form many small bogs along the river's edge. Ripe red raspberries were abundant along these slopes, but were not seen elsewhere, I believe, on the whole trip. The springy character of these *débris* is apparently the only serious obstacle to the building of a railroad through the cañon, which has been suggested by parties who desire to facilitate access to the geyser-basins; but the disintegrated rock reconsolidates so well that I should anticipate no trouble from the springs. A noticeable feature of the river along here is its apparent freedom from freshets; the vegetation runs down to the water's edge, and no accumulations of drift-wood were observed. Does the heat which escapes so freely in these upper basins remove the snows so constantly and steadily throughout the winter that no accumulations are left to cause freshets by rapid melting in spring?

The cliffs along the cañon at various points are both beautiful and grand; but we resisted the temptation to give names to all the different points, which is said to have overcome others who have passed this way; though Mr. Raymond has not yet seen fit to publish the names for which he would claim priority. (See Christian Union, New York, May, 1872, p. 437.)

We had supposed ourselves the only travelers in this region, when suddenly we encountered a party of officers and soldiers from Fort Ellis and other northern posts, under the leadership of General Gibbon, who had been visiting the wonders of the Yellowstone and geyser regions. After a brief exchange of courtesies and information, both parties were again on the march, and we soon emerged from the cañon and camped at the forks of the river. While the main stream came from the southward, yet the real continuation of the valley we had been following was occupied by the stream coming from the eastward with perhaps 40 feet of water. As this stream had been partially explored by General Gibbon, who gave us some useful information concerning it, we have called it Gibbon's Fork of the Madison. Its valley continues eastward for some eight or ten miles, when the depression terminates, the stream entering it from the north, where its sources evidently lie high up on the divide toward Gardiner's River. Following directions given by General Gibbon, we found, about half a mile above our camp, the first indication of our approach to the geyser region, in a cluster of hot springs, which have formed a terrace a little back from the north bank of the stream, and from 60 to 80 feet above its level. The water flows from a dozen or more different openings, of which the principal one is a pit from 2 to 3 feet in diameter and 15 feet or more in depth, from which water is ejected with constant ebullition to a height of from 1 foot to 3 feet above the level of the surrounding pool. The pool itself is of an irregular form, something like the outline of a goat-skin bottle, with the spring in the mouth of it, about 200 feet long by from 50 to 90 feet wide in its main part, while the narrowest part of the neck is from 10 to 15 feet wide. The temperature, at the point of nearest safe approach to the center of ebullition, was 146°; 100 feet distant, the water escaping from the pool gave 126°; while the farthest point of the pool gave 120°. The exit flow was rapid, along a channel averaging about 3 feet wide by 9 inches deep. This had built up its banks a few inches above the surrounding level, and at two or three points the deposit had even bridged the stream. The second pool in size was quadrangular in form and measured about 50 feet on a side. The center of ebullition could not be approached; and the water along the edges of the pool gave only 113°. The smaller flows varied from 110° up to 134°, and in one case up to 150°. Several old openings along the outer edge of the terrace were long since deserted; and the flow is now only from higher levels farther back. The deposit thus appears to stop up the channels and so to force the water back until it finds or makes new openings in the disintegrating jointed masses of the porphyry which form the underlying stratum and the hill behind the terrace. At only one point is there a strong flow from below: this is on the immediate bank of the stream, and the temperature, being only 92°, indicates a mingling of cold and hot springs.

The other fork of the Madison has from this point been called the Fire-Hole River; but it is hardly a distinct stream, and should more properly be called the Fire-Hole Fork of the Madison. For about five miles above its mouth it passes through a succession of small cañons with precipitous walls, which render the stream inaccessible in most places. At one point there is a fine fall of about 30 feet. There are also two long successions of rapids, with many points of artistic beauty. After emerging from the cañon, and getting far enough out in the bottoms to clear the timber and look back, we found that we had risen so rapidly as to be now on the level of the top of the cliffs on the south side of the great cañon through which we had passed on the previous day, while those on the north side are seen to rise rapidly from the borders of the cañon into a lofty mountain-mass, whose northern slopes must give rise to some of the head-waters of Gallatin River.

We now come to the stream which Dr. Hayden descended in coming from the Yellowstone in 1871, and which was named to him, by his guides, as the east fork of the Madison. That name has been applied to at least three different streams. If such a point-of-compass title is ever proper, this should most properly belong to that part of the stream which comes out of the Gallatin Mountains and joins the Madison nearly opposite Tyghee Pass. We now propose to call the stream which joins the Madison at the lower end of the geyser-basins Hayden's Fork, after its first known explorer. Here we first met with the hot springs of the lower geyser-basin. One of the first, directly on the bank of the river, had a temperature of 197°. In the mucilaginous deposit upon its sides, Dr. Curtis found skeletons of diatoms, but no living ones; but, for further statements of these microscopical observations, I must refer to his detailed report. About a quarter mile farther up the stream, above the first bend, a strong spring, boiling intermittently, but rarely over a foot in height, with a pool about 25 feet long by from 6 to 12 feet in width, gave a temperature of 200°, the highest found in the whole region, and a fraction above the boiling-point theoretically due to that elevation. And now we were in the midst of hot springs and geysers, and shortly camped on a wooded knoll which overlooks a considerable part of the Lower Basin. We had expected to meet Dr. Hayden's party in this neighborhood, and soon learned that they had reached the Basin, coming from Bozeman, *via* the Yellowstone valley, a few hours before us, and had pitched camp about a mile farther east. Next morning, therefore, we moved over and joined them. The collections of both parties were now packed up; specimens were gathered from the geysers; and Mr. Stevenson started with them, on August 17, for Virginia City, both to ship the specimens and to procure provisions for our return trip. Dr. Hayden's party also started down the Madison, on the 20th, and we were again nearly alone, though a few visitors from Montana were also in the Basin and camped near us part of the time. Among them was probably the first lady who ever saw the geysers—Mrs. Stone, of Bozeman.

CHAPTER III.

YELLOWSTONE FALLS—GEYSER BASINS—MADISON LAKE—SHOSHONE LAKE—MOUNT SHERIDAN—HEAD OF SNAKE RIVER—JACKSON'S LAKE—RETURN TO FORT HALL.

During Mr. Stevenson's absence, seven of us made a short trip to the Yellowstone Falls and Lake, starting on the morning of the 21st. As far as to the forks of Hayden's Fork, we had no difficulty in following the trail; but here, among the swampy ground, it spread out so as to be very blind, and we finally decided to make one for ourselves, following a northeasterly course. The slopes of the dividing ridge are heavily timbered; and, at some points, we found difficulty in forcing our way, though much twisting about was generally the extent of our trouble. The pack-mule, however, was continually running against trees and loosening the rope; so that either "tightening up" or "re-packing" was necessary at least twenty-five times, in making not over five miles. Upon reaching the crest, we found that this was the highest point of the ridge for several miles, being about 8,893 feet above the sea; but this we did not regret, when we came to view the surrounding scenery; for we not only enjoyed the sight of a broad expanse of beautiful country, but were able to select a route which saved us some miles of travel. From the summit, we descended directly to the head of a stream-valley which shortly opened out into broad, grassy areas, along which we traveled rapidly toward the main valley. Near the head-waters of this little stream, we passed several mud-pots and warm springs, some of the latter showing considerable deposits of sulphur. Emerging from the foot-hills, we found that this stream joined the Yellowstone south of the Crater Hills; we therefore crossed the rolling prairie to the northward, and camped near the mouth of a large creek which joins the river just north of the Crater Hills, having traveled, as we judged, about twenty-seven miles. Next morning we struck the trail near the mouth of the creek, and reached the falls in about eight miles.

Here, there is little to add to the descriptions already published. We examined and admired the cañon and falls from all the customary points; but those of us who descended to the red knob which stands out in the middle of the cañon, in front of the lower fall and slightly above its level, agreed that this was by far the best point from which to view it. Mr. Jackson's best photographs of the fall were taken from this point. Descents to the bottom of the cañon below the fall have heretofore been made on the east side, the slopes on the west side having been held impracticable. But, with considerable difficulty, I made a way down, often reaching ahead with my hammer to cut holes for the next steps, and stood at the foot of the fall. The water is mostly broken into drops before reaching the bottom, and the air is filled with spray, driven violently down the cañon by the strong wind created by the rush of the fall. The slopes which are thus kept wet are well covered with grasses and flowers, of which several species were gathered. This is evidently a favorite grazing-ground of deer and elk, whose tracks abounded, even on the steepest slopes. I was here the victim of a curious delusion. Looking up toward the fall, I saw what appeared to be patches of small flowers, of a rich, blue color, closely resembling the patches of brilliant blue "forget-me-nots," which ornament the higher crests above us. In pursuit of them, I pressed on until the spray became a drenching rain, when suddenly I saw at my feet patches of the same blue; but they were only sky reflections from the wet rocks! The walls of the cañon are largely composed of soft volcanic ashes, hardly cemented, which disintegrate rapidly; and the slopes are largely covered with sliding masses of the sand thus formed. Where this is reached by the spray of the fall, it is partly further disintegrated into a bluish-gray mud, and subsequently partially cemented into a fine-grained argillaceous sandstone, stratified parallel to the slopes. These slopes descend directly into the river, so that, even at the bottom, the utmost care must be used in walking. Along the edge of the river, several small hot springs occur, which steam moderately, but rarely to such an extent as to be visible from the top of the cañon. I was able to reach but one of these, which had a temperature of 150°. On the opposite bank, a miniature geyser was in operation; from the top of a steep cone, about a foot high, a half-inch stream was constantly spirting about a foot from the orifice. In ascending, I followed the track of an elk, part of the way, and found much less difficulty than in the descent. On the east slope, regular game-trails are numerous; and I think that most of the animals which graze on the western spray-slope approach and leave it by fording or swimming the river.

The upper fall, though less than one-third the height of the lower, appears far grander, by reason of the momentum of the mass of water, gained while rushing down the rapids which extend about a half mile up stream.

About 11 a. m. on the 23d, we started southward, passing the Crater Hills and the Mud Geysers, and camped on the shore of the lake, near its outlet, about 5 p. m., the distance being eighteen miles. The trails were distinct and tolerably level. The soil here is very loose and washes easily; so that, in many places, the trails made in 1870 and 1871 are already badly gullied. This should be considered, in laying out roads and trails through the park.

On most of the early maps of this region, a large lake is represented at the head of the Yellowstone, under the name of Eustis's Lake, a name supposed to have been given in honor of General Eustis, of the Engineer Bureau. Later, it appears as Sublette's Lake; and now, for several years, it has been called by the general name of Yellowstone Lake. If any law of "priority" is to hold in geography, it would appear that the name of Eustis should be again and permanently applied to it, unless the original Indian name be ascertained and substituted for all later ones. Aside from this general principle of priority, there is no doubt that the present name is the best; and it has become so generally known that it is likely to hold. The first map which, so far as known, represents the lake with anything like its true form is a manuscript one by Jedediah S. Smith, who hunted through the mountains from California to the British Possessions, during the years from 1821 to 1830. The original was purchased in Oregon for the War Department, but is supposed to have never reached Washington. A copy, taken in 1853, exists in the hands of Mr. George Gibbs, of New Haven, Connecticut.

When we arrived at the lake, in the afternoon, the usual daily wind was blowing, and considerable waves were dashing upon the beach; but both wind and waves subsided during the night, and both air and water were perfectly calm at sunrise next morning. While getting breakfast, we heard every few moments a curious sound, between a whistle and a hoarse whine, whose locality and character we could not at first determine, though we were inclined to refer it to water-fowl on the other side of the lake. As the sun got higher, the sound increased in force, and it now became evident that gusts of wind were passing through the air above us, though the pines did not as yet indicate the least motion in the lower atmosphere. We started before the almost daily westerly wind, of which these gusts were evidently the forerunners, had began to ruffle the lake.

Grasshoppers were so scarce that we did not succeed in catching a single one of the wormy trout for which the lake is famous.

Reaching the mud-geysers about 10 o'clock, we found the principal spring just ready to erupt, and so were detained only a few minutes.

Having thus briefly inspected the wonders of the Yellowstone, we turned back along the regular trail toward the geyser-basins, and got to camp that night by a rather hard march of about thirty-seven miles. Considering the characters of ground and timber along this trail, we were satisfied that we lost nothing by leaving it on our outward trip.

During this time, Mr. Bechler had gone, with his assistants, to examine the divide to the west of the Fire-Hole, and to locate a stream supposed to exist in that direction and which had been mapped as the south fork of the Madison. But no such stream exists, unless it be the short one before described as forming in the north face of the mountain, just east of Tyghee Pass. The divide is high and largely covered with dense timber, mostly young, the old growth having been burned off. Only volcanic rocks were found, being mostly obsidian sandstones, which are very porous. Accordingly, he found but little water. Springs and pools occasionally appeared in the cañons, but soon sank again. From what I saw elsewhere in this neighborhood, I judge that he would probably have found more open timber and more water along the spurs than he did along the cañons. Hollows among and upon the spurs become partially puddled, and so frequently hold water; while the flow of springs, constantly wearing their channels, however slightly, is quickly absorbed by porous soils. At two points the party found small clusters of hot springs, some of which spouted a little, but no considerable geysers. The cañons, running westward, finally lead out to the basin of Henry's Lake, whence the party returned by our old trail through Tyghee Pass.

Concerning the geysers, springs, and pools of the main geyser-basins on Fire-Hole Fork, so much has already been written that I propose to merely note a few of the more prominent points which especially attracted my attention, and which have to do rather with generalities than with details, except in case of localities not visited by those who have published descriptions. In this latter case I think it best to be pretty full, in order that we may reach as far toward a complete description of this interesting region as is possible for those who only make brief visits to it. It is to be hoped that means will be found, ere long, to locate two or three persons here for an entire season, so that, by protracted detailed observations, we may obtain something like an approximate idea of the laws which govern the wonderful phenomena here displayed on so grand a scale.

At one point in the lower basin, near the Architectural Geyser, we found masses of volcanic sandstone, perforated by numerous irregular holes from a quarter inch to an inch in diameter, which had evidently been dissolved out by the hot waters, in their escape to the surface.

Here, I think, we have an example, on a small scale, of the process by which the large cavernous pools, of which so many examples occur all about us, have been excavated. It would appear that, in many cases at least, the hot alkaline (?) water, as it reaches the surface, is not thoroughly saturated with silica, and accordingly dissolves away the walls of its orifices, so as to undermine the surrounding area, the surface of which falls in, until, in many cases, large caverns are excavated. This action appears to be limited in two ways: first, the pool may reach such dimensions that the quantity of water constantly supplied bears so small a ratio to the whole contents that the whole pool becomes partially cooled as well as somewhat concentrated by evaporation, and so the excavation is checked, if not stopped; and, secondly, the supply-pipe may become almost entirely stopped up, so that barely enough water is supplied to make good the loss by evaporation, in which case the solution of silica would become supersaturated, and the silica itself be deposited on the walls and bottom of the pool until it be ultimately closed again, unless the stoppage of the tube be removed, and the succession of conditions thus begun again. If, however, the stoppage of the tube be complete, the silica will soon all be deposited by reason of the evaporation of the water, and the pool will become a dry cavern, except in positions where it may be kept full by the drainage of surface-waters. The large deep pools, however, are generally very hot, showing a constant supply from beneath, and many of them are in constant ebullition, though rarely true geysers; indeed, I believe that the Giantess, in the Upper Basin, is the sole exception to the rule, so far as yet observed; and this is probably in its last stages and near extinction, if we may judge by the length and irregularity of its intervals.

The smaller vents vary greatly in temperature, depending apparently upon the greater or less freedom of their connection with the heat-centers below. In some cases they are few and solitary, with little or no deposit about them, as if they had been but recently opened. Again, they are in large clusters, of which the more elevated vents are generally, though not always, the hottest. It would appear that the comparatively compact deposit of nearly pure silica, formed by the flowing water, is much less readily dissolved and disintegrated, by the hot flow beneath, than is the silica of the more porous and partly argillaceous volcanic rock which forms the slopes of the hills; so that, when a vent is once stopped, it is very rarely re-opened, unless by earthquake-cracking, and the checked water is forced backward and escapes at higher and higher points on the hill-sides. In the geysers, the tube, being exposed to the air at frequent intervals, while it is yet dripping with the rapidly evaporating water of previous eruptions, receives constantly new layers of silica, which are but slightly, if at all, re-dissolved by the next eruption; and so its size is constantly decreased, until the tube becomes entirely closed and a new vent is opened elsewhere.

In the clusters of small vents, there is generally more or less sympathetic action, showing that they open into some common chamber below, but that the connecting passages are more or less contracted, so that the flow of steam and water is far from being controlled by the ordinary laws of hydrostatics. Frequently a large vent, whether a geyser or simply a boiling pool, is surrounded by a number of small ones, which are active while it is quiet and quiet while it is active. I stood, one morning, upon the mound of Fountain Geyser, in the Lower Basin, whose pool was filled to overflowing, and was watching a vehement steam-jet, a hundred yards away, on the lower slopes of the terrace.

Suddenly this ceased, and, at the same instant, Fountain commenced playing, throwing a body of water, some 10 feet in diameter, though mostly broken into drops, to constantly varying heights of from 5 to over 40 feet. This continued for about thirty minutes, and then ceased rather abruptly; as suddenly, the steam-jet commenced again. About twenty minutes later it ceased again, and a small pool, a few yards from Fountain, which had been empty before the latter's eruption, but partially filled by its overflow, immediately began to boil and to spit water from 5 to 10 feet high, and continued intermittently for a half hour or more. During its periods of moderate boiling, the steam-jet opened again, but ceased when the boiling became more violent. Other vents in the neighborhood seemed to have some slight sympathy with these. Similar facts were noted elsewhere. Thus, in the Upper Basin, Grand Geyser has only a small pool, and erupts only at long intervals. Close by its side, Turban Geyser is almost constantly disturbed, and has frequent small jettings of from 5 to 20 feet; but, when Grand, without giving any warning, sprang suddenly into its magnificent eruption, nearly 200 feet in height, Turban seemed startled into more violent action, reaching 70 or 80 feet, and rising and falling synchronously with Grand. Giant stands, with another good-sized mound, upon a broad platform on the river-bank. As I first saw it, water was spirting, intermittently, to heights varying from 6 inches to 20 feet, from some fifteen or twenty small vents on various parts of this platform. When the two large vents began to show activity, though boiling to only small elevations, these little ones became quiet. When Fan Geyser was in full eruption, its partner, 30 yards off, was steaming gently. Fan stopped for a moment, and its partner fairly roared with a rush of steam, which stopped as soon as Fan opened again. Yet they are not in full sympathy; for, on another occasion, Fan was steaming or boiling very gently, while its partner was boiling furiously, and throwing water 5 or 10 feet high, but with quiet intervals, during which Fan showed no access of force. (Under such circumstances, one is inclined to question whether Fan's partner may not possibly serve as the vent for two distinct geyser-tubes.) The three pools which surround Giantess lost much water by her eruption, but were not drained as low as the bottom of her pit when that was empty.

In many cases, however, vents almost side by side show not the least sympathy. About 200 feet east of the Steady Geyser, in the Lower Basin, which constantly spouts from 5 to 20 feet, Young Hopeful spirts from 2 to 10 feet high for from sixty-five to eighty seconds, with quiet intervals of about the same length. About 60 feet from it, another small vent spirts from 6 inches to 2 feet, for from thirty to forty seconds, with intervals of from forty-five to sixty seconds. Here is evidently no sympathy.

The deposits made by the springs and geysers vary greatly. Where the flow is gentle, the deposition generally takes place in thin laminæ, of thickness varying from that of a sheet of paper to a quarter inch. Though, as previously stated, this is so compact as to be dissolved with difficulty from below, yet its thin laminæ are readily separated and broken by frost, and form a very peculiar fine gravel, immediately recognized after having been once seen, which has served to indicate the former location of hot springs over broad areas which give no other evidence of such vents ever having existed. In the small pools which surround many of the geysers, we frequently find great numbers of apparently water-worn pebbles; but, upon breaking them, we find their structure concentric, and it becomes evident that they have grown by constant surface-accretions, while the frequent agitation of the pools, by water falling from the geyser-jets, has prevented their being cemented to the bottom, and has at the same time aided in keeping them smooth. Where these are few, so as to have plenty of room for rolling, they are commonly quite regular, and often nearly spherical; but, where they are numerous and crowded, they wear each other quite irregularly, so that polyhedral forms abound. Often, while the lower portions are thus polyhedral, the exposed upper surfaces are quite regularly spheroidal. The original centers of concretion seem to have been very minute fragments, broken from the surfaces of the geyser-cones, probably by the rush of the eruption. In some cases, the upper surfaces of these concretions are pearly, in others they are beaded; occasionally the whole surface is beaded, or is covered with prickly points. These surfaces are also frequently deposited upon fragments of the laminated material which may have by any means found their way into these crystallizing baths. These pearly and beaded and prickly surfaces are also individual characteristics of the deposits of different geysers, and vary greatly in detail. The immediate orifice of a geyser is almost universally beaded, and this character extends to greater or less distances from it, according to the distribution of the falling water, surfaces frequently thus washed or sprinkled being almost universally of this character. Such surfaces, on the contrary, as are frequently bathed in steam, without much spray, are nearly always pearly, as if the steam itself carried enough silica to form the extremely thin layers which are essential to pearly luster. This is commonly the character of the upper surfaces of those coral-like growths which form along the borders of many of the quiet hot pools, while their lower surfaces are covered with prickly points. In nearly every pool, except where ebullition is so strong as to break up such tender tissues, we see gelatinous vegetable forms allied to *mycelium*, or the "mother" of vinegar, sometimes in broad, thick sheets, sometimes in thick branching forms, resembling sponges, sometimes in long waving fibers. The former kinds are generally either green or rusty brown; the fibrous forms are generally pure white. These are very common in the rapidly-flowing outlets of the hot pools, and are continually reproduced as these channels fill up with newly-deposited silica; so that, in breaking through the crust, we often find laminæ filled with molds of those fibers, and sometimes to such an extent as to closely resemble silicified wood.

From our camp on the east side of the lower basin we saw on several occasions tall columns of steam rising from near the foot of the ridge on the extreme western side of the basin, but at first referred them to the cluster among which we had camped on the evening of our arrival. But upon examination we found a considerable stream coming from west of the Twin Buttes, which had not been seen by previous explorers, and whose valley included a cluster of large geyser-mounds, from which these columns of steam must have escaped. Though this group was visited on three different occasions, none of us were so fortunate as to witness any eruption from these vents. On entering the valley from below, we see before us a range of four large mounds running diagonally across it. The two central ones are the highest, and appear so much as if they were guarding the upper valley that this was called Sentinel Branch. Approaching this row from the east, the first spring observed is upon a low mound, near the foot of the spur which separates this valley from the main one. It is a deep oval pool, whose two diameters are about 12 and 15 feet, with a beautifully-scalloped edge, not raised above the general surface of the mound. The temperature is 198°, and this is probably a geyser. Several small vents also appear on this mound, but no other is important. A little to the left, as we advance across the valley, upon a very flat mound, we find a cluster of four large and several small vents. The beady deposit about them is very pretty. One of the larger vents apparently spouts moderately, though not frequently. The temperatures vary from 191° to 193°. A few rods farther on, we come to a truncated conical mound, rising about 22 feet above the creek, on whose bank it stands. Upon the summit is a shallow, nearly circular, pool, about nine feet across, bordered with an exquisite frilled edging, from four to six inches high from the surface of the mound. From this, three or four small streams flow over the edge and down the side of the mound through deeply-imbedded channels. This appears to be a strong spouter, and is probably the source of the tall column of steam before mentioned. The creek cuts into the base of the mound on the north and west sides, and will probably before many years cut into the central tube and cause the eruptions to take a horizontal direction, as well as, or instead of, a vertical one. The temperature is 198°. A few rods farther, on the west side of the creek, stands another mound of the same form, but from two to three feet lower, and its pool is a little less regular. It has also a small conical vent just outside the pool. This has probably been a strong spouter, but I think that it does not now erupt; temperature, 197°. The ornamentation about these two pools appeared to me, as well as to others, to be the most beautiful of any in the whole basin. Still going westward, we find, in the extreme edge of the valley, on the top of a low mound, a cluster of four vents, from one to two and a half feet across, quite irregular in shape, and all boiling too violently to allow one to take the temperatures. All were surrounded by bead-like incrustations. I judge that they all spout moderately. Along this western side of the valley, the base of the hill is thoroughly saturated by the flow of very numerous cold and slightly warm springs. About a quarter-mile above the mounds, we found the creek flowing rapidly in a narrow deep channel with muddy banks, and not easily crossed. Its temperature of 52°, and the entire absence of the siliceous fragments elsewhere so abundant, satisfied us that no hot springs exist in the upper part of its valley. Returning to our former crossing, between the high mounds, we turned south along the east side of the valley. Here is a low mound on the foot of the spur, which had shown only the smallest whiffs of steam, and had been supposed to be nearly extinct; but, upon approaching the vent, we found a deep basin, apparently hollowed out of dark basalt, but really lined with a smooth-surfaced dark reddish-brown siliceous deposit, made by the spring itself. This is very different in color from any other known in the whole Fire-Hole Valley, and was called the Iron Pot. It was boiling moderately at about six feet below the surface, when first seen, but afterward filled nearly to the surface. Its temperature could not be obtained. The form of the pool is ovate, about 7 feet by 5 at the lowest level seen, and expanding above to about 10 feet by 7. Though it may often fill its pool, it probably does not spout much. A hundred yards farther south, along the foot of the spur, there is an irregularly-oblong, steaming pool, about 100 feet by 30, and from 15 to 20 feet deep, with two or three deeper pits. At the east end it boils constantly and sends off dense clouds of steam. Along the edge at this end, the ordinary pearly-beaded deposits are abundant, while a few inches within the rim, and sometimes attached to it, were numerous coral or mushroom-like forms with broad tops expanding from a slender base. The portions of these forms which are toward the steam, and so are constantly moist, are covered with small points, reminding one of the polyp-cells of the Madrepores, while the opposite sides, which must be alternately wetted by the steam and spray and dried by the wind, have the beautiful pearly luster, partly due to the thin lamination of its structure and partly to the opaline composition of the material. The west end of the pool is shallow, and the water flows from it to the foot of the slope over broad and shallow terraced steps, resembling the deposits of the calcareous springs of Gardiner's River, though on a much smaller scale. The main pool nowhere showed a higher temperature than 187°, but a little vent two feet from its rim gave 195°. Several small pools and vents were noticed in the adjoining timber, but none that deserve special mention.

Though this whole valley is more or less miry, yet its luxuriant growth of grasses and other forage-plants attracts the game, whose trails abound in every direction; and this is probably the best location for a ranch that can be found in the Lower Basin. The camping-ground on the east side of the valley is low and damp, so as to be unhealthy for a prolonged stay. If a hotel were to be located in the region, the best place would probably be on the foot-hills on the east side of the river, between the Lower and Upper Basins, since cold springs and abundant forage within easy reach would there be combined with dry locations for building, while the wonders and beauties of either basin would be but a short distance off.

Most of the cold ponds found at intervals throughout the valley are plainly extinct hot springs; but, among the timbered hills about a half mile southwest of the White Dome Geyser, there is a large one which is not of this character. It has no outlet. Just south of it is another hollow, once occupied by a still larger pond, of which only a small pool now remains, while the old bottom is covered with a very luxuriant growth of grasses and sedges.

Between the two basins, Rabbit Branch enters the river from the east, with a strong flow of hot water. The whole of its short valley is filled with warm and hot springs. The principal one, at the head of the northern fork, a large steaming pool, reaches 148°, and is not surpassed by any of its neighbors. About the forks of the stream, a considerable cluster of steam-vents, pools, and mud-pots give various temperatures up to 186° and 192°; yet, as a whole, the group shows but little activity. Steam-vents and small pools run far up the side of the mountain. At the head of the southern fork, separated from the last group by from 200 to 300 yards of timber, is a cluster of mostly small springs, which shows rather greater activity. The principal vent is situated under the precipitous bank, and is apparently working backward by undermining the overhanging rock. Large masses have already slipped off and fallen into the narrow pool, so as to greatly interfere with the free motion of the water; and, accordingly, though steaming and boiling furiously, it spatters only a short distance. It was impossible to reach the boiling center; the nearest accessible part of the pool gave a temperature of 192°. Crossing the spur to the southward, we found, instead of a broad, flat valley, like the one we had just left, a narrow, steep ravine, partly with precipitous sides, at only one point of which did we see slight indications of warm springs. There was, however, an abundant flow of cold springs, fully equal in volume to that of the hot springs of Rabbit Branch. As no difference was noticed in the rocks of the two hollows, we could refer their difference in form of erosion only to the solvent power of the hot waters.

As we approach the Upper Basin, we find considerable stretches of swampy flats, now nearly destitute of any signs of hot-spring action, but probably occupied by such springs in former times. In the Upper

Basin, we find fewer of the mire-holes which render travel difficult and even dangerous in some parts of the Lower Basin. The surface is made up largely of the thinly-laminated sinter, broken up by frost and sun, and partly of the clay left behind in the disintegration of the volcanic rocks and the removal of the silica by the hot waters.

The larger geysers, so far as yet known, are clustered within a rather limited area, so that one can generally watch three or four at once. The different ones have very different periods of eruption; and, in many, the successive intervals of any one vary considerably. The violence of eruptions also varies greatly; but no law of connection between relative violence and length of interval has yet been determined. Many of the geysers erupt without any noise, other than the mere rush of water and steam; but the eruptions of several of the larger ones are constantly accompanied by violent regular pulsations, audible to a considerable distance, and shaking the earth for many rods, as if a fifty-thousand-horse-power steam-pump were in full action down below. In one eruption of Giantess, five or six pulsations were heard before the water began to rise. Their rate was at first seventy-three per minute, but slightly decreased toward the close of the eruption. One eruption of Grand started with seventy-two pulsations per minute, which decreased to seventy, in the course of twenty minutes, and became fainter and fainter. Another, of the same geyser, started at seventy-three per minute, slowing gradually. In most instances, these pulsations cease when the flow of water ceases; but they were once observed to continue for some minutes after the opening of the final rush of steam. This escape of steam often comes with greater velocity and noise than that of the water, and is really a part of the eruption, though generally not so considered.

The erosion effected by the erupted water is generally very slight, being confined, even in case of the most abundant flow, to the channels by which the water escapes and to the space immediately about the vent, where, however, the sinter is generally very compact, and is increased by deposition from evaporation rather than eroded by the falling jet. In the case of Fan Geyser, the main jet, instead of being vertical or nearly so, escapes at an angle of about 60° with the horizon, and the falling water has hollowed out the disintegrating sinter quite deeply for a space of about 115 feet from the vent.

In some of the shallower hot pools, we find beautiful rosettes of sinter, of variable thickness, slightly attached to the bottom. In their earliest stages, these are extremely thin, and from the lower side small spiny processes fall to the bottom, much like the rooting-processes of the bryozoans, or the roots which depend from the branches of the mangrove and the banyan. Judging by their general appearance and conditions, these probably originate as fragments of very thin pellicles formed by evaporation upon the very surface of the pool, and, broken up by the wind, each fragment tends to sink; but some of them escape that fate, and more material accumulates by evaporation upon their wet edges, so that they become basin-shaped and float securely. I cannot account for the basal spires, about which a solid pedestal finally accumulates, except by supposing that they have central nuclei of the small fibers of *mycelium*, which are floating in all these pools in greater or less abundance.

With the exception of these low-grade vegetables, and the larves of *Helicopsyche*, found by Mr. Taggart in water of temperature of 180°, we saw no evidence of the existence of living forms in these very hot pools.

A small stream, carrying, perhaps, 15 feet of water, enters the river from the west, just below the mouth of Iron Spring Creek. It rises far up on the western divide. About a half mile up from the river, we enter a sharp, narrow cañon, along which small hot springs still occur, and arrive, in about a half mile farther, at a fine fall and cascade, some 80 or 90 feet high. The chief interest of the spot is in the inclined bedding of the volcanic sandstone, which dips strongly to the southwest. So far as I could judge, this was not consequent upon disturbance and upheaval of the beds, but upon the slope of the surface upon which the materials were originally deposited. Upon the west side of Sentinel Branch, I found westerly dips, and upon the divide, toward the Yellowstone, northeasterly dips. Though the question cannot positively be decided without many more detailed observations, yet I am strongly inclined to believe that we have at these points remnants of the outward slopes of a huge crater, whose central area was large enough to include most if not all of the heat-vents of the two geyser-basins. Possibly there was a central cross-division between the two basins; but I noticed no decisive dips thereabout. On the foot-hills of the eastern ridge, perhaps a hundred and fifty yards southeast of Giantess, westerly dips occur, which, according to the above supposition, must represent the internal slope of the crater.

Mr. Stevenson returned from Virginia City with supplies on the last day of August, and we started upon our return-trip the next day. Stopping one day in the upper basin, to make our final observations upon the geysers, whose like we expected to see no more for years, we again moved southward on September 3.

Above Old Faithful, which is recognized as the last large geyser of the upper basin, there are only a few hot springs, mostly small, including one small geyser. The valley soon narrows to a deep, impassable cañon, with perpendicular walls of trachyte, with nearly vertical dips and east and west strike. The trail is here forced to the top of the bank, following the east side of the cañon, and, in the next half mile, passes close by a set of beautiful cascades at the head of long rapids. The principal fall is 30 feet high and 40 feet wide, with a side jet about 5 feet wide, like a mill-tail. The water was about 1 foot deep on the crest of the fall. Fifty yards below, all this water is forced through a passage only about 5 feet wide, and rushes with great violence into a deep, still pool below. From a rocky point directly in front of the fall, there are fine views up and down the ravine; and it is well worthy of a visit from all who would see the beauties as well as the wonders of the geyser-basins. The main fall much resembles the Middle Fall at Trenton, New York. From this point, the parties of 1871 turned across the divide toward Yellowstone Lake. The rapids above the fall are moderate, and the banks spread out into a flat bottom, much of which is swampy. To avoid this swampy ground, the trail, which here crosses the river, turns up over the bounding range of hills on the west. In the hollows, we now find many small ponds covered with lily-pods; but only a few of the yellow blossoms appeared. A few of these ponds have small outlets, and small but apparently constant supplies of water, but most of them are entirely inclosed by hills. The surface is here densely timbered, but mostly with young growth.

These hills soon approach the river again, which has here a very narrow valley. This, however, suddenly widens again into a third geyser basin. The first intimation of hot springs, if we follow up the river-bank, is a strong column of steam appearing among the timber on the east side of the valley, just as we enter the basin. Mr. Taggart visited this vent and reported a boiling pool, temperature 190°, overhung by rocky banks, which showed no signs of spouting. As we emerge from the timber on the west side, we find the lower angle of the basin occupied by an area of hot springs, perhaps 500 feet long by 250 feet wide, with the usual floor of disintegrating silicious sinter, and containing numerous vents, mostly active. Near the center of this area stands the chimney of a single geyser. This is a dome-shaped mound, averaging 15 feet in diameter and from 11 to 14 feet high, completely covered with most elegant varieties of the pearly beads before described. It is striped vertically with bands of white, dark-green, brownish black, and various shades of yellow and orange, the white being ordinary geyserite, while the other colors are apparently of purely vegetable origin. On the north side of the dome, where the main flow from the eruptions is now generally scattered, the geyserite has also a beautiful, delicate pink tinge. The summit of the northwest side, as seen from the northeast, is ornamented with a fine profile of a mild-featured human face done in the bead-work. The top of the mound is perforated with numerous small three, four, and five-angled apertures, and a single larger one between 2 and 3 inches in diameter. In eruption, this larger opening throws a stream from 20 to 50, and even to 70, feet in height, mostly in drops with much steam. Though the amount of water ejected is small, yet the force is very great; and, in this respect, the eruptions much reminded us of those of the Castle Geyser. Its highest jets are generally about the middle of the period of eruption. Eruptions take place at somewhat irregular intervals, but generally are about two hours apart. During such as were carefully observed, there was first a period of violent activity, continuing from three to four minutes and ceasing suddenly; then, a quiet interval of from eleven to twenty-four minutes; then, a second active period of from twenty-three to twenty-six minutes, closing gradually with a rush of steam and occasional water-jets. The small vents spit furiously all through the eruption, their jets reaching 3 feet or more in height when the main jet was at its culmination. About 10 yards off, on the platform, a small vent is in sympathy, but is so nearly stopped up as to be generally overlooked. I think it probable that this was wider in the younger days of the geyser, and has become stopped up equally with the latter. It is evident that eruption at this point must soon cease, unless the great force developed beneath shall be able to break away the upper part of the dome. It is more probable, however, from facts observed in the other basins, that a new vent will be opened and a new mound built. I could not obtain the temperature of the water of the geyser, since the water, except just before and during the eruption, retired below the surface-openings; and we had no self-registering thermometers with which to measure its heat from a safe distance. The surrounding springs, which are nearly all boiling, gave temperatures varying from 185° to 192°. The general elevation of the basin is about 7,770 feet, at which the theoretical boiling-point is about 198°. The single geyser of the basin was called the Solitary.

This small basin spreads perhaps a half mile from the stream, and includes, near its northwest corner, another cluster of hot springs, some of which reach 186°, surrounded by variously-colored deposits, including some sulphur. The trail of our main train entered the basin at this point. The central part of the basin shows the vents and deposits of numerous scattered springs, most of which are nearly or quite extinct, only a few of them still boiling.

A small stream, which comes in from the west near our camp, has a fine cascade, 130 feet high, about a quarter mile from the river. Its supply apparently comes from the flow of the numerous small ponds among the hills before mentioned.

Showers for two days had softened the soil so much that portions of ground immediately about the springs, which are perfectly safe in dry weather, were now too soft for passage, often letting one down a foot or so, and that, too, in places where at that depth one was likely to find scalding-hot mud. Fortunately, no serious accidents occurred.

After a short interval of timber, another small meadow-like basin opens to view, occupied by a few small warm springs of no importance. Again the mountains close in; so that the stream flows for nearly a mile through a narrow rocky cañon, with sharp ridges rising from 1,000 to 1,200 feet high on either side, down whose almost precipitous slopes beautiful cascades rushed to the river. The banks are mostly composed of obsidian sandstone in tumbling masses; so that I had great difficulty in leading my horse through it, while the train was obliged to climb over the bounding ridge on the east. The strata are mostly upturned at various angles through the cañon, but become more nearly horizontal at its upper end, where we approach the level of the last flat basin about the head of the river. Mr. Bechler reports a large amphitheater, resembling a crater, passed by the train as it reached the top of the ridge on the east side of the cañon.

The basin surrounding the head of the river is occupied by quite a large meadow, tolerably dry in the middle, where the stream winds along, but very swampy all around its borders, where numerous cold springs escape from the rocky hills. The sites of a few old hot springs, long since extinct, are marked by patches of the much-disintegrated white geyserite, now mostly buried under the tall grasses and sedges which cover the meadow. A small lake, covering perhaps sixty acres, occupies the southern end of the valley, where it bends to the eastward; and, as the ultimate lake-source of the Madison River, is the only proper possessor of the name Madison Lake, which has heretofore been applied by the hunters to a large sheet of water upon the other side of the divide, under the mistaken idea that it was the head of this river. The lake once occupied the entire extent of the basin, having then covered a curving area about two miles long by about a half mile wide, but has been mostly drained by the erosion of the last cañon. The terrace-borders of the old lake are faintly indicated at some points, but not so plainly that their elevation could be definitely determined. The present border of the timber, from 20 to 30 feet above the stream, in the lower part of the basin, marks the lowest level at which the lake stood for any considerable time. Though the basin receives only three small brooks, supplied by the banks of snow which constantly rest upon portions of the divide, yet the main stream, where it leaves the basin, carries a good body of water, mostly supplied by the large springs already mentioned. Some of these are large pools, from 10 to 20 feet across, with a strong flow of water boiling up from beneath, sometimes through quicksand, sometimes through numerous large openings in the stiff clay bottom.

A storm of mingled snow, sleet, and rain detained us here for one day, September 5; but next morning it cleared, the snow rapidly melted, and we went on. Our hunter, Frank Mounts, had reported a valley about two miles south of us, through which a stream flowed westward. Accordingly, while the train moved about three miles nearly due east, to a new camp on Shoshone Lake, Mr. Bechler and I crossed the southern divide to the head of the newly-reported river. We found it to be a large stream, formed, within a short distance, from the abundant flow of numerous large springs bursting from low down in the sides of a high plateau of very porous volcanic sandstones, which we afterward found to extend for several miles to the southward. This was evidently the head of one branch of the stream crossed and camped on by us on the evening of August 3, as we were ascending the valley of Henry's Fork. In the absence of any prior designation, I have called this Bechler's River. Its upper course is among deep ravines, with sharp slopes, but well timbered, for some six or eight miles. It then passes through a rather narrow cañon, with bare, precipitous walls, whose extent was not determined, and emerges into a broad, grassy basin, which reaches nearly to our lower crossing-place.

The snow lying among the timber gave us an opportunity of observing the game-trails; and we were surprised at seeing so few. A few miles farther east, game is very abundant.

In crossing the divide eastward from Madison Lake, the western slopes are quite steep, and porphyritic obsidian sandstone appears in heavy rounded masses, but slightly disintegrated. On the eastern face the slopes are much more easy, and the rock is much disintegrated into a very loose, spongy soil, which, where the timber has been burned from the upper spurs, makes very slumpy traveling, at least in wet weather.

Descending the valley of a small but rapid stream, the principal affluent of this part of the lake, the trail crosses a considerable area of hot springs and geysers, to a good camping-ground on the edge of the marsh, which here prevents easy access to the immediate shore of Shoshone Lake.*

If we had not been fresh from the wonders of the Great Geyser-Basins of the Fire-Hole Fork, we should have considered the phenomena now about us as extremely grand and beautiful. In beauty, indeed, these springs are probably unsurpassed; but the geyser-eruptions exhibit much less force than those we had just left. Still, I consider it desirable to make the recorded descriptions of all these phenomena pretty full, and will therefore give a general description of the vents of the Shoshone Lake Geyser-Basin. The area occupied by active springs

* This lake was seen by Dr. Hayden in 1871, while he was returning, with a small party, from the Fire-Hole Basins to Yellowstone Lake, but at a point some miles east of this camp. His guides informed him that the name Madison Lake had been applied to it by the hunters, and that it was considered the head of a fork of the Madison River. On the strength of this information, in the absence of an opportunity of exploring it sufficiently to verify or disprove the statements, the maps of last year's report give the name as Madison Lake and show a stream which was supposed to connect it with the Madison River. Its connection proving not to be with the Madison and Missouri, but with the Snake and the Columbia, it became at once a question whether the old name should any longer be used for this body of water or should be transferred to the true lake-source of the Madison. This latter course was unanimously decided on. The latest published map of this region, for many localities the best, and supposably the best for this particular neighborhood, since the author claims to have traveled here, is one recently compiled by W. W. DeLaccy, of Helena, and published by G. W. & C. B. Colton, of New York, (edition of 1872.) This shows a so-called Madison Lake, a so-called DeLacey's Lake, located some miles west of the head of the Madison and about fifteen miles long, and still a third, called Lake Bessie, all three of which we were ultimately obliged to identify with the body of water now before us. It has, therefore, been considered whether we should adopt either of the two latter names. The last, Lake Bessie, was at once rejected, as having been originally proposed for the lake long known to the hunters of the region as Heart Lake, for changing whose name there was and is no valid reason. The numerous and outrageous errors of the map show that neither as discoverer nor as mapper of this lake has Mr. DeLacey any claim to a perpetuation of his name; and, since the lake occupies a position entirely different from that assigned to DeLacey's Lake, we have decided to drop that title, and to call this, in our maps and reports, Shoshone Lake, as being the head of one of the principal forks of the Shoshone or Snake River.

DEPt OF INTERIOR
U.S. GEOLOGICAL SURVEY OF THE TERRITORIES.
F.V. HAYDEN IN CHARGE.
MAP OF
THE
SHOSHONE GEYSERS
ON THE
S. WESTERN TERMINUS OF SHOSHONE LAKE.
By Gustavus R. Bechler, Ch. Top.
Snake River Division.
Scale 8 in - 1 mile
Densely timbered country
intersected with numerous Ravines & rugged gorges
SHOSHONE LAKE
Rocky Beach
WARM WATER POOLS
HOT MUD MARSH
SULPHUR SPRINGS
SULPHUR BUTTES
CALCAREOUS DEPOSITS
Marshy Meadow
Pine Timber
Elk Trail Creek
Yellow Crater Geyser
Boiling Pond
Little Giant Geyser
Shield Geyser
WESTERN GEYSER DIVISION
ORION GROUP
GEYSER PLATEAU
LOOKOUT POINT
Soft sulphurous Bottom
Reed Grass
Pasture
Shoshone Creek
15 feet wide
76 inches water (average depth
HOT SPRING MARSH
Impregnated from Hot Springs
SWAMP LAKE
Marshy Meadow
Green Meadow Terraces
DENSELY TIMBERED WITH SPRUCE AND PINE
Prairie with fine Grass (partially wet)
Sandy Beach
Good Grass
Cold Mountain Creek

J. Bien, Lith.

extends up the stream on both sides about a half mile. In the upper edge of the narrow belt of timber which separates the spring-area from the lake-shore, is a small mud-pot, whose borders were ornamented with exquisite cock'scomb-like deposits of a bluish-gray geyserite, containing sufficient clay to give their pointed tips far more toughness than their form would lead one to expect. These forms have not been seen at any other point.

About fifty yards west from this point stands the most important geyser of the basin. It has now three vents, standing closely in a row, each of which has built up a small mound, beautifully beaded without and pointed within. The eastern vent has an irregularly-oblong opening, about 2 feet long and from 8 to 12 inches wide; its mound is about a foot high, and stands upon a base of about 3 feet by 4. The central mound is about 5 feet in diameter at the base, and about 3 feet high, with a deep central, triangular opening, measuring about 30 inches on a side. The western one is about 1 foot high, on a base of about 20 by 30 inches, with two small openings about 2 or 3 inches in diameter. These stand in the mouth of an old geyser, once probably of great power, though now nearly inactive, of which there remains a deep pool about 8 feet wide by 12 feet long, in which the surface of the water during our stay at this camp was about 3 feet below the top; but it evidently overflows at times, and it is possible that it still spouts occasionally. It showed no sympathy with the present vents during their eruptions. The section of the layers constituting the old mound is well shown in the walls of this pit. During eruptions, the west vent spouts a little water, 2 or 3 feet high, for from 1 to 2 minutes, and then yields a moderate flow of steam. Meanwhile, the center vent is throwing a very powerful jet from 70 to 90 feet into the air, which, after about 5 minutes, gradually gives place to steam, the mingled steam and water giving the highest jets. The east vent, spouting from 10 to 50 feet, throws a solid body of water for about 10 minutes, when the whole supply of water seems to be exhausted, and the rush of steam from all the vents becomes more violent and continues some 40 to 50 minutes longer, gradually declining, however, though with many spasmodic renewals. A small flat opening in the space between the central and western vents gives exit to a little water while the geyser is preparing for eruption, but takes no part in the eruption itself. We called this Union Geyser, because of its combination of the various forms of geyseric action. Its temperature, immediately before eruption, was 198°. Its periods of eruption are irregular, and no law of irregularity was ascertained. An eruption was heard by the men on guard on the night after our arrival, but the time was not noted. The first recorded one began at 10.28 a. m., and continued, steam and all, 47 minutes. Its highest jet reached the elevation of 92 feet. The next began at 1.55 p. m. on the same day, reached 70 feet in height, and lasted 56 minutes. Still another was heard at 10.25 p. m., but no further time observations were recorded.

About this spot, there are several quiet and boiling springs; but none of the latter spout more than from 1 to 3 feet. Passing up this side of the stream, however, for about a hundred yards, we find, just above the point of the hill upon our right, the first of a group of larger vents, of which several seemed to us to deserve names. This, which was called the Minute Man, has built up a mound about 4 feet high and from 12 to 15 feet across, beautifully ornamented with bead-work and with the sharp points which usually accompany the more frequent and abundant flows of water. This ornamental work spreads far beyond the mound, covering an area at least 40 feet across. Just behind the mound, and at its immediate base, there is a large ornamented opening, which partly fills before eruptions, but is emptied by them. Much of the ejected water falls in such a way as to flow back to this reservoir, so as to keep up the supply necessary to the eruptions. These occur pretty regularly for some hours, at intervals of from 2 to 3 minutes, but gradually decline in force, until the supply of water becomes exhausted. Then the geyser is silent for several hours, until all the crevices, as well as the surface-pools, are again filled with water, when its eruptions recommence with much violence, the jets then reaching altitudes of from 30 to 40 feet. These again decline, and the series of phenomena is repeated. As water gets low, the back pool sometimes receives some of the steam-pressure and spouts from 5 to 8 feet. At one point on the top of the mound, there are some small sulphur-vents, which seem to be entirely disconnected with the water-pipes, but maintain communications of their own with the volcanic laboratory beneath.

About 50 feet farther on, Shield Geyser has an ornamented mound about 15 inches high, which incloses a shield-shaped opening, measuring about 8 feet on each of two sides and 7 feet on the third, at the top, but narrowing to 4 feet on each of the two sides and 3 feet on the third, a little lower, at what was water-level when I measured it. This spouts moderately at intervals of a few hours, but no special notes of its eruptions were taken. By its side its partner has an irregular opening about 8 feet long and varying from 10 inches to 3 feet in width. These vents exhibited no sympathy with Minute Man. Their temperature is 190°.

Between Shield Geyser and the foot of the hill, Rosette Spring has a triangular basin with sides of about 15, 20, and 25 feet, in whose shallow waters form many most perfect specimens of the beautiful thin-leaved rosettes already described as occurring in the Fire-Hole Basin. The muddy bottom of this spring contains much sulphur.

A little rocky knoll intervenes between this and the Bulging Spring, which every few moments gives vent to large bubbles of steam, which raise a considerable part of its surface from 1 foot to 3 feet, with a bulging sound like that of liquid escaping from the bung of an overturned barrel.

Forty feet beyond, the Soap-Kettle keeps up a furious boiling of colored water, more or less covered with foam, looking like dirty soap-suds. Its basin is lined with a yellowish-brown deposit. This has probably been a strong spouter, but now erupts only at long intervals, if at all. Its mound is about 8 feet across, and is still 1 foot high, though disintegrating.

Forty yards farther, the Black Sulphur Geyser has three vents, in small dark-colored mounds, which almost constantly spit, but do not spout much. An abundant black sulphurous deposit is formed along the run from these vents.

The Twins are two small symmetrical vents, from 4 to 6 inches across, in a small mound which stands back against the foot of the hill. They spout rarely and to but small elevations.

Several boiling springs occur at short intervals along the bottom. About seventy yards farther on, a flat mound includes two large flat openings which spout to the height of from 20 to 30 feet at short intervals; temperature, 192°. Above this point, the springs are of little importance, though a few vents and old deposits occur at intervals for a mile or two up the valley. One, near those last described, is a narrow fissure, along which for 6 or 8 feet the water boils constantly. Near this is a small geyser-mound strongly colored with iron.

On the opposite side of the creek is a broad terrace of the siliceous spring-deposits, upon which stand several small mounds very prettily ornamented, from 1 foot to 2 feet high, whose pools boil considerably, and evidently spout occasionally, though no one of them was seen in eruption. One of these, near the creek and nearly opposite to Minute Man, is shaped like a conch-shell and strongly colored with iron, and was called Iron-Conch Geyser.

Nearer the base of the hills, there are several large hot pools. One of them was so well furnished with coralliform masses, standing in the shallow water near its edge, as to be called the Coral Pool. This measured about 40 feet by 50, with a shallow border, and a deep central pit about 10 feet across, from which numerous bubbles of gas were escaping. There is a strong flow of water of the temperature of 160°. A little to the west of this, a valley runs well up into the hills and contains several large boiling pools, but no geysers. One boils with great violence, with a very large escape of steam. The pools and old deserted basins extend up the slopes of the hills to elevations of from 100 to 150 feet above the creek.

As a whole, these springs and geysers show far greater amounts of sulphur, and especially of iron, in their deposits than any of those on the Madison. The geysers also show much greater irregularities of eruptions. The group seems to me, as a whole, younger than those in the Fire-Hole Basins. The little geysers on the west side of the creek are plainly young, and are just beginning mounds which promise to attain considerable size.

On the east side of the creek, between it and the lakes, we find a cluster of ragged hills, separated by crateriform hollows and valleys, which are occupied more or less completely by mud-springs and sulphur-vents. Upon breaking up the surface-crust about these latter, we find all its hollows lined with sulphur, either in distinct crystals or in moss-like aggregations of imperfect ones. Upon first observing the shape and contents of these hollows, one would naturally suppose them to be old volcanic craters, whose connections with the interior fires were becoming nearly stopped up; but, upon more careful examination, it becomes evident that they have been hollowed out of the surrounding sandstone by the action of the hot springs themselves, which have disintegrated and removed portions of the sandstone and conglomerate of the old lake-terrace. Worn bits of rocks, penetrated by numerous small irregular holes, are abundant on all the lower parts of the slopes, as well as about the existing vents, showing that the process is still going on. These springs are evidently much affected by variations in the supply of water. Many which were entirely dry gave abundant evidence that they sometimes give forth considerable streams. The effects of these variable supplies upon the activity of the different springs and geysers are probably very different in different cases. Since a full basin seems to be essential to an eruption, a greater supply of water to fill the place of that ejected would, in many cases, cause more frequent and powerful eruptions. On the other hand, it is probable that too large a supply, causing a continuous stream to pass through and escape from the basin of a geyser, would cool down its contents below the temperature essential to an eruption.

The springs extend eastward along the shore of the lake for several miles near its present level, and some were seen boiling up from its bottom, several yards from shore. Many occur also in the marsh about the mouth of the creek, which is constantly extending itself into the lake. Some large lagoons are here inclosed by narrow sand-bars, some of which are scantily covered with pines. On this marsh, a little back from its present border and a foot or so above its level, an old shore-line is faintly marked. The only plainly-marked terrace is about 112 feet above the lake. It consists of thick beds of sand and gravel, which form the hills just described. The gravel has formed a loose conglomerate, but the sand has been compacted into a pretty solid quartzite by the siliceous deposits of the springs which filled it when it was beneath the lake-waters. This consolidation, so diametrically opposed to the disintegration just now described, was probably consequent upon the pressure of the overlying lake, which caused a very slow percolation of the spring-waters through the sand, except at the points of more active ebullition.

The present level of the lake is about 7,792 feet, at which the theoretical boiling-point of water is about 198.1°. Springs were observed in active ebullition at various temperatures, from 198° to 182°, and one even at 160°; in this latter case the ebullition was probably due to an escape of gas, though that was not apparent. Quiet springs were of all temperatures, up to 186°. Certain sulphur-vents gave 190°.

For some six or eight miles north, along the divide, the ridges consist mainly of obsidian-sandstone, inclosing heavy bands of reddish-brown and variegated obsidian, having a nearly east and west strike. Most of the subordinate ridges had about the same course. All of this district is heavily timbered, with few openings, so that it became necessary to climb trees when we wished to get any idea of the surrounding country, even upon the highest crests.

On September 9th we moved to the outlet. The lake is of a very irregular form, something like that of a well-filled purse, contracted in the middle to quite a narrow passage. Besides the Geyser Creek, it receives only one stream of any size, which enters at the southern end of its more eastern pocket, coming from the high plateau on the south, before mentioned. The northern and eastern shores and the central part of the southern ones are mostly precipitous, with deep water near them, but along the western and parts of the southern shores one can ride most of the way in the edge of the water, thus avoiding the swampy ground and fallen timber of the steep hill-sides. The center of the lake was apparently deep, though, as we did not put the boat together here, we were not able to take any soundings. The water was clear, and the shore sand and gravel quite clean, even from diatomaceous growth, except at the mouths of the streams. At the entrance of the southeastern tributary, a considerable marsh has formed, on the eastern side of which small spring-deposits were noticed; but no springs were seen here except cold ones.

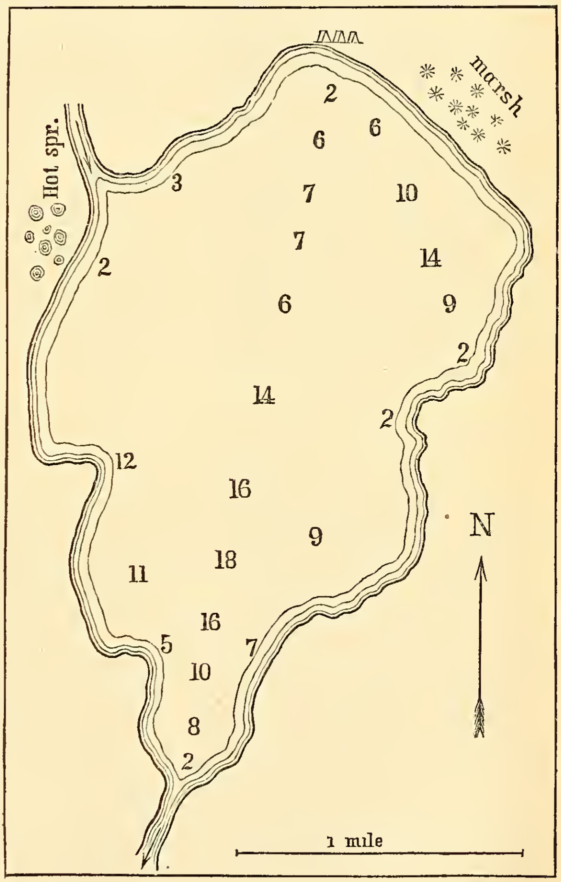
Near the outlet, the rocks are mainly mottled black and red spherulitic obsidian-porphyry.

At 6.33 p. m., (9th,) just as we were camping, we felt three slight earthquake shocks.

On the 10th we moved about five miles, to a camp at the north end of Lewis's Lake. In leaving Shoshone Lake, the river has at first wide bottoms, but the valley soon becomes quite narrow, with steep banks. About one and a half miles below the lake, the stream widens to between 600 and 700 feet, and becomes very shallow, with muddy bottom. Then it narrows suddenly, and rushes through a rocky gateway, perhaps 75 feet across, formed by the projection into the stream of a mass consisting of two layers of obsidian-sandstone, with a rapidly disintegrating central layer of pink porphyry. There was evidently a fine fall here at one time, and the valley which comes to the river on the north bank, just below the gate, was then a second channel of the stream. Below, the stream continues deep, with steep banks, gradually widening until it reaches Lewis's Lake.*

This is a much more regular and symmetrical body of water than Shoshone Lake. It is about two and a half miles long and from one to one and a half miles wide, tapering southward, and is surrounded by mostly gently-sloping shores. These are steepest on the west side, where a few bluffs run out into deep water. Our canvass-boat being put together, Mr. Adams took a series of soundings, with the results indicated upon the accompanying sketch, (Fig. 48,) in which the depths are given in fathoms. The deepest part found is seen to be 108 feet, somewhat south of the center of the lake. The deepest sounding yet obtained in Yellowstone Lake, 300 feet, was made also by Mr. Adams in 1871.

Fig. 48.



From our camp at the north end of the lake, the valley of its outlet at the south end lay directly in a line toward the Tétons; and, early in the morning, before the lake was stirred by the wind, those snow-patched peaks, though forty miles away, were most perfectly reflected by its mirror-like surface. In its setting of the deep-green foliage of the pine and spruce forests which cover the surrounding slopes, this seems to us one of the most beautiful of the many fine views seen upon our trip.

*This lake was seen from a distance, in 1871, by Mr. Schönborn, and was located, from his notes, by Mr. Hergesheimer, but its connections were not known. It was also seen on two occasions, and once visited, in the same year, by Captain Barlow; but its connections were wrongly determined, and the lake itself is represented on his map by two bodies of water, some miles apart, and of very different outlines. As it had no name, so far as we could ascertain, we decided to call it Lewis's Lake, in memory of that gallant explorer, Captain Merriwether Lewis. The south fork of the Columbia, which was to have perpetuated his name, has reverted to its Indian title, Shoshone, and is commonly known by that name, or by its translation, Snake River. As this lake lies near the head of one of the principal forks of that stream, it may not inappropriately be called Lewis's Lake.

The accompanying panoramic view, (Fig. 49,) taken from Mr. Bechler's field-notes, will give a general idea of the relative positions of the Tétons, the lake, and the slopes of the Red Mountain group, of which Mount Sheridan is the culminating point.

On the west shore of the lake, near its northern end, numerous hot springs occur, over a considerable area, a few being seen far up on the western ridge. Those near the lake were examined by Mr. Taggart, who reports as follows:

The hot springs found on the west bank of Lewis's Lake occur mostly in two groups, separated by a low ridge. In the first group examined, all of the springs issued from the sides of a marsh, and were mostly covered either with masses of leafy vegetation or with the soft, thick, pulpy masses of fungoid growth so common about the hot springs of the Fire-Hole basins. Some of the springs were constantly bubbling with an escaping gas, whose character was not ascertained. The temperatures of all the springs are low. A few of them are as follows: 112°, 122°, 124°, 126°, 128°, 130°, 138°, 140°, 148°. As an interesting fact, I noted that all the springs whose temperatures reached or exceeded 120° had the growth of fungoid pulp or a deposit of gray geyserite, while those cooler than 120° were covered with leafty vegetation. This cluster of springs is evidently the last remnant of a much more active group, since, all along the shore of the lake at this point, there are large deposits of old geyserite. At some points, this extends far out into the lake.

The second group of springs differs from the one just described, in that its vents are larger and the water hotter. The springs are surrounded by solid ground, and, in their general features, resemble the hot springs of the Fire-Hole basins, so that they need no general description. The following are the temperatures and sizes of a few of the principal ones: 1, 152°, 2 feet in diameter; 2, 156°, 10 feet by 6; 3, 176°, elliptical, about 40 feet by 20.

Both Mr. Stevenson and Mr. Taggart brought specimens of the geyserite, including many vegetable fragments, apparently some of the coarse sedges common along the lake-shore.

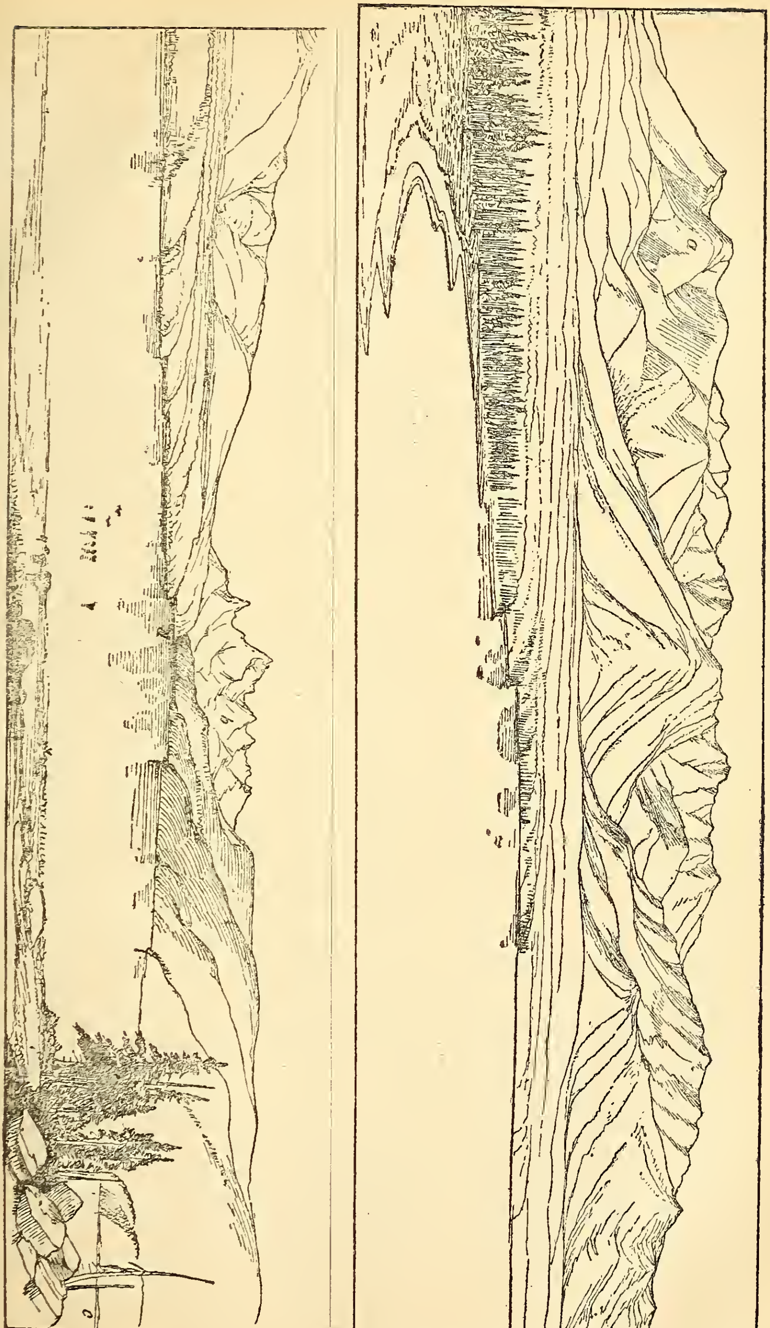
CHAPTER IV.

MOUNT SHERIDAN—HEADS OF SNAKE RIVER—FALLS RIVER PASS—JACKSON LAKE—GLACIER LAKES—GRAND CAÑON OF SNAKE RIVER—FORT HALL.

Leaving the main train to find its way southward to the stream which flows from Heart Lake, a small party of us started, on the morning of the 11th, for Mount Sheridan and the country beyond. At the north end of the lake, there is a considerable marsh and a lagoon, which, when full, throws good streams into the lake; but its outlets were now choked up with beach-sand. Its water comes from the drainage of the broad, flat area, partly in meadow, partly in timber, which stretches across to Yellowstone Lake. Our course, holding to the left of the main peak, led us over moderate slopes, for some miles, until, passing one or two small ponds, with no outlets, we struck the foot of the spur which, running out from the second crest of the Red Mountain range, counting from the north end, forms the divide between Lewis's and Yellowstone Lakes. Upon that divide lies the small lake, without outlet, called Lake Riddle,* visited by Dr. Hayden's party on their return from the Fire-

* "Lake Riddle" is a fugitive name, which has been located at several places, but nowhere permanently. It is supposed to have been used originally to designate the mythical lake, among the mountains, whence, according to the hunters, water flowed to both oceans. I have agreed to Mr. Hering's proposal to attach the name to this lake, which is directly upon the divide at a point where the waters of the two oceans start so nearly together, and thus to solve the insolvable "riddle" of the "two-ocean water."

Fig. 49.



A, Red Mountain Range—slopes toward Yellowstone Lake; B, Téton Mountains—forty miles distant; C, Inlet; D, Outlet; E, Mount Sheridan.

Hole basins in 1871. Mr. Hering visited this lake, and found it to be 7,999 feet above the sea, while Lewis's Lake is 7,750 feet and Yellowstone Lake is 7,788 feet. A high terrace is faintly indicated on the east side of Lewis's Lake, but its level was not determined. This region should be more carefully examined, with a view to ascertain whether there is not some continuous terrace higher than the divide just described, which shall prove that the whole of this broad comparatively flat area was, as its general form suggests, covered by a large lake, which was really tributary to both oceans. The lowest point of the actual divide was determined to be 25 feet above Lake Riddle, or 8,024 feet above the sea.

In ascending the mountain, we found the easiest slopes very steep, so as to make much zigzagging necessary in getting our animals to the summit. As we occasionally looked back, we saw beneath us, on our left, the large cluster of hot springs which occupies the head of the valley of the longest tributary of Heart Lake, and, beyond, caught glimpses of Yellowstone Lake. Upon reaching the first crest, both lakes lay spread out before us, while, to the westward, Lewis's Lake and Shoshone Lake were also in full view. Between us and Heart Lake lay a great hollow of the mountain, looking much like a broken-down crater, and very probably it may once have been one. The highest peak was still beyond us, and we made but little delay, except to shoot grouse for supper, in riding to its crest. This range was called Red Mountain by Dr. Hayden's party of the previous year; but its highest peak lacked a name, until Captain Barlow visited its summit and dubbed it Mount Sheridan.* It is one of the most sightly points in the whole region. Surrounded by deep valleys on all sides, and itself standing 10,420 feet above the sea, it gives one a range of vision over an immense area. Sweeping round the horizon, I counted four hundred and seventy-five distinct mountain-summits, at distances varying from thirty to two-hundred miles. The Tétons on the west loomed up grandly, while, through the broad depression just north of them, the Crater Buttes, the Three Buttes, the Salmon River Mountains, and Sawtelle's Peak, were in full sight. To the north, the Gallatin Mountains, the Belt Mountains, and Crazy Woman Mountains appeared close at hand, while along the eastern horizon stood the high walls of the Yellowstone Range and of the Big Horn Mountains, and far to the southeast stood what we supposed to be Frémont's Peak and other crests of the Wind River range. There appeared to be a considerable depression in the Big Horn Mountains nearly due east from the head of Yellowstone Lake, as if there might be a practicable pass through the range at that point. This should be examined. Throughout all this wide area, with its numerous lofty crests, there were *no* "snow-*covered*" peaks, though many large bodies of snow appeared near the summits in every direction.

The lower slopes of the mountain are heavily timbered; but, as we approach the summit, the trees become scattered and stunted, consisting mostly of *Pinus flexilis* and a small spruce, *Abies Douglasii*, both characteristic of high levels. The coarse, yellow lichen (*Ever (?) nia vulpina*,) often called "Montana moss," which is somewhat abundant at lower levels, but is there rarely found well fruited, grows here in immense quantities, magnificently fruited, the spore-disks (apothecia) being fre-

*Mount Everts had been used for it, but that name was already in use for a peak farther north, and duplication of names is as objectionable in geography as in the other sciences. It is not improbable that this may have been the peak to which the name Mount Madison of the old maps was intended to apply, but the location of that peak was so many miles distant from the position of this, and had so different relations to surrounding ranges, that we cannot consider the identification at all certain, and therefore must reject the name.

quently an inch or more in diameter. At the very crest, vegetation is reduced to a few grasses and Alpine plants, and the gray, red, and yellow rock-lichens which so commonly make these high levels brilliant.

The extreme crest consists of a dark, brecciated porphyry; but, only a few feet lower, we find an abundance of the purplish-pink laminated porphyry, which forms a large part of the mountain. All the rock is quite ferruginous, so that, on weathering, it attains the dark-red tint so characteristic of the mountain as seen from a distance.

In the south slope of the mountain there is another huge crater-like hollow, but I doubt its being really an old crater. Its slopes are steep, with loose rubbish, on which we could hardly stand, while at the same time we could with difficulty *drag* our horses down it to our chosen camping-spot in a grassy opening by the side of the small stream formed from the snow-banks, which probably never entirely disappear from the head of this hollow. A snow-fed pond lies on a small flat near the head of the stream. A large dike of very compact trap crosses this ravine just above camp, running about north 44° west. Mr. Hering, with his assistants, remained upon the summit until after dark, for star-observations, but succeeded in bringing his instruments safely to camp.

Next morning (12th) Mr. Hering and Mr. Stevenson returned to the main party, while the rest of us went on to examine the head-waters of the Snake, whose general position we had seen from the summit of the mountain. About a mile below our camp, we came to a curious little spring-pool, standing on a marshy bottom. Around its edge there was a dam-like border of roots, grass, and moss, by which the water was held at perhaps a foot above the surrounding marsh. Apparently the spring had burst up through an old turf, which had turned up at the edges, and through which the water had never been able to break down an open passage, though escaping through its mass and over its edges.

Our descent continued to be quite rapid for nearly two miles farther, when we reached the meadow-like bottom of a stream coming in from the left, which apparently gathers the water from the springs which escape from the foot of the mountain, nearly round to the basin of Heart Lake. From the junction of the two streams we held our course southeasterly, over a spur about 500 feet high, until we struck Heart River not far above its junction with Barlow's River. As the stream leaves Heart Lake, it flows for some miles through dense forests of pine and spruce, and then through a deep, narrow cañon, apparently of volcanic rock, from which it issues just above where we struck it. This river is evidently not subject to the great freshets which are common on many of the streams hereabout, and it is therefore probable that Heart Lake acts as a retaining reservoir for the waters of the melting snows, while the melting itself goes on more slowly in this densely-timbered basin than on the barer slopes.

The valley about the junction of the two streams contains a considerable area of beaver-ponds. Continuing southward, up, the valley of Barlow's River, we rode for two or three miles over a level, sage-covered prairie, but little above high-water mark. The stream has a very wide, gravelly channel, in contrast with which its present flow seemed very small, though really of pretty good size. The lower slopes of Mount Hancock on the west, and those of an unnamed peak of nearly equal height on the east, soon close in upon the stream, forming a deep and narrow cañon. To avoid traveling in the bed of the stream, we followed some of the numerous game-trails, which led us to from 300 to 400 feet above its level, but finally brought us down again about ten miles from Heart River, and just below some small falls and rapids, where the stream descends about 30 feet in about 200. About two miles below this we began to find outcrops of a fine-grained, ferruginous, laminated sandstone, destitute of fossils, but probably of Tertiary age. Some of the layers showed abundant ripple-marks. At the falls, the rock is heavy-bedded. The dips are mostly about 22°, varying somewhat on either side of due east. Just above the falls, and opposite to our camp, four thin layers of coal, varying from 1 inch to 6 inches in thickness, and two layers of clay ironstone, (iron carbonate,) varying from 6 inches to 1 foot in thickness, are all included within 10 feet of shales. About three miles above this point, the cañon opens out into a broad valley, with rather narrow bottoms, but with broad, gentle, grassy slopes, topped with gently-rounded hills, partly timbered, partly grassy. The huge rocks which lower down had encumbered both bottoms and slopes gave place to cobble-stones, pebbles, and sand. From this point Captain Barlow turned eastward, in 1871, after following up the cañon, as we had now done; and here we turned eastward to climb the hills. From a higher point, we saw that the rest of the valley is mainly a broad basin. There appears to be no pond at the head of the stream, which is apparently near the summit of a flat divide, from the other side of which the waters run to Buffalo Fork. This is mostly fine grazing-ground, and the numerous game-trails give evidence that it is frequented by deer and elk; indeed, we found two herds of elk, of about twenty each, among the groves on the top of the ridge. The mountains shut off the winds on all sides, and the valley lies so well to the sun that the snows must melt rapidly here, thus causing the great freshets of which the broad, gravelly bottom of the river below had already given so abundant evidence. The upper slopes of the ridge on either side are mostly bare of timber, and many parts of them are badly washed. Those on the east are composed of mostly thin-bedded sandstones, probably of Tertiary age, at least 2,000 feet thick, with variable south-easterly dips. A few red layers appear, but the majority of them are gray. No fossils were found, though careful search was made for them.

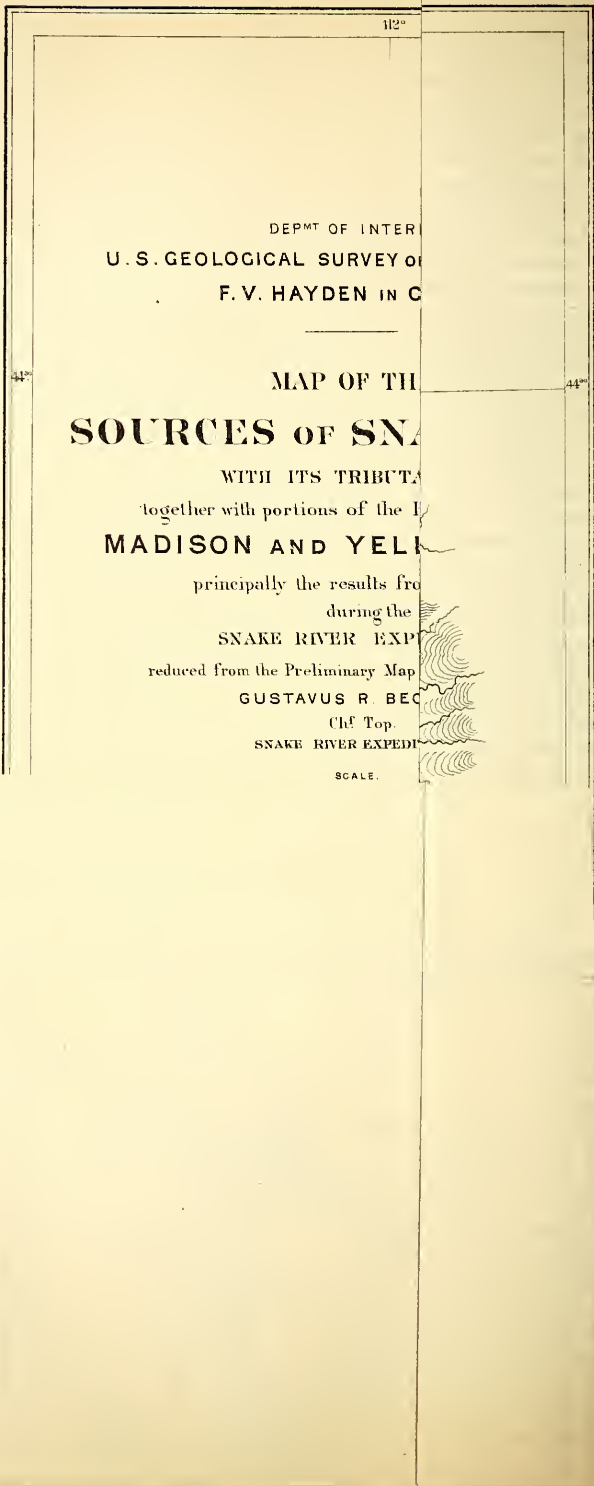
From the summit of this ridge, we again saw Yellowstone and Heart Lakes, and had a fine view of the rugged Tertiary (?) crests of the Big Horn Mountains to the east, running down to Union Pass.

The scattered groves of spruces, with occasional pines, which are so constantly characteristic of the upper edge of the timber, occur scattered over these upper slopes, and nearly every cluster contains some young trees; but we nowhere encounter the patches of dense young growth which at a lower level so constantly start up, in a short time, whenever a body of old timber has been burned over and has fallen, and often even before the dead trees have fallen. The idea has been advanced that the burned patches are *not* thus renewed in these mountains; and, *under some circumstances*, this seems to be true; but the *rule* is just the opposite, as those of us who have had occasion to penetrate the vigorous growth of this dense young pine, whether alone or with a pack-train, will most vividly remember while memory lasts.

Crossing this ridge, we came to the valley of a stream which we afterward ascertained to be the head of the main stream of Snake River. At its upper extremity we found a flat valley-divide, upon which are two small ponds, near together, covering from eight to ten acres each, one of which is the ultimate source of Snake River, while the flow from the other joins Buffalo Fork, and so reaches the Snake just below Jackson's Lake. Ascending the high, sharp ridge on the west side of this valley, at least 500 feet high, we find its slopes to consist entirely of large and small well-rounded pebbles of variously-colored quartzites,


DEPmt OF INTERIOR
U. S. GEOLOGICAL SURVEY OF THE TERRITORIES
F. V. HAYDEN IN CHARGE.
MAP OF THE
SOURCES OF SNAKE RIVER
WITH ITS TRIBUTARIES
together with portions of the Headwaters of the
MADISON AND YELLOW STONE
principally the results from Observation
during the
SNAKE RIVER EXPEDITION
reduced from the Preliminary Map after Surveys by
GUSTAVUS R. BECHLER,
Chf Top
SNAKE RIVER EXPEDITION
SCALE
EXPLANATION.
Abbreviations for Camp Stations
Jy. 3 - 12 etc = July 3rd until 12th etc
A . . = August
S . . = September
O . . = October
dotted lines mark the route of the Expedition
S.P. dotted lines marked with S.P. refers to side trips of the Surveying Party.
The Figures thus 7083 express the Elevation above Sea
This line indicates the Rocky Mt Divide
UPPER MADISON BASIN
LOWER GEYSER BASIN
UPPER GEYSER BASIN
YELLOW STONE LAKE
7788
FLAT DIVIDE
SHOSHONE LAKE
MT SHERIDAN
ROCKY MOUNTAINS
RED ROCK RANGE
Undulating Basaltic densely timbered
basaltic Plateau
Henry's Fork of Snake River
Middle Fork
Fall River
FALL RIVER BASIN
Undulating Table Land
North Fork
South Fork
Pierre's River
Gradual rising Prairie
TETON RANGE
MT MORAN
JACKSON'S LAKE
MT HAYDEN
MT LEIDY
MT HANCOCK
ELK RIDGE
Sources of Snake River
BUFFALO FORK P.
Upper Grosventre Butte
Gros Ventre Creek
Lower Grosventre Butte
TETON PASS
JACKSONS HOLE
SNAKE RIVER MOUNTAINS
Camp Reunion
Highest Point of Range
Market Lake
Moody Creek
Snake River
Part of ROCKY DESERT covered with LAVA BASALT destitute of Water & Vegetation.
TAYLORS BRIDGE
BLACKFOOT MTS
MOUNTAINS
Blackfoot River
HIGHAMS RANCHE
Highams Peak
FT HALL
MT BAIRD
MT PUTNAM
112°
111°30
111°
110°30

J. Bien, Lith.


112°
DEPMT OF INTER
U. S. GEOLOGICAL SURVEY O
F. V. HAYDEN IN C
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SOURCES OF SN
WITH ITS TRIBUT
together with portions of the
MADISON AND YEL
principally the results fro
during the
SNAKE RIVER EXP
reduced from the Preliminary Map
GUSTAVUS R. BE
Chf. Top.
SNAKE RIVER EXPEDI
SCALE.

up to the very summit, where this deposit is just pierced by an outcrop of the gray trachytic lavas and red basalt, partly vesicular, though mostly compact, which form the nucleus of the ridge. We here stood upon one of the highest points in that neighborhood, about 8,654 feet above the sea; so that we were entirely at a loss as to the source from which had flowed the large river which had distributed such immense amounts of gravel and sand. We could obtain no local data which should enable us to judge whether the stream had flowed northward or southward, but the general levels of the country would imply a northerly drainage. The deposit is evidently very ancient, but no considerable consolidation had taken place.

Looking westward, a heavy mass of mountains, broken by very few water-courses, at least on their eastern face, lies between us and the basin of Jackson's Lake, and I believe that this is here properly the "main range" of the Rocky Mountains. It is certainly part of the *highest mass-connection* between the Wind River and Big Horn Mountains, on the east, which really form the northern termination of what is the main range farther south, and the range west of the Three Forks of the Missouri, which there bears the name of Rocky Mountains, and the continuation of which really appears to be the main range farther north, so far as the best maps indicate.

Above this mountain-mass the Tétons loom up grandly. A peak of that range, some fifteen or twenty miles north of Mount Hayden, is second only to that peak in elevation.

Passing westward the quartzite-gravel continues for several miles, though the mass of all the ridges is composed of a coarse volcanic breccia. The slopes are here much flatter and more rounded, with heavy growths of fine spruce, of which large areas have been burned and have fallen, so that we found some large patches absolutely impassable with animals, and were obliged to make considerable *détours* to avoid them. The small streams heading here have flat valleys, with some good meadows.

Descending the valley of Coulter's Creek, we found that the high divide between the head of this creek and the head of Snake River consisted of rapidly-disintegrating volcanic rocks, mostly conglomerates of trachytic porphyry, obsidian, &c., like those which form the very precipitous banks of the streams. Many bare spots on the slopes indicate old land-slides, some of them of large size. The main valley is narrow and in some parts deeply cañoned, so that, with both steep, rocky slopes and badly-interlocked fallen timber, we had great difficulty in making a passage out to the valley of the main Snake. This stream, we found, after a course of about twelve miles from its ultimate sources, running through a broad graveled channel, 200 feet or more in width, with three considerable terraces on either bank, along which we rode to the junction, of Barlow's River. The gravel is in some places washed away by the stream, so as to expose a solid river-bed of volcanic rocks. Near the junction, the terraces are at the levels of about 25, 80, and 140 feet above the present level of the bottoms. These are also developed to some extent along Barlow's River, which enters the Snake at a sharp, reversed angle, through a narrow cañoned valley, from the upper slopes of which we could see the broad flats about the mouth of Heart River. Though this fork brings at this season the most water to the united stream, and has the longest course, draining the largest area, yet the relative forms of the valleys at once decided that this could not properly be called the main Snake River.

On the broad lower terrace, about a mile west of the mouth of Barlow's

River, stands a large conical mound, about 65 or 70 feet high and perhaps 250 feet in diameter at the base. Though circumstances prevented me from making the desired examination of it, yet, from the regularity of its outline, I feel quite certain that it is a structure of the age of the Mound-builders. No other relics of that interesting people were seen upon the entire trip, unless the rude rock-wall reported by Mr. Stevenson as existing upon the summit of Mount Hayden should prove to be such.

The broad valley soon narrows again to a deep cañon, walled by red shaly sandstones, containing no fossils beyond indistinct fucoidal markings, which are referred with doubt to the Triassic period. The gray beds of the lower part of the series make their appearance in the lower end of the cañon. The stream is here broad and shallow and easily forded, so that the cañon can be easily traversed at this season. From this point the valley is wide and terraced, the bordering ridges being a mile or more apart; and this continues, gradually widening, to the basin of Jackson's Lake. Just at the mouth of the narrow cañon, the river bends sharply to the right and then to the left, so that the form of the slopes gives the descending traveler reason to expect here a large affluent; but none exists. About a mile lower, we came suddenly upon a small basin of hot springs, most of which are now nearly extinct, though some large mounds on the river-bank give evidence of great activity in former times. The active vents seen were all in the bed or on the bottoms of the river, so that their flow was more or less mingled with river-water; and no temperatures were taken. The deposits are siliceous. Mr. Taggart found, near here, at the foot of the second terrace, several conical depressions, from 30 to 40 feet deep and from 75 to 100 feet in diameter, which *might* have been old spring-basins, though their origin is by no means certain. At the bottom of one of these lay two dead rabbits, upon which there were no signs of violence. No other signs of escaping gas were noticed.

This hot-spring basin occurs at the upper edge of a belt of basalt, which forms, a little farther on, lofty vertical walls, from 300 to 500 feet high, through which a small stream, coming in from the north, has worn a deep, narrow cañon. About two miles below this, high walls of nearly white limestone appear on either hand, though the fading light of evening prevented a clear understanding of the relative position of the beds at the junction. It is probable that the basalt, escaping from some vent in the volcanic range of Red Mountain, filled a large north and south valley, of which the limestone had previously formed the western wall; and semi-metamorphism should be found in the limestones near the line of contact.

About three miles more brought us to the camp of the main party, at the mouth of Lake Fork, where the broad valley of the Snake makes a sweeping curve into its future southerly course, while Lake Fork itself joins it from the north through the narrow cañon which it has worn down through a high barrier of volcanic rock.

In descending from Lake Lewis, the main party found the river-banks low and rocky for a short distance, before the stream enters a cañon with walls from 150 to 200 feet high, in which were encountered sharp rapids and a vertical fall of about 30 feet. Then, for a mile or two, the slopes are gradual, with narrow, swampy bottoms along the river. About three miles below the lake, high, rocky banks indicate the approach to a deep cañon, which really commences at about three and a half miles, with perpendicular walls on both sides, inclosing a narrow channel with a rapidly-sloping rocky floor, in some places partially obstructed by huge tumbling masses of rock, but apparently without any accumulation of gravel. Considerable rapids occur through nearly the whole cañon, and one fall of nearly 50 feet was noticed. The cañon deepens rapidly to from 700 to 800 feet, with widths of less than half the depths at the deepest precipitous portions, though in some places widening above, so as to have sloping banks of about 50° from the horizon. About three miles down, it reaches its culmination, and is truly grand. It has none of the brilliancy of coloring so characteristic of the Yellowstone Cañon, but the somber tints of its gray, brown, and dark-red lichen-covered rocks, occasionally variegated with smaller patches of green and yellow, constitute a peculiar style of beauty and add greatly to the effect of its narrow dark depths. The only deficiency is in the supply of water, which is small at this season. The rocks are all volcanic, mostly porphyries and trachytes, with some porphyritic obsidian. Some two miles below the end of the main cañon, the cliffs close in again to the river, for a few hundred feet, to a width of about 200 feet, with a height of 400 feet or more, forming a suitable gateway to the cañon from below. The valley below this is still narrow, but opens enough to give room for a few beaver-dams in its swampy bayou-banks before it rushes out into the valley of the Snake.

The high ridges which form the slopes about Lake Lewis bear back from the river and form no part of its lofty cañon-walls. Between the river and this upper slope, on the west side, a large stream gathers its waters from the abundant springs of the mountains and occupies a broad flat valley on the lower level, filled with beaver-dams, whence it rushes, through a narrow, winding cañon and over a 30-foot fall, to meet the river about a mile above its junction with the Snake. On the foot-slopes of the mountain, along the west side of the beaver-dam flat, there are considerable numbers of warm springs oozing out, and considerable accumulations of siliceous deposits are indicated by the soil. A small run, formed from a number of these springs, gave a temperature of 101°. It is possible that active springs of some size exist in this neighborhood, but the contrary is indicated by the extensive bodies of dense timber, which also hinder exploration. From the south end of the cluster of beaver-dams aforesaid, a stream flows southward, which attains a pretty good size before it joins the Snake, about three miles below the camp at the forks. Its source is probably in strong springs on the flat divide, which have been dammed up by the beavers so high that the ponded waters can escape in both directions.

The mountain which bears off westward from the head of the cañon forms the steep northern wall, while the extreme slopes of the Téton Range form the more gently-sloping southern boundary of a flat valley, from five to eight miles wide, which breaks through to the basin of Henry's Fork, and is occupied by the sources and main stream of Falls River. The extreme source of this river is in the great water shed of the northern mountain, from whose southern face it bursts in four immense springs, which leap from its steep rocky sides as full-grown streams, and rush in beautiful cascades, from 75 to 100 feet high, down a slope of about 40°, to form two large branches, which, a mile below, unite in a stream carrying about 20 feet of water. After a winding course of two or three miles, from several points of which it could with very little difficulty be turned eastward into the main Snake, it flows with a still rapid current into the more northern of two small lakes, known to us as Beulah Lakes, which lie upon the lowest part of the divide and are each from 600 to 800 feet across. The southern one has now no surface-outlet, but marshy grounds extend to the more northern one, over which outflow must pass when the surface of the lake is from four to six feet higher. The divide toward the east is only 8 feet above the lake. From the west end of the more northern lake, about 30 feet of water flow out rapidly, soon jumping over a fall of 12 feet. Strong branches soon join the stream from the north and one from the south, and double its supply of water. Five other falls succeed, of 6, 12, 40, 20, and 30 feet, before we reach the Great Falls. These show a total descent of 141 feet, consisting of three larger falls above, the third being 47 feet high, with three small ones at the bottom. The upper two are somewhat of horseshoe form, while the third and highest has a nearly straight edge. The amount of water in the stream is fully 80 feet. The porphyritic trachyte of its walls forms perpendicular cliffs, with rounded tops. A stream of some size comes in about a half mile above there, on the south side, with fine cascades on its upper course, while its sources lie in a basin of the mountain whose form indicates that it may inclose a small lake; the left-hand branch of this stream comes from two small lakes on the divide, as hereinafter described.

From the lakes downward, we find laminated porphyries, succeeded by trachytes and red and black porphyritic obsidian. Below the falls, a high knob consists of a fine-grained, compact, white trachyte, which contains disseminated plates of black mica, (muscovite ?) and which, with but a slight change of texture, might readily be mistaken for granite. From this knob we have a fine view westward to the lower basin of this river and its tributaries. The largest of these, Bechler's River, comes out of the plateau of the great water-shed, about ten miles to the northward, into a large basin apparently containing extensive grassy meadows, and then passes among rounded timbered hills to join Falls River, apparently but a few miles above our lower crossing of that stream. Large grassy meadows, some miles farther north, indicate another large stream, probably tributary to Bechler's River; but it was impossible to trace its course with any certainty at that distance. Some miles down Falls River our guides report another fall, about 40 feet high; so that it will be seen that the stream deserves its name. The slopes near the river are mainly well-rounded and fairly timbered, though, at a few points, steep and even precipitous and bare. The stream presents the utmost variety of water-scenery within a short distance; from the still, deep pools, which accompany a short stretch of beaver-dams, to short, sharp rushes over steep rock-slopes, to successions of steps, forming various styles of rapids, and to vertical falls of various forms and sizes—a perfect treasury of artistic bits.

The elevation of this divide and the moderate character of the slopes, averaging about 54 feet to the mile from Henry's Fork to the summit, indicate this to be a favorable line for railroad-access from the south to the region of Yellowstone Lake, if such should be thought desirable. From the main line up Henry's Fork to Montana, of which this would doubtless be a branch, the road would follow up the ridge on the south side of Falls River to the divide, thence keep around the foot of the northern mountain to Lake Lewis, cross Lake Fork, and, passing along the eastern shore of the lake, cross the flat divide, striking Yellowstone Lake about the middle of its western side, and thence follow down the valley. It is probable that a route could be located from Lewis's Lake, past the north end of Shoshone Lake, to the Fire-Hole basins; but the most easy access to the Fire-Hole is by way of Henry's Lake Valley, Tyghee Pass, and the Upper Madison Cañon. Between the Fire-Hole and Yellowstone Lake, the ridges are too sharp to be passed by railroads, unless by very winding routes or by long tunnels.

A short distance southwest of Beulah Lakes, over a divide about 300 feet high, and at a level about 100 feet lower, Mr. Bechler found two other small lakes, at the head of a branch of the stream which enters Falls River from the south, just above the Great Falls. The upper one has an area of something over one hundred acres, with rocky banks, and flows to the lower, which occupies about 40 acres in the center of a marshy basin of perhaps a hundred and forty acres.

Southeast of these latter lakes, over a divide about 350 feet high, we reach the head of a valley running eastward to the main Snake. Its upper portion is a flat basin, about one and a half miles long by a mile wide, bounded on the east and north by from 400 to 500 feet of volcanic rocks, of which the upper 200 feet present a vertical front, while the remainder is mainly covered by a slope of tumbling rubbish down to the stream. The other slopes are rounded, as are also most of those along the lower course of the stream down to its junction with the Snake.

All this wide area, from these northern slopes of the Téton Range nearly to the Tyghee Pass and to the mountains on the north side of the Upper Madison, though actually quite elevated, is relatively much depressed below the summits of the limestone, quartzite, and granite mountains on either side. From the general distribution of the volcanic rocks, as well as from facts observed elsewhere, I am inclined to believe that, before the ejection of these immense bodies of lavas, there was here a broad valley, through which the drainage of the upper mountain-region to the eastward found its way out to the great basin of the Snake, while the cañon by which it now escapes through the high mountain-mass south of the Tétons had not been cut down.

Immediately opposite the camp at the mouth of Lake Fork, there is a considerable cluster of dead and dying hot springs. Several mounds indicate the former positions of geysers of considerable size. The temperatures of ten springs were taken by Mr. Taggart, varying from 102° to 158°. Three were above 150°. The deposits are now rapidly disintegrating. Upon one large conical mound this process had developed a columnar or fibrous condition of the geyserite. Similar spring-deposits also occur on the west side of the river, from one to four miles below this camp, and some of the mire-holes so common in the Fire-Hole basins were also encountered. Upon looking back from below, two large columns of steam were seen, about a mile up the Beaver-Dam Creek, which seemed to indicate the possibility of geysers still existing there. The lower part of that stream was full of purple-nacred *unios*, apparently like, or closely allied to, those found in the branches of Henry's Fork.

Along the east side of the river, the face of the high ridge shows the following rocks, according to notes taken and specimens brought in by Mr. Taggart:—At the base lie about 200 feet of white and light-gray quartzites, overlaid by from 500 to 600 feet of light-drab and dark-gray limestones, and about 100 feet of gray sandstones, followed by heavy beds of red, shaly sandstones, apparently the same as those seen higher up the river. I am not satisfied as to the age of either the limestone or the quartzite. The ridge is capped with beds of porphyritic trachytes, having a dip of about 30° to the southeast, while the limestones beneath dip about 40° in the same direction, showing that their tilting commenced before the deposition of the trachytes.

The main trail crosses the Snake about a mile below camp, and passes over the hills so as to cut off a considerable bend of the river. From six to eight miles below the forks, a spur, which runs nearly to the west bank of the river, shows a high bluff face of porphyritic trachyte. The valley is here wide and flat, mostly marshy, with some large bayous. There are considerable areas of fine grazing-ground and many large patches of willows. One island-like, rocky knob, with part of the first terrace, which has been protected by it from erosion, stands out in the middle of the valley, about a mile below the cliffs. The river is here of moderate depth, with a bottom of small pebbles and muddy sand, but good fords are few and mostly difficult of access by reason of the marshes bordering the stream, so that the necessary crossing to the east bank should be made near where our train crossed, unless special reasons take one down the west side. As we approach the lake, the stream gets deeper and more sluggish, being somewhat checked by the back-water of the lake. Broad marshy flats stretch back from the shore of the lake on both sides of the river. On all these flats we find an abundance of "bitter cottonwood," which had formed, higher up, only a very small part of the timber-growth, though its young plants had, for the last fifteen or twenty miles, furnished rapidly-increasing patches of yellow and pale-red along the slopes, thus replacing, in some degree, the autumn-tints of the hickories, chestnuts, and maples of more eastern regions, while a small mountain-ash was doing its best to replace the deeper crimsons of the oaks and of some of the maples. The development of these tints did not seem to be at all connected with any special increase of cold; and, indeed, we had been having frequent freezes all the summer, without any apparent effect upon the vegetation, which seemed to be accustomed, as the grasshoppers are, to being frozen up every night and thawed out every morning.

The Téton Range had been before us for many days as a prominent feature of the landscape, but now its peaks stood up as the features of main interest, bounding the valley on the west with a series of roof-like ridges and pointed peaks, well besprinkled with patches of snow. Farther north and east, we had been having pleasant weather, while this portion of the valley had several successive days of cloud and rain, as reported from our guide, Beaver Dick, who met us again here, having crossed from the valley of Henry's Fork. When these storms reached the higher portions of the mountains, their deposit took the form of snow, so that the drifts were now much larger than when we struck the range on the other side, in July.

On September 21, the minimum thermometer recorded $4\frac{1}{2}°$; and a clear sky, with cool weather, gave us unusually fine views. The peaks stood out sharply, while the gaps and cañons were full of a deep-blue, smoky light, which would touch the heart of the least artistic.

On the northeastern slopes of the range, several hundred feet of limestones represent the Lower and Upper Silurian and the Carboniferous, as on the other side of the range. Their area here is limited, and has not been traced to its abutment against the volcanic rocks, which fill the depression to the northward. The range is much flattened and rounded off at this extremity; and I am inclined to believe that the granitoid nucleus declines so much as to allow of the connection of the limestones of the east and west slopes being exposed between it and the volcanic rocks. At least, the dips indicate that such a warped connection once existed; and I shall not be very far wrong in coloring the map according to that supposition. The underlying quartzite (Potsdam?) was not seen here, but is probably in place, as it appears a few miles farther south. The most northern large cañon of the range exposes, beneath the limestones, a heavy body of dark micaceous gneiss, with both granite and quartz veins. The local dip is northeasterly; but the main dip of the metamorphic rocks here is southerly.

Along the shores of Jackson's Lake there are no outcrops which would enable one to decide where the different strata lie; but, at its southern end, there are high knobs of porphyries and trachytes, which indicate, by their position, at least a former connection with the more northern beds, which we traced to within five miles of the northern end of the lake.

Jackson's Lake is a very irregular body of water, much cut up along its borders by long, narrow promontories jutting out into it from both sides, and containing one large island, which nearly separates the lake into two. The main lake is from two and a half to three miles wide, and the total length is about eight miles. In the soundings taken by Mr. Adams, the greatest depth found, 258 feet, was about a mile from the western shore. The series of soundings was far from complete, by reason of a squall coming down from the Tétons and raising dangerous waves, so that they had to give up the rest of the work. The lower slopes of the more northern Tétons come sharply down to the lake on the west, and these steep slopes, together with the tangled undergrowth of willow, cottonwood, mountain-ash, and iron-weed, with occasional box-elder and maple and some tracts of fallen timber, make passage along there difficult for a train; but its other shores are surrounded by low hills and by broad meadows, largely occupied by beaver-dam and other swamps. These flats are much cut up by bayous, and include several ponds of considerable size. Others are found among the rounded hills of gravel, which remain from the upper terrace of the old river-border. Two of these, lying from two to three miles east of the outlet, toward the valley of Buffalo Fork, are each about two miles long by a half mile wide. They apparently occupy portions of ancient river-channels. A stream of about the size of Barlow's River, with broad gravel-bottom and rapid current, comes out of the hills opposite the lower end of the lake and joins the Snake just after it has escaped from the lake.

The views from the east shore of the lake are wonderfully grand. The Tétons rise majestically from its western shore to the height of 7,000 feet above its surface, with sharp slopes and walls of bare rock above, and their bases buried in a dark mass of pine and spruce, while at this season (September 24) their snow-covered summits give the beholder a strong sense of sublimity. At times they are wrapped in heavy masses of cloud; but even then they are grand. The accompanying sketch of the face of the range, as seen from near the North Gros Ventre Butte, has been copied from Mr. Bechler's field-notes. (Fig. 50.)

A few miles below the lake, Buffalo Fork enters from the east through a broad valley with grassy and willowy bottoms, bringing a very large body of water. These bottoms contain some large groves of Menzies's spruce, (*Abies Menziesii*,) whose peculiar cones were seldom seen elsewhere by us. Near the mouth of the stream gray and buff, fine-grained, shaly sandstones of indeterminate age dip sharply to the southeast, and similar rocks appear in the bed of Snake River, at the ford just above the mouth of Buffalo, but the dips are here much confused. Mr. Bechler followed the Buffalo nearly to its head, and reports that, for about twelve miles from its mouth, its broad, open valley shows no rock, but has rounded slopes covered with "quaking asp," (*Populus tremuloides*,) and bottoms full of beaver-dams. About twelve miles up, the valley narrows to a cañon from 350 to 400 feet deep by from 50 to 200 feet wide, for about three miles, with coarse, gray sandstone walls. About one and a half miles of a rounded basin, with beaver-dams, then intervenes before reaching the second cañon, which has nearly the same character as the first and is about two miles long. A broad basin succeeds, from five to seven miles across, reaching up to the foot of the high vertical limestone-walls of the main divide (?), whose ragged crest shows plainly from the mouth of the valley, and from whose many gorges come the numerous small spring-branches which form the main stream. Besides the main fork, seven or eight large creeks come in from either side, showing that the basin as a whole occupies a large area, and its amount of water makes this one of the most important tributaries of the Upper Snake. At this season, indeed, it carried fully two-thirds as much water as the Snake itself. About the mouth of the valley, the slopes are covered with partially-cemented Post-Tertiary sands and gravels, with occasional exposures of white marly clays, supposed to be of the same age, though no fossils were seen. The gray sand-stones of the cañons are plainly the continuation of the Tertiary (?) beds of Barlow's River directly to the northward; and the limestones of the high cliffs at the head of the valley are probably of Quebec Group age, perhaps capped with Carboniferous. A small bit of fine-grained, compact sandstone, found loose on the rubbish-slope near the top of the mountain by Mr. Brown, contains fragments of some thirty trilobites of the genera *Conocoryphe* and *Dicellocephalus* (?).

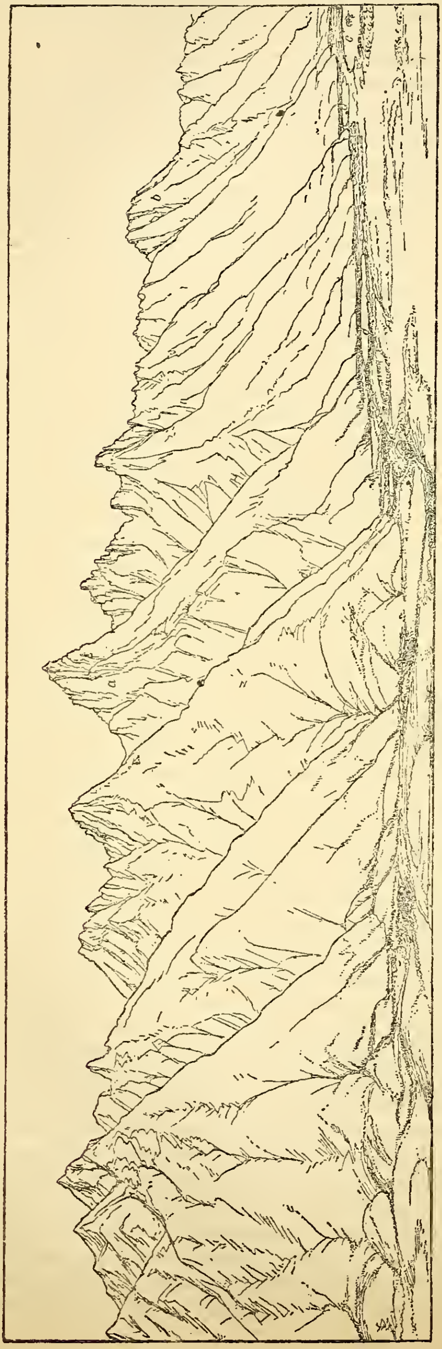
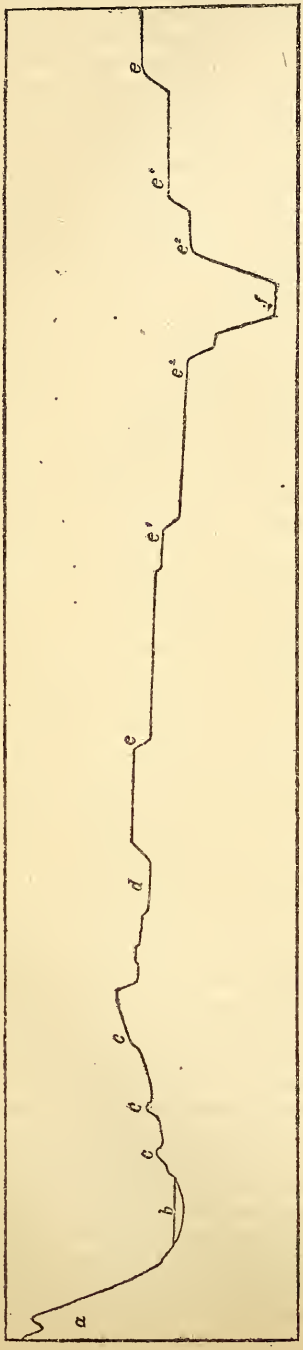


Fig. 50.

a, Mount Hayden; *b*, Mount Leidy; *c*, Jackson's Lake; *d*, *d*, *d*, small lakes.

Snake River escapes from Jackson's Lake at its southeastern angle and runs off eastward to the valley of Buffalo Fork before renewing its southerly course. Yet, from the top of the butte at the mouth of the lake, it is plainly seen that a broad valley extends directly southward from the southern extremity of the lake; and it at once becomes a question why the river has thus deserted its own proper valley and has turned off so far to the east to find another outlet. Four old terraces are strongly marked along the river, and the third, above its present level, forms broad plains, on both sides of the river, below the mouth of Buffalo. Moreover, the old river-gravel, consisting mostly of quartzites, runs to the top of the island-like knobs in the center of the valley as well as of some of the hills which border it. Crossing westward over these broad plains, which are mostly covered with sage-brush, except about the isolated ponds, which seem to give evidence that much of this third terrace has been worked over by the river and cut up by bayous, we cross a narrow belt of spruces covering the surface of the fourth terrace, and then descend to the old deserted channel of the river, which is nearly on a level with the third terrace. Crossing this valley directly toward the mountain, we come at once to a series of high, steep, narrow ridges, covered with immense masses of granite and heavily timbered. Within the last of these concentric ridges, we come to a small lake, lying at the mouth of a deep cañon which runs far back into the mountain; and here at last we have the clew to the mystery. This cañon, like all the other large ones of this range, was occupied by a glacier, whose terminal moraines now hem in this lake; and, though the old river-valley seems to have been not fully blocked up by the flow of silt which passed beyond the moraines, so that its general features are still plainly marked, yet it is evident that the deposition which caused its bottom to slope from west to east so much as we now find it to, was sufficient to considerably delay the wearing down of this channel. The cañon next north of this was also occupied by a glacier—a moraine-dammed pond will probably be found in the mouth of it—and doubtless its *débris* aided in checking the erosion. At that time, the flow of water through all this region was much greater than at present, and the duplicating of channels in the broad bottom was far from being uncommon. If a channel had then joined the eastern streams, though only as a bayou in time of flood, there was reason for its being ultimately cut down, so as to drain the western channel, which is the true valley of the Snake. The summit of the highest and outermost moraine is partly covered with river-gravel, as if the stream had at least once reached this height after the glacier began to recede. This crest is 122 feet above the bottom of the adjoining part of the old river-channel, 222 feet above the present level of the included lake, and 366 feet above Jackson's Lake. These and other levels across the valley were taken at my request by Mr. Hering, who has furnished the data for the accompanying section from the lake, across the old channel and the present one of Snake River, to the eastern hills. The length of the section is so great that it became necessary to distort it by increasing the elevations considerably beyond their proportional size. (Fig. 51.) We have called this lake, which is about two miles long by a half mile wide, Leigh's Lake, after our guide, Richard Leigh, (Beaver Dick.) It appears to be mostly shallow, and has a small island near its center. Can it be possible that the glacier, which was formed by the flow from two cañons whose junction is only a very short distance above the lake, split again after it emerged, so as to leave this island uneroded? No special depression of the moraines opposite the island was noticed; but examinations just at that point were not carefully made. On the other hand, if we pass to the north end of the lake, we find a flat divide, not 5 feet above its level, and less than a hundred yards across, which separates it from a large beaver-pond, whose waters escape through two or three other ponds and marshes to the head of Jackson's Lake. A very trifling cut would thus give the lake a second outlet; and it appears not improbable that the glacier did split, as suggested, during at least a part of its existence, and flow out at this end as well as at the southern one. These waters come so near together that, without any connected examinations, and without recognition of the rise of 144 feet from Jackson's Lake to Leigh's Lake, water-communication between the two had been inferred and reported; and Mr. Adams attempted to find a passage across in his canoe, but, failing in that, was obliged to make the long *détour* by the true outlet of Jackson's Lake.

Fig. 51.



a, Téton Mountains; *b*, Leigh's Lake; *c*, *c*, *c*, Moraines; *d*, old-river channel; *e*, e^1, e^2, river terraces; *f*, present channel of Snake River.

About a mile south of Leigh's Lake, another, of about the same size, which we have called Jennie's Lake, after Mrs. Leigh, lies in the mouth of the Great Cañon of the Téton Range. Passing up this cañon for a short distance, Mr. Taggart found a cluster of falls and rapids about 250 feet high, with lofty, precipitous walls on either hand, which prevent ready access to the upper part of the cañon, which winds around to the western side of the peaks, where its lofty walls were seen by us in July. This cañon gathers the entire drainage of the western side of the three principal peaks, so long known as the Three Tétons. The water of these mountain-streams is so pure as to make it certain that not the least glacial erosion is now going on at any point on the range. Though many schists occur in the mountains, very few of them have contributed to the terminal moraines, nearly everything except the granites having been ground or weathered fine during the downward passage. The moraines about Jennie's Lake are not very largely developed; possibly, the more abundant flow of water from beneath this glacier, consequent upon the greater size of its basin, washed away the *débris* from here more thoroughly than was done elsewhere. At two other cañons, farther south, similar lakes occur. The more northern of the two, which we have called Taggart's Lake, is surrounded by five concentric moraines, the elevations of which above the old river-channel, which passes just outside of them, were taken by Mr. Taggart, as follows: The outer one, 162½ feet; second, 206 feet; third, 271 feet; fourth, 316 feet; fifth, 422 feet. The present level of the included lake was found to be 249 feet above datum. The last of this series of lakes, which we have called Phelps's Lake, after a hunter of the region, who had seen and reported it, is hemmed in by three moraines, according to Mr. Taggart, the outer one 162 feet, the second 244 feet, and the third 287 feet above the lake itself, there being no special surface-feature near the moraines on their outer side to which to refer these levels, as to a recognizable base. In this last case, the cañon forks above, and the two arms extend in opposite directions along the line of separation between the granites and the flanking limestones. Each of the two glaciers, therefore, gathered, from the rocks overhanging it, granites on one side and limestones on the other, so that, after their junction, the central moraine of the united glacier consisted of limestone, and we find small fragments of limestone filling the low central portion of the terminal moraine, while its high flanks, which received the material of the lateral moraines, are composed of the granites, which are less easily disintegrated, and are therefore mostly in large bowlders. No remnants were anywhere seen of any lateral moraine deposits along the courses of the glaciers. It is possible that such may be found by more careful search, but the slopes are here so steep that most of their lower portions are buried in the tumbling rubbish, so that we can have little expectations of such a discovery being made.

A little south from the second large cañon south of Mount Hayden, the limestones come forward to the front of the mountain, above the granites, which shortly afterward disappear from sight altogether. The length of the exposure of the granitic nucleus of the range is about thirty miles.

About eight miles below Leigh's Lake, its outlet, which we have called East Téton River, enters the Snake. A hundred yards back from the opposite bank stands a high, rocky butte, known as North Gros Ventre Butte. Its northern end consists mainly of Carboniferous limestone, dipping about 70° N. 56° E., and containing many characteristic fossils. Along the west face of the butte, none of the lower rocks are visible, being buried under the Post-Tertiary whitish sandstones and marls, inclosing fragments of limestone and chert, but no fossils, of which all the southern part of the butte is composed; but, near the northeast corner, the lower part of the series of older limestones presents the conglomeratic texture so characteristic of the Quebec Group, on the west side of the Téton Range and elsewhere, and it is probable that they represent that group, though no fossils could be found. Beneath this we find gray quartzitic sandstones, which are probably of Potsdam age.

This butte stands near the middle of the broad basin which has long been known by the barbarous name of Jackson's Hole. This has a length of about twenty miles, and varies from five to ten miles in width. This includes portions of the different terraces, all of which are more or less covered with sage-brush. Near the butte, large areas of the sage had been burned off, and the grasses had grown up densely, forming fine pasturage; and on these we again encountered antelope, which had not before been seen by us since we entered the Upper Madison Cañon. It is said that, during the winter, when the grass is covered, they live upon the sage itself. This plant was now full of seeds, and the innumerable little chipmunks which burrow in the plains and hills were busy gathering them, biting off the long spikes and stripping them from end to end, passing them back and forth through the mouth, as one would an ear of corn.

The pebbles of the terrace-gravel have thus far been mainly quartzites, and still continue such on the east side of the basin; but, nearer the western range, considerable proportions of granite and gneiss pebbles are now mingled with them. A considerable excitement was stirred up, a few years since, by reported discoveries of placer-gold in large quantities on the Upper Snake, and many prospectors visited this region. A small hydraulic operation was undertaken near this point; but the gold was too fine and in too small quantities to pay, and the whole region was entirely abandoned after a few months. The coarse gold, found on the lower part of the Snake, appears to have entered the river below the cañon, which is still to the southward of us.

The Gros Ventre Fork emerges from the eastern hills about opposite the North Butte, but runs off down the valley, some eight or ten miles, before joining the Snake. Passing up its cañon for a short distance, the following section was taken:

1. White, friable, false-bedded sandstones, 10 feet.
2. Covered space, about 100 feet.
3. Irregularly-bedded, pale-gray and buff, magnesian limestones, 50 to 60 feet.
4. Pale-red friable sandstones, darker and shaly below, 300 to 350 feet.
5. Compact, fine-grained, gray sandstone, 15 to 20 feet.
6. Brown, coarse, friable, false-bedded sandstone, 60 to 80 feet.
7. Coarse, friable, red sandstone, 40 to 50 feet.
8. Compact, dark-drab, fossiliferous limestones, 300 to 400 feet.

Near the mouth of the cañon, the Carboniferous limestones of No. 8 form the walls, capped, as we ascend, by Nos. 7 and 6. As these pass below the stream's level, No. 5, which forms the top of what I suppose to be Carboniferous, commences a new cliff, and is covered by the Triassic (?) beds of No. 4, which form prominent red bluffs along the stream for many miles. The compact to vesicular, variously-colored and partly bituminous limestones of No. 3 showed no fossils, and I am uncertain whether to refer them to the Triassic or to the Jurassic, but favor the latter reference. The covered space of No. 2 showed nothing from which one could even infer the character of the buried strata. The friable sandstones of No. 1, which cap the hills for some miles, are probably late Tertiary. The dips of their false bedding imply an open sea to the northward during their deposition, while those of No. 6 face eastward and southeastward. The lower beds, which should make their appearance along the face of the mountain to the south of the Gros Ventre, are so much covered with the partially-cemented Post-Tertiary sands and gravels as to be not readily recognized from the plain, and time did not permit a closer examination. Judging from the dips of the lowest beds seen, I should expect to find here the lowest Silurian, underlaid by metamorphic rocks, forming an axis which may connect the Tétons with the Wind River Range.

Just south of the mouth of the Gros Ventre, on the east side of the Snake, stands a cluster of buttes, known as the South Gros Ventre Buttes. The western one has a high, broad northern face of red, gray, black, brown, and variegated porphyritic breccias, including much jasper, but partly porous, loose-textured, and even ashy. The beds are much distorted, but have a general northwesterly dip. The lower end of the butte is tapering, long and low, and appears to consist mostly of Post-Tertiary sands and gravels. At its southern extremity it rises quickly into a sharp butte, composed of horizontal beds of gray limestone, unfossiliferous, but apparently of Carboniferous age. The same beds form the face of the mountain to the eastward. Three other buttes lie east of the more northern part of this one, and evidently originally formed one with it.

These buttes greatly narrow the plain, which, immediately below them, expands into Jackson's Little Hole, whose flats are mainly upon the east side of the river and measure about four miles wide by perhaps ten miles long. Here, also, the sage has been burned off and replaced by grass. For several miles, from above the mouth of the Gros Ventre, the river has gravelly bottoms from half a mile to three-fourths of a mile wide, cut up by the several channels and partly occupied by beaver-dams. Of course, fords are numerous.

The only practicable pass across the Téton Range, so far as known, is about opposite to these South Buttes; and our main party left the river at this point. Mr. Taggart reports both slopes of the pass tolerably regular and gentle, except for a short distance just at the summit, but that the eastern is somewhat the steeper. The Carboniferous limestones, which were the only rocks noticed until the summit was passed, are nearly horizontal, have only a slight southerly or southeasterly dip; but, in descending the western slope, this dip increases to about 45°; and overlying, red, shaly sandstones, probably of Triassic age, appear at one point on the trail, while limestones, apparently those previously referred to the Upper Silurian, form considerable cliffs or spurs, a short distance to the northward. There would seem to be considerable displacement thereabout. The porphyries of Pierre's Hole appear at the mouth of the pass, at the elevation of about 7,000 feet, and form all the foot-hills of the mountains on the southwest side of that basin, until the actual bottoms of the Snake are approached, where the basalt appears. The track of the party lay so far out in the basin that there was little or no opportunity for examining the character of anything more than the foot-hills of the western mountains.

At the lower end of Jackson's Little Hole, the so-called Grand Cañon of the Snake commences. The river turns sharply to the eastward and cuts through the laminated sandstones which apparently overlie the Carboniferous limestones. Just at the mouth of the cañon, the upper terraces close in, and are capped by bastioned walls, 100 feet or more in height, of a pale-red sandstone, overlaid, as we see in looking back from lower down the cañon, after this turns south again, by heavy beds of dark-red, shaly sandstone, appearing like, and occupying nearly the relative position of, the Triassic (?) on the Gros Ventre, except that, below them, there come in several hundred feet of thick and thin bedded and shaly, gray and green sandstones, with interlaminated calcareous shales. These contain plant-remains, but so thoroughly comminuted that I was not able to find a single recognizable fragment. At the angle of the cañon, these dip strongly to about N. 78° E., and a long section of them is exposed on the east side of the stream; but in about a half mile they become horizontal, and, again, a mile lower, at the mouth of Hoback's River, dip 10° to about S. 63° W.

Hoback's, so named for a hunter of the Pacific Fur Company in 1812, by Mr. Wilson G. Hunt, as reported in Irving's Astoria, brings in a large volume of water from the eastward and plainly drains a large area upon the western slope of the Wind River Mountains. Its valley, though narrow near its mouth, was at one time the favorite route for the Indians in crossing to the Green River Valley; but, latterly, they have preferred the Gros Ventre route for some reason. The red beds hold a prominent place near the top of the high cliffs, for a half mile or more above the forks, but the valley is too winding to give much of a view. Just below here, a strong creek comes in from the west, apparently draining a considerable area of the mountain. It approaches the river by a succession of cascades over successive layers of the sandstones. As we descend the river, these beds come up in two anticlinals, one low and flat and the second mountainous, with dips reaching 70°, and coming down steeply to the river on both sides. The axis of the second anticlinal is occupied by a narrow fold of limestone, through which escape several warm springs. A small cluster of these, escaping among the gravel in the edge of the river, on the south side, emit an abundance of sulphureted hydrogen. Though somewhat mixed with the river-water, they gave a temperatnre of 117°. About a hundred yards below this, a group of calcareous springs has built up a dam of tuff, so as to flood several acres about the vents, which are now inaccessible. The general flow from the pool gave a temperature of 94°. Just opposite these springs, in the lower part of the sandstones, as they re-appear on the west side of the anticlinal, there are exposures of two or three heavy beds of black, calcareous shale and friable clay, with some harder bituminous mud-stones, which appear, from short distances, precisely like coal outcrops. Fragments of teeth and bones, probably belonging to amphibians, occur in these layers. Above them there are some thick beds of chert.

Here the river turns south again, and runs for about two miles along the west side of the anticlinal, with sharp slopes on either banks. Turning west again, we cross three anticlinals, in the third of which considerable displacement has taken place, so that the Carboniferous comes boldly up, and, after this, forms the mass of the mountain clear through the cañon. The lower portion of these beds consists largely of sandstones and shales, though including heavy beds of limestone; higher up, the limestones form a heavy mass for several hundred feet, partly compact, partly fragmentary, overlaid finally by more shaly beds, making a total thickness of 2,000 feet or more. A few fossils of the genera *Spirifer*, *Macrocheilus*, and *Zaphrentis* were seen in the *débris*. The lower layers weather to nearly white, while the upper ones are strongly buff. All through this series, the cañon is narrow, with steep, often perpendicular, slopes and hardly any bottoms. The river mainly occupies a deep channel, with a broad shelf of rock on one or both sides, which is barely covered at this season. Crossing would be impossible without swimming the stock. Many of the steep slopes are covered with spruces, and their angular tops, lapping over each other, on the opposite side of the cañon, give the effect of diamond-slating on a roof, though with the angles reversed. Upon these limestones we begin to find again great numbers of the small maples seen farther south. These are said by the hunters to be somewhat on the increase in this region.

About ten miles through these limestones bring us to the mouth of the cañon. Through much of its upper course the stream is quite rapid, and almost deserves the name, Mad River, applied to this part of it by the early trappers; but there is little that would have proved troublesome to experienced *voyageurs*, and probably none that would prove really dangerous. (See Irving's Astoria, chapter xxxi.)

The terraces, though only fragmentary through the cañon, now spread out into broad sage-covered flats on either side of the river, and the higher slopes become much more rounded. Just at the mouth of the cañon, John Gray's River, which heads far to the south, on the divide toward Bear River, comes from the southeast, through the same mountain-mass, and with apparently just such a cañon as the one we have just left. At its mouth, a heavy mass of cemented bedded gravel shows down-stream dips of 17°, apparently implying great rapidity of current over a rapid into a deep pool at some former period.

About two miles below, Salt River also enters the Snake, through a broad-terraced valley, which looks as if it were really the continuation of the lower valley of the Snake. But for misinformation as to distances, we should have explored this valley up to the salt-works before descending the Snake. It seems to afford an easy passage through a valuable region. The cañon through which we had just come, though having a reputation for very difficult traveling, was passed by us with ease, and really presents but very slight obstacles to building a railroad, if one were desired from this point to Yellowstone Lake or beyond, or merely to give convenient access to the rich basins of Jackson's Hole and Little Hole. Furthermore, a road, reaching this point from either the lower or the upper Bear River Valley, would have then the alternation of passing down the Snake with easy grades to the east side of the valley of Henry's Fork, with the advantage of crossing the river where its channel is narrow and its banks far above any floods.

The Snake here turns sharply northward into the continuation of the valley of Salt River, with high mountains of Carboniferous limestones on the east, showing some castellated walls, and lower and more rounded ones on the west. Two or three miles below the mouth of Salt River, a small stream from the west was thick with mud from the Caribou gold-washings.

The valley is here located by an anticlinal fold; and the nearly vertical limestones of its axis are finely exposed along the foot of the western hills. Here, also, is located a cluster of warm springs, making calcareous, sulphurous, and saline deposits. The largest spring, the Wash-tub, has built up a flaring table, 1 foot high, of an oval form, measuring about 4½ by 7½ feet, upon a mound consisting of calcareous mud, scarcely solidified, of from 5 to 7 feet above the creek-bottom in which it stands. The central table has contracted so as to crack across diagonally, and the flow now escapes at its western base, depositing a fine mud tinged in the full pools with a faint sulphur-yellow, but pure white in the dry ones. These pools cover the mound in descending steps of great beauty. The present flow is southward, though it has been on all sides in succession. The deposit on the surface of the mound is still very soft, and showed at the time of our visit (October 6) the tracks of a small bear, who had recently investigated the wonders of the mound, even setting his foot on the central table. One mound, no longer active, is 5 feet high, with a circular base of about 5 feet diameter and an oval summit of about 1 foot by 6 inches. Many small springs escape along the bank for a hundred yards or more. The deposits vary greatly in color. At some points, the odors of sulphurous acid and of sulphureted hydrogen were quite noticeable. The older deposits have built up a bank 10 feet high, along the base of the terrace; and the beavers have taken possession and have dammed up on it the waters of the cold springs which flow from the second terrace at short intervals along this plain. On the opposite shore, two considerable springs have built up their deposits against the foot of the mountain, one of which appears to be nearly dead. The highest temperature observed here was 144°. The Wash-tub gave 142° and others 142°, 140°, 90°, 88°, &c.

The deep channel, seen through all the lower part of the cañon, continues for several miles down the valley, and fords are at all points much rarer than in the upper valley. The stream is narrower on the average, and the amount of water has been much increased.

As the valley turns westward, it becomes somewhat narrower; and laminated porphyritic trachytes appear on the northeastern side, at first capping the spurs like isolated forts, and then forming, as it were, a row of casemates just below the crests of the hills. At two points this rock descends nearly to the water's edge; but the valley soon opens out again, with broad bottoms on the east for several miles, to opposite the mouth of Fall Creek, where basalt appears upon the eastern side as it had done on the western some miles higher up. The upper part of this valley-flat is covered with sage-brush, but the lower half is full of the richest of pasturage, except only such portions as are occupied by beaver-dams and bayous. Along these water-courses, large thickets of black-haws were most thickly covered with ripe fruit, but the crop of service-berries was almost an entire failure in all this region. At several points we noticed the abundant rose-bushes covered with hips, which were so soft when ripe as to have the translucent appearance of berries and to be very pleasant eating. This did not appear to be a specific character, but was probably consequent upon the shortness of the season, which, after the fruit is well developed, prevents the secretion of the large amount of woody fiber which elsewhere commonly forms so hard a covering to the rose-hips. All through the cañon, as well as along this lower valley, we noticed innumerable young plants of the lupines, which abound in this region, prepared to make vigorous growth as soon as the short summer opens.

Fall Creek heads some miles to the southward, in John Gray's Lake, near the Caribou mines, and here leaps into the river over a terrace of basalt perhaps 30 feet high, forming a very pretty fall, which has given the local name to the stream. A short distance below, we forded with difficulty, the water coming over our saddles. From this point the basalt lines both sides of the river, with very slight exceptions, to the Great Snake River Basin, and, according to report, to the Columbia. About four miles below Fall River, these basalt-walls close in the river's edge and form the lower cañon. At this point, two distinct beds of basalt appear, separated and underlaid by beds of river-sand, partly loose and nearly white, partly dark greenish and rusty brown, and considerably cemented with iron. These sands include great numbers of pebbles of basalt partly rounded. At one point, the lower bed of basalt slopes eastward at an angle of about 15°, indicating a probable source of flow situated in the mountains to the southwestward, though possibly due rather to upheaval. At another point, the basalt is curved above beds of sand and gravel having a curved surface, which plainly formed a bar in the old river-bed. These deposits spread up against the edges of limestones and sandstones of the mountains on either side.

At the base of the mountain on the southwest side of the valley, just above the head of this lower cañon, calcareous deposits, from now extinct springs, form a heavy mass, reaching about 100 feet up the mountain side. A small butte, nearly separated from the mountain behind, divides from the main valley the basin of a small stream which goes by the name of Swan Valley. The base of these western mountains is composed of gray quartzites. followed by coarse and fine white sandstones, and a very fine-grained white dolomitic limestone, all of uncertain age, though older than the overlying limestones, which contain a few Carboniferous fossils. The dips are sharp to the southwest, and the wash of the stream brings down fragments of red sandstone, which indicate that the higher beds here occupy their regular position.

The lower cañon is walled with basalt for from 200 to 400 feet, in many places perpendicularly, though elsewhere the slopes are more moderate. On the upper slopes, west of the broad plain which borders the top of these cliffs, there are two other beds of basalt and one of porphyritic trachyte, separated by only thin beds of sand and gravel, which reach to the top of the southern hills, about 6,700 feet above the sea. The cañon bends northward to the base of the northern mountains, and there winds for some fifteen or twenty miles before opening gradually to the broad plain of the Great Basin of the Snake River.

As we had descended from the mouth of Salt River, the timber had gradually disappeared from the hills, until we now found only the scattered groves of small cottonwoods which mark the hollows where the snow lies late, or mingle with the willows along the banks of the few small streams which escape from the hills into the sage-covered plain. From near the mouth of the cañon, a belt of cedars runs along the course of a high-water bayou on the south side of the river and forms a conspicuous feature of the otherwise featureless plain for many miles.

Some three or four miles below the mouth of this last cañon, a small hot spring, 4 or 5 feet across, stands on the north bank of the river, about 20 feet above the bottom. This was not visited by any of our party, but was reported by our guide to be too hot for one to hold his hand in it for more than a half minute. White spring-deposits were seen, from a distance, at several points on the north bank, but there is believed to be no flow at these points at the present time.

Joining the main party here on the evening of October 8, we passed over the sage-plain described in the record of our outward trip, crossed Willow, Sand, and Blackfoot Creeks, and reached Fort Hall on the 11th. The facts observed during that time, and during the following twelve days, while we awaited Dr. Hayden's arrival to pay off and discharge the party, have been incorporated in the earlier part of this report.

PHYSICAL GEOGRAPHY

AND

AGRICULTURAL RESOURCES

OF

MINNESOTA, DAKOTA, AND NEBRASKA.

BY

CYRUS THOMAS, PH. D.

PHYSICAL GEOGRAPHY AND AGRICULTURAL RESOURCES OF MINNESOTA, DAKOTA, AND NEBRASKA.

WASHINGTON, D. C., *March* 1, 1873.

DEAR SIR: Herewith I present a partial report of the results of my explorations of the year 1872 in Minnesota, Dakota, and Nebraska.

The time employed in preparing another report (which has already been submitted) and a temporary separation from the survey have prevented me from preparing and submitting at this time a full and complete report in regard to the agricultural resources of the very interesting region visited by me. I have, therefore, thought it best that I should prepare at present but a preliminary report, elaborating one or two points only which bear upon the agricultural resources of this section, and which I might make somewhat complete in time for publication the present season. Another important reason for this course, aside from the want of time, was that, having entered upon the discussion of the climatology of this region, as exhibited by the meteorological records, it became evident that important and valuable results might be obtained by a more full and complete discussion of all the records of that portion of the West situated between the Mississippi River and the Sierra Nevada Mountains. But to do this required more time than remained previous to the publication of your annual report for the year 1872. It also required the preparation and printing of certain charts, which could not be properly done in time. Therefore, with your consent, I determined to devote a portion of the present season to the preparation of a special report on the climatology of the West. For this reason much of the material I had already prepared does not appear in this report.

These explanations will suffice to account for the meagerness of the report herewith submitted, although the material obtained was equal in amount and importance to that of any former year of my connection with the survey.

In my introductory remarks I give an outline of what the full report may be expected to contain. At present I have confined myself chiefly to a discussion of the physical geography and topography of that portion of the Northwest visited during the summer of 1872.

As in our former visits to the West, I have met with the kindest treatment at every point and on the part of all with whom my duties brought me in contact. The railroad and stage companies in Minnesota, Nebraska, Dakota, and Kansas have, in every instance where I stated my business and my connection with your survey, granted me passes over their lines, thereby greatly lessening my expenses, and enabling me with the means at my command to extend my examinations over a much larger area than I could otherwise have done.

It is, perhaps, proper that I should mention by name those companies from which I have received these favors. The railway companies were: Northern Pacific, Saint Paul and Pacific, Saint Paul and Sioux City, Illinois Central, Union Pacific, Burlington and Missouri River, and Kansas Pacific. I also received a pass from Mr. Blakesly over all the stage-lines he represented in Minnesota, and from Messrs. Haskell & Cheney over their line from Sioux City to Yankton. I am especially indebted to Governor Burbank, General McCook, General Beadle, and others, of Southern Dakota; Colonel Stutsman, of Pembina; General H. Thomas, Colonel J. C. Bates, Dr. Dubose, Mr. Skinner, and others, for their assistance and for information furnished by them.

As a summary of results, I may state that, although in some respects the portion of our country visited did not meet entirely my expectations, founded on the exaggerated and glowing descriptions of speculators and others interested, yet it presents a bread-producing area equaled by but few and surpassed by none on the continent. Its capacity as a wheat-growing section is immense; so great, in fact, that the figures stagger our belief when first presented. As a beef-producing section its resources are great, the grazing excellent throughout the entire area.

The fact of its great capacity in reference to these two articles renders its development of great national importance.

Trusting that my action may meet with your approval and that this report may be satisfactory, I remain, yours, very respectfully,

CYRUS THOMAS.

Professor F. V. HAYDEN.

INTRODUCTORY REMARKS.

The chief object of my explorations during the past season was to examine into and report upon the agricultural resources of Dakota Territory; yet it was expected that I would at the same time extend my observations to the immediately surrounding portions of the Northwest similar in character and which might have any bearing upon the development of the resources of Dakota.

A slight examination of this section, added to the previous knowledge I had obtained in regard to it, sufficed to convince me that, to thoroughly understand its agricultural resources, it was important to investigate the climatology and physical geography of the great prairie-belt lying along the eastern margin of the great trans-Mississippi plains.

Here, running north and south, is found the dividing line between two regions and climates as different from each other as that of Europe from that of Asia; here, in fact, in an agricultural, climatological, and physical point of view, is the real dividing line between the eastern and western portions of the continent. We have long looked upon the great Rocky Mountain Range as the dividing line of the continent, and, so far as the flow of water is concerned, this is so; but the more this region is examined the more apparent does it become that in other respects this is far from being the rule. The chief dividing line between the two great continental climatic areas stretches north and south along the broad undulating plains of Kansas, Nebraska, Dakota, &c., and corresponds very nearly with the one hundredth meridian. Here, too, is the dividing line between great agricultural, faunal, and floral areas.

In regard to climatology several important questions arise, two of which deserve special attention, and which, if possible, should receive at least approximately correct answers. The first relates to the isothermal lines through Wisconsin, Minnesota, and Dakota, especially the lines of mean summer temperature. This is the more necessary from the fact that Mr. Blodgett, in his work on meteorology, has assumed that the mean lines of summer temperature make a rapid bend northward after passing west of Lake Michigan; and this statement has been used largely in the efforts to induce emigration to that portion of the Northwest. If it is true that this remarkable flexure does occur here, it must, as a matter of course, have an important bearing upon our estimate of the agricultural resources of this extensive region. I have, therefore, made it a special object to test the correctness of this assumption by all available data, which have been considerably increased since the date to which Mr. Blodgett's calculations extend. Without intending to forestall my investigations on this point, I may state that, while it is true a very remarkable flexure in the isothermal lines does occur here, yet the investigations I have made indicate that it is much less than Mr. Blodgett represents it to be.

The second climatological question relates to the rain-fall. It is well known that on the east side of the plains, as in Minnesota, Iowa, Missouri, and Arkansas, the average annual rain-fall is sufficient to supply the moisture necessary for the production of the cereals and other agricultural products. On the other hand, it is almost as well known that irrigation is necessary at all points on the plains lying along the east base of the Rocky Mountains. Therefore, it is evident that the boundary between these two regions—that of sufficient and that of insufficient rain—must be found somewhere between the east base of the Rocky Mountains and the west line of the States last named. It becomes, therefore, very important to determine where this line is. It is true that the transition may be gradual and render it difficult to fix it with any great degree of exactitude, yet it must be possible to determine it approximately. The importance of this will scarcely be appreciated by those who have not come practically in contact with the question; but the individual who has gone beyond this line and opened a farm upon the broad prairie, depending upon the rain-fall alone to supply his crops, has learned by sad experience that knowledge which ought to be supplied to the public. But land-speculators and others, who are interested in settling up this portion of the West, are often too sanguine in their belief in regard to favorable climatic changes, or are regardless of the sufferings and hardships they cause by a too favorable representation of the climate of this uncertain section. I dislike to make such statements, but I deem it a duty to speak plainly on this point. There is no necessity for any misrepresentations in regard to this part of the West; the facts are sufficiently favorable; and if these, and these only, are presented, in the end the result will be better for the country and even for the particular section. I have, therefore, made this matter the subject of special investigation, but in this report will only give a short summary of the facts, as I expect hereafter to present the whole subject of the climate of the West in a special report.

Although the topography of the country presents great uniformity in character, the general level being interrupted by no elevated peaks or extensive mountain-ranges, yet the physical geography is not devoid of interesting and important features, as within the bounds of the region under consideration are the initial points of three of the most important water-basins on the east side of the continent.

As the surface-soil also presents great uniformity in character, another important item to be examined was the nature of the subsoil; but as this has been penetrated at comparatively few points in the newly-settled or unsettled portions, the data obtained was necessarily meager; yet sufficient has been ascertained to show that it varies much more in the different sections than the surface-soil. I do not allude so much to its chemical ingredients as to its productive qualities.

Although a knowledge of the present condition of climate, soil, and topography is sufficient to determine the agricultural value, yet there are some questions relating to the physical conditions which are so intimately connected with these practical points that a full and exhaustive report should embrace them. I allude particularly to the last geological changes which have resulted in the present condition of the surface and climate. I include "climate" because I am thoroughly convinced, after studying this subject for several years, that, so far as the amount of moisture is concerned, the present condition has resulted, in part at least, from the effect of the last geological change that took place in the surface. But, unfortunately, my knowledge of geology is not sufficient to discuss this question properly, even if I had all the data necessary to do so, and the geological surveys which have been made of this section have not been directed particularly to the surface-features. It is true that Professor Hayden, in his very interesting *résumé* (Chapter XII) of his report of 1870, touches upon this subject, alluding to its importance and expressing the desire to return to its investigation at some future time. It is to be hoped that he may be permitted to carry out this desire at an early day, as there is no one who more highly appreciates the value of the surface-geology of this section, in which he spent so many of the early days of his explorations, than he does. Professor Winchell, in his first annual report of the Geological and Natural History Survey of Minnesota, has devoted a short chapter to this subject so far as it relates to that State. Owen, in his Report on the Geology of Wisconsin, Minnesota, and Iowa, mentions numerous important facts bearing upon this subject, but does not discuss it specially. But no one, so far as I am aware, has as yet discussed the relation of the last geological change in this section to its present climatic condition. This, therefore, still remains an open field for inquiry and investigation.

The valleys of the rivers, the weathering of the bluffs and terraces, the dry *coulées*, as well as the vast amount of local drift near the base of the Rocky Mountains, show beyond a doubt that, at some very recent period in a geological sense, the amount of water which fell was much greater than at present. I allude not to the remote period, when it was submerged, but to a period since the waters receded, for it requires no geological eye to detect these evidences and to determine that they relate to a time long subsequent to the last emergence, hence attributable to rain and snow.

It is therefore evident that between that time and the present a great change has taken place in the climate in regard to humidity; that it is much less now in the western portions of Dakota, Nebraska, and Kansas than it was in the past. This question then arises: Has the change in this direction ceased? If not, then we are forced to the conclusion that this section is still growing drier. If it is true—and I think it will scarcely be denied by any who have directed their attention to the subject—that such has been the direction of the climatic changes in the past, one of two conclusions is inevitable, viz, that there are no grounds for expecting a more favorable climate (in regard to humidity) in the future, or that the change in the direction indicated has ceased, and consequently a reaction must take place. On this important point I have collected some data which I expect to present in my meteorological report.

As the immense belt under consideration is one almost continuous prairie, devoid of forests, which must be devoted almost wholly to farming and pastoral pursuits, it is apparent that its future development depends to a great degree upon the means of transporting its products to market and of reaching the forests of the States lying east of it. It is therefore very desirable, in this connection, to obtain some idea of the extent and character of the forests and the extent and direction of the constructed and contemplated railroad-lines.

Although I have not made the former a special object of inquiry and investigation, yet sufficient information in regard thereto has been obtained upon which to found a conclusion in regard to the adequacy of the supply of lumber for the next generation. To examine the immense forests of Minnesota and Wisconsin in person, with sufficient thoroughness to determine their character, would require several years; but, fortunately, these States have for several years been gathering statistics concerning them, which are accessible, and of which I shall avail myself in this or a future report so far as I deem it necessary to do so.

Any report relating to the present extent of the railroads would be of but temporary value, as the various lines are being so rapidly extended, and new ones being formed in such rapid succession, that what is true to-day will fall far short of being true a few years hence.

A very important question, and one of national interest, arises in connection with this subject. What is, or is likely to be, the effect upon the industries and development of this portion of the country of land-grants to railroads by Congress? This has assumed such vast proportions that it behooves the statesmen of our nation to examine the subject with great care, and not be led away by the simple and conceded fact that these grants hasten the settlement of the section of country in which they are made.

This is a matter which already agitates the public mind; and in no part of the country have we a better opportunity of studying its effects than in the Northwest, where the grants have been most numerous and extensive.

When the public mind becomes aroused in relation to a given subject, and a tendency to reaction becomes manifest, politicians are apt to seize upon the opportunity of riding into position upon the current of opinion, and, instead of striving to lead it to a correct conclusion, strive to carry it to the other extreme, and often thereby cripple national industries instead of correcting abuses. It is proper, therefore, that the facts in respect to such subjects should be spread before the public at as early a day as possible. As I cannot enter upon an examination of this important question, I desire to call attention to it.

PHYSICAL GEOGRAPHY.

As the surface features and configuration of any section have an important bearing upon its climatology and agricultural resources, I will present first a sketch of the physical geography of that portion of the Northwest at present under consideration. Although I shall, when I discuss the climatology, embrace a larger area, I will at present confine my remarks chiefly to Minnesota, Dakota, Iowa, and Nebraska.

Foster, in his excellent work on the physical geography of the Mississippi Valley, has presented in a very attractive form a description of the leading characteristics of the West; therefore it will be unnecessary for me, in describing the features of a limited section, to repeat what has been so well set forth. I will, for this reason, confine myself to the more minute details, and especially to the hypsometrical data.

Notwithstanding this region, which has been not inaptly termed the "New Northwest," presents no elevated mountain-ranges or lofty peaks, to break the somewhat monotonous contour and form sharp dividing-lines between the water-systems, yet its geographical features are not devoid of interest in a scientific point of view, nor without important influences on the climate. Who can predict with certainty what would be the climatic effect of a rugged forest-clad mountain-range running east and west from the base of the Rocky Mountains to the Mississippi River? Who can tell what would be the result of such a barrier to the winds which now sweep across these vast plains? Who can foresee with certainty the effect even of a continued forest over this immense area?

This country may be described in general terms as one immense comparatively level area, consisting of slightly rolling and marshy, timbered sections in the northeast and broad, open, undulating prairies in the west and southwest.

The eastern portion, from Lake Superior to the Mississippi, is covered chiefly with pine and tamarack forests, and to a large extent more or less marshy, especially in the eastern and northeastern part of Minnesota, but fading out and changing somewhat in character as we move southward, the marshes entirely disappearing in this direction. A lengthy but narrow forest-strip runs north and south along the west side of the

Mississippi River, consisting almost entirely of deciduous trees, such as oak, elm, ash, &c. But this strip, as it approaches Iowa in its southern extremity, is more or less broken up by prairie-belts, and there confined chiefly to the river valleys.

The remaining portion of the entire area lying west of this timber-line, and extending to the base of the Rocky Mountains, consists of broad, undulating, treeless plains, channeled by numerous streams, and dotted in its eastern portion with numerous small lakes, which decrease in numbers and acquire a saline character as we move westward. This part is, in fact, one section of the great plains of the interior, which stretch northward from Mexico to Arctic America.

The great uniformity in appearance and sameness of character of this part of the country would apparently forbid any lengthened description of its geographical features—and to a great extent this is true—yet there are some facts and peculiarities worthy of our attention and study, especially as there are some problems connected with these broad, open areas which have not as yet been satisfactorily solved. Why are they devoid of forests? is a query often propounded, and, although approaching solution, has not been answered to the entire satisfaction of our leading physicists. If we reject the view of Lesquereux, that the "prairies are due to peat-growth," and the view of other physicists, that they are due "to the texture of the soil," and also exclude as unworthy of consideration the very general opinion that they have been produced by the annual burnings—for this applies only to their perpetuation and not to their production—and accept the very plausable theory of Newberry, Foster, Hayden, and others, that this condition arose from a want of sufficient moisture, we have advanced but one step in the process of solution, and find ourselves confronted by another question equally difficult to answer: What caused this lack of moisture on the plains? And why are the prairies of Nebraska, Kansas, and Dakota drier than those of Iowa and Illinois? Doubtless the presence of the large body of water in the lakes of the north—Superior and Michigan—over which currents of air already charged with moisture sweep down from the northeast, the approximation of the Gulf of Mexico, and the Mississippi running north and south along the border of the entire area, will go far toward furnishing an answer to the latter inquiry. But it is not my intention to pursue this investigation at this time; when I enter upon a discussion of the climatology I may present some facts which I think bear upon the subject.

The water-drainage of Minnesota and Dakota forms one of the most interesting and important features in the physical geography of this section of the West. Although there are no marked or prominent water-sheds here, yet the streams which originate in this limited area belong to three different water systems or basins: that of Hudson Bay, the lake or Saint Lawrence Basin, and the Mississippi or Gulf Basin—one draining north, one east, and the other south, showing a higher general elevation of the surface here than in either of these directions; that is to say, if we move north, east, or south from this area, we descend. Professor Wenchell makes the following statement in regard to the topography of Minnesota:*

The intimate relation subsisting between the geology and topography of the State is more evident than in some of the other States in the Union. The causes which determine the location of the great continental water-shed are those which determined the existence of the Laurentian and Lake Superior ranges of igneous and metamorphic rocks. The area of these rocks in Minnesota, as well as in Wisconsin and Michigan,

* Geological and Natural History Survey, Minnesota, (1873,) page 45.

includes some of the sources of the great river-systems of the Northwest and of the continent. From this area, since pre-Silurian times, streams have run in all directions toward the ocean. Within this area, in the State of Minnesota, are the headwaters of the Saint Lawrence system of drainage, which enters the Atlantic Ocean toward the east; those of the Mississippi, which enter the Gulf of Mexico toward the south, and those of the Red River of the North, which, taking an opposite course, find the ocean-level toward the north through Hudson's Bay, in British America. This water-shed consists not in the form of a definite and abrupt ridge.

This fact, which does not find an exact parallel at any other point in the comparatively level portion of the interior of the continent, marks this area as one of peculiar interest in the study of the physical geography of the Mississippi Valley.

The Mississippi and Red Rivers form the chief lines of drainage, and it is worthy of notice that these run in exactly opposite directions. The Missouri River, from its great bend in the northwest corner of Dakota, runs a little east of south, the Mississippi almost directly south, while the intermediate waters find their way directly north through Red River to Lake Winnepeg.

It has been remarked by some writer that geologists and geographers often fail to appreciate the value of the facts they obtain in regard to the direction of the leading streams and elevated ranges of the countries they explore. Although I do not claim to be a geologist, yet I am strongly inclined to believe that the fixing of the channels of these streams belongs to the closing scene of the Drift period. And this opinion corresponds with the idea already expressed by Professor Hayden: *

At a modern period it is probable that the waters of the ocean swept high upland, reaching nearly to the foot of the mountains. The great water-courses *had already been marked out;* consequently we find the yellow-marl or loess 50 to 150 feet thick in the immediate valley of the Missouri, but thinning out as we recede from it or the valleys of any of its branches.

The cuts given in Professor Winchell's report on the survey of Belle Plaine, Minnesota, indicate that he holds substantially the same opinion. But in his geological report, before referred to, and which was received after this report was draughted, he expresses his opinion on this point as follows: †

The course of the surface drainage is, in this case, (where the drift is very thick,) dependent very little on the character of the underlying rock. But where the drift is lighter, the direction of the subordinate streams is often determined by the bearing of the sedimentary rocks. A stream is most likely to be located in the depression caused by the erosion or other destruction of the outcropping edge of a soft or friable rock, the more persistent formation adjoining it, above and below, forming the divides between it and other streams. Other causes, however, principally those superinduced by undulations in the strata over long distances, so as to cause them to leave the direction of the principal or tributary valleys, and the variations of level brought about by the unequal deposition of the drift during the prevalance of the ice of the glacial epoch, have very generally marked the effect of unequal erosion of the strata on the direction of surface-drainage.

The direction of the streams of Dakota and Northern Nebraska undoubtedly falls within the last category, as their channels seldom reach the bottom of the drift. We may, therefore, safely assume that the direction and lines of water-drainage were already marked out at the close of the Quarternary period, and doubtless previous to the last submergence of this portion of the Northwest.

An examination of the direction of the tributaries of the leading

* Report 1870, page 175.
† Geological and Natural History Survey of Minnesota, page 46.

streams mentioned will serve to indicate the direction of the descent of the different parts of their basins. Thus, the tributaries of the Missouri which flow into it below the bend present a very marked contrast in direction; those on the west side, as Heart, Ree, Big Cheyenne, White, and Niobrara Rivers, flow almost directly east; while those on the east side, as James, Vermillion, and Big Sioux, flow almost directly south; showing clearly that the channel of the Missouri marks the termination of the effect of the descent from the mountains, and that east of it the descent is from the north. But it must not be inferred from this that the descent toward the east absolutely ceases at the Missouri, for this is not correct, as (in Dakota) it continues—as will be seen by the tables of altitudes—as far east as the valley of Red River; but the channel of the Missouri is the boundary of the eastward flow. After giving the tables of altitudes I will again allude to this subject, and mention some other causes for this change of direction.

A somewhat singular feature is presented by the tributaries of Red River; as a general rule, those on the west side flow southeast and those on the east side southwest until they strike the immediate valley of the river, where they bend abruptly northward. This would indicate a southern descent for the bordering plains, while it is evident the broad, level valley of the river has a slight northern descent.

Although, as will hereafter be shown by the tables of elevations, the plain from which the waters of the Upper Mississippi are gathered is, in a manner, segregated from the broad western slope, yet the same direction of drainage is preserved, the western tributaries flowing southeast, while the few eastern ones within Minnesota flow southward. This direction is preserved, notwithstanding, as in Southern Minnesota the descent of the bordering surface of the country is directly opposite to the course of the streams.

If we move southward to the latitude of Iowa and Nebraska, we shall find the drainage almost wholly eastward or southeast, that toward the south being less marked than in the northern section. In Nebraska it may be said to be entirely eastward, some of the northern tributaries of the Platte only bearing a little southeast. The drainage of Iowa is in great part to the southeast, a few minor streams running southwest into the Missouri River, indicating a narrow western slope along its western boundary.

It is evident that the vertical topography is of the utmost importance in studying the physical geography of any section, and more especially is this the case where the outlines are not rugged, but where the long rounded swells and apparently level plateaus are calculated to deceive the eye. I have, therefore, collected all the data to be obtained on this point, particularly what refers to the surface of Minnesota and Dakota; and fortunately the recent surveys of lines through this section of the Northwest for the purpose of locating railroads have furnished us with sufficient material to enable us to form a tolerable correct idea of its topography. Therefore, before proceeding further, I insert the following lists of elevations and distances, which have been furnished in most cases from the officers of the roads mentioned. One or two have been copied from the report of Professor Winchell, heretofore referred to, and some of the tables furnished me have been corrected by this report.

TABLE I.—*A list of elevations and distances along the line of the Lake Superior and Mississippi Railroad, running from Duluth on Lake Superior to Saint Paul, Minnesota.*

	Distance from Duluth.	Height above the sea.
	Miles.	*Feet.*
Surface of Lake Superior		600
Duluth		605
Thomson	22	1,027
Highest point on the road	33	1,166
Moose Lake depot	45	1,052
Kettle River depot	60	1,112
Hinckley, at Grindstone River	78	1,023
Lowest between Hinckley and the next summit		1,005
Summit	80	1,023
Summit	86	985
Pine City, at Snake River	90	944
Point two and one-half miles south of Snake River		978
Rush City, at the creek	101	908
Goose Lake		886
Next highest point		915
North Branch, at the creek	113	883
Between North Branch and Wyoming		906
Wyoming, at the river	125	887
Wyoming, at the depot		897
Forest Lake depot	129	904
Summit between Forest Lake and Rice Creek	132	953
Rice Creek	133½	916
Centreville depot	138	927
Junction at White Bear Lake	143	920
Summit between White Bear Lake and Saint Paul	145	959
Between Phalen's Lake and Saint Paul	151	870
Lowest water in Mississippi, at Saint Paul	155	676
Highest water in Mississippi, at Saint Paul		697
Standard generally used for Mississippi, at Saint Paul		680

TABLE II.—*A list of elevations and distances from the western extremity of Lake Superior, at Duluth, to the Missouri River at the mouth of Heart River, along the line of the Northern Pacific Railroad.*

	Distance from Duluth.	Height above the sea.
	Miles.	*Feet.*
Lake Superior, at Duluth		600
Fond du Lac	6	606
Thomson, (Dalles of Saint Louis River)	22	1,036
Junction	24	1,080
Otter Creek, (bed of the creek)	27	1,126
Norman, (natural ground)	34	1,333
Kettle River, (bed of the river)	42	1,285
Kettle River, (natural ground)	45	1,359
Island Lake, (grade)	46	1,302
Tamarack River, (natural ground)	52	1,309
Sicottes, (grade)	58	1,265
Sandy River	65	1,222
Kimberly	76	1,231
Rice River	81	1,248
Aiken	88	1,203
Cedar River, (bed of the river)	92	1,193
Cedar River, (natural surface)	97	1,299
Withington	98	1,270
Brainard, (at Mississippi River, grade)	115	1,205
Brainard, (river bed)		1,138
Frenchman's	121	1,206
Pillager	127	1,195

TABLE II.—*A list of elevations and distances, &c.*—Continued.

	Distance from Duluth.	Height above the sea.
	Miles.	*Feet.*
Crow Wing River, (bed of the river)	136	1,197
Motley	137	1,220
Hayden's Branch, (creek bed)	143	1,224
Aldrich	151	1,330
Wadena	161	1,349
Leaf River	166	1,310
Frazee	175	1,409
Otter-Tail River, (bed of the river)	183	1,318
Perham	185	1,360
Hobart	196	1,387
Otter-Tail River, (natural ground)	201	1,420
Pelican River, (bed of the river)	206	1,337
Detroit	207	1,362
Oak Lake	211	1,367
Audubon	214	1,308
Lakeside	219	1,325
Hay Creek, (bed)	224.2	1,200
Hay Creek, (bed)	226.6	1,167
Buffalo River, (bed)	227.4	1,150
Buffalo River, (bed)	230.1	1,132
Hawley	230.4	1,145
Muskoda	235	1,083
Red River Flats	242	978
Glyndon	243	927
Moorhead, (on Red River)	252	903
Red River, (top of bank)	....	902
Red River, (bed of river)	....	857
First Cheyenne crossing	258	900
Summit between the two crossings	306	1,445
Second Cheyenne crossing	311	1,230
Lake Eckelson	329	1,418
Summit between Cheyenne and James Rivers	342	1,495
James River	346	1,393
On Coteau of the Missouri	366	1,861
Divide, Coteau of the Missouri	387	1,795
On Coteau of the Missouri	425	1,873
Missouri River, (at mouth of Heart River)	440.5	1,700

TABLE III.—*A list of elevations and distances along the Saint Paul and Pacific Railroad, from Saint Paul to Breckenridge, on Red River, assuming low water in the Mississippi River at Saint Paul to be* 680 *feet above the sea.*

	Distance from Saint Paul.	Height above the sea.
	Miles.	*Feet.*
Mississippi River, at Saint Paul	0	680
River at Saint Anthony	9.5	795
Minneapolis Station	10.5	825
Wayzata	24	926
Delano	40	918
Howard Lake	54	1,044
Darwin	62	1,122
Willmar	105	1,119
Benson	134	1,037
Summit	151.5	1,162
Morris	159	1,117
Summit	161	1,146
Herman Station	178	1,058
Gorton	185.5	1,012
Rabbit Run	201	972
Breckenridge	217	953

TABLE IV.—*A list of elevations and distances along the Saint Paul and Sioux City Railroad from Saint Paul to Le Mars, assuming low water at Saint Paul to be* 680 *feet above the sea-level.*

	Distance from Saint Paul.	Height above the sea.
	Miles.	*Feet.*
Belle Plaine	47	785
Blakeley	52	789
East Henderson	58	795
Le Sueur	63	815
Ottawa	69	851
Kosata	77	857
Mankato	86	853
South Bend	90	870
Crystal Lake	100	1,057
Madelia	110	1,002
Saint James	121	1,061
Butterfield	130	1,167
Mountain Lake	137	1,281
Bingham Lake	143	1,401
Windom	148	1,330
Wilder	154	1,427
Heron Lake	160	1,398
Hersey	170	1,469
Worthington	178	1,568
Bigelow	188	1,607
Sibley	196	1,489
Le Mars	245	1,200

TABLE V.—*A list of elevations along a line running from Morris, on the Saint Paul and Pacific Railroad, southwest across the Coteau of the Prairies and the Coteau of the Missouri to Fort Sully, on the Missouri River. Measured by Mr. J. D. Skinner, engineer. Estimated from low water at Saint Paul.*

	Height above the sea.
	Feet.
Low water at Saint Paul	680
Morris Station	1,120
Lake Traverse, (top of the bluff)	1,080
Lake Traverse, (bottom of the bluff)	960
Summit between Morris and Lake Traverse	1,168
Summit of the Coteau des Prairies, (on the line)	1,968
Western foot of the coteau	1,498
Bank of James River	1,288
Water-level of James River	1,260
Summit of the coteau between James River and Fort Sully	1,942
Average of the Missouri bottom at Fort Sully	1,420
Water-level of the Missouri River at Fort Sully	1,398
Water-level of the Missouri River at Cheyenne Agency	1,415

TABLE VI.—*A miscellaneous list of elevations in various parts of Minnesota and Dakota, mostly barometrical.*

	Height above the sea.
LOCALITIES IN MINNESOTA.	*Feet.*
Leech Lake	1,330
Around Lake Itaska	1,680
Lake Pemidji	1,456
Lac qui Parle	946
Plain near New Ulm	1,064
Plain, latitude, 44° 15′; longitude, 95°	1,160
Near Lake Shotek, latitude, 44° 10′; longitude, 95° 42′	1,578
Bluffs east of Big Stone Lake	1,070
Bottom-land around Big Stone Lake	966
LOCALITIES IN DAKOTA.	
Latitude, 47° 10′; longitude, 97° 30′	1,102
Latitude, 47° 42′; longitude, 97° 30′	1,168
Latitude, 44° 10′; longitude, 99° 40′, (bend of the Missouri)	1,463
Latitude, 46° 30′; longitude, 97° 30′, (Cheyenne River)	1,228
Devil's Lake	1,467
Mouth of Little Missouri	1,830
Burnt Island, near the mouth of Heart River	1,690
Fort Union, (two estimates)	{ 1,970 { 2,017
Upper plains, near the mouth of the Yellowstone	2,200
Fort Wadsworth	1,896
Surface of the Coteau des Prairies	1,860–2,046

TABLE VII.—*A list of elevations and distances along two lines running northward; one up the Mississippi, from Saint Paul to Brainard, the other along the Red River Valley, from Glyndon, on the Northern Pacific Railroad, to Pembina.**

	Distance from Saint Paul.	Height above the sea.
UP THE MISSISSIPPI.	*Miles.*	*Feet.*
Saint Anthony, (water-level)	9.5	791
Rice Creek, (water-level)	17	807
Rum River, (water-level)	27.5	831
Elk River, (water-level)	43	881
Saint Cloud, (water-level)	75	953
Sauk Rapids, (water-level)	....	982
Platte River, (water-level)	95	1,054
Nokay River, (water-level)	120	1,134
Buffalo Creek, (water-level)	134	1,167
Brainard, (water-level)	137	1,184

* In this table low water at Saint Paul is estimated at 676 feet above the sea-level.

TABLE VII.—*A list of elevations and distances, &c.*—Continued.

FROM GLYNDON TO SAINT VINCENT OR PEMBINA.	Distance from Glyndon.	Height above the sea.
	Miles.	*Feet.*
Glyndon	....	923
Buffalo River, (grade)	3	919
Wild Rice River, (grade)	28	910
Rolette Station	42	894
Kittson Station	58	886
Red Lake River, (grade)	64	862
Three hundred and forty mile-post	102	851
Tamarack River, (grade)	113	830
South Branch, Two Rivers, (grade)	137	815
Red River bank at Saint Vincent, (opposite Pembina)	156	792

Four of these tables (II, III, IV, V,) give us the elevations of transverse sections almost and in some cases directly along east and west lines, crossing the direction of the leading streams at right angles, enabling us to judge quite correctly in regard to the topography so far as it relates to this direction. From Table VII we learn the descent of the Mississippi River from the crossing of the Northern Pacific Railroad to Saint Paul, and the descent of Red River from the same line northward to the British line; and by bringing together the elevations on the same meridian from the different lines mentioned in these tables and from the Union Pacific and Kansas Pacific lines, we can obtain at least an approximately correct idea of the topography along north and south lines.

Beginning with the north line along the Northern Pacific road and tracing it westward, we find a somewhat unexpected uniformity of elevation in the timbered district which extends from Lake Superior westward some fifty or sixty miles beyond (west of) the Mississippi River, and as we move farther westward, although, with one material exception, we find the variation to be gradual and generally ascending, yet we shall notice very marked and striking changes in the character of the country traversed.

Starting from the surface of Lake Superior at Duluth with an altitude of 600 feet above the sea-level, we rapidly ascend the rugged encircling bluffs, and in a few miles reach a height of 1,280 feet. This we find, by examining Table II, is about the average level of a line across the State of Minnesota at this latitude, until we reach the valley of Red River, when we again descend some 300 feet. From this average the extremes along the railroad-line seldom, if ever, vary more than 100 feet. There is a slight depression in the immediate valley of the Mississippi, as at Brainard and Pillager, but it is certainly much less than we would be led to infer from a comparison of the higher margins of this plain or plateau with the much lower level of Lake Superior on one side and that of Red River Valley on the other. Even this central depression will, in a great measure, disappear if we follow a direct line from Duluth to Moorhead, instead of following the southward curve of the road as it approaches the river, for in moving south it descends proportionally. As we approach the divide between the waters of the Mississippi and Red Rivers, there is an ascent of about 100 feet above the average, and nearly 200 feet above the former river. As a matter of course, the road is constructed along the lowest levels; therefore our figures in the tables, as a rule, represent the lowest points of the surface, and give us but little idea of the local and isolated irregularities in the contour; and especially is this the case where the line crosses a divide between different water-basins. In this case we should probably add 150 or 200 to the figures given in the table to get a true average of the elevation of this divide, which is here called Leaf River Hills, and which extends some distance north and south.

If we move north from the point where we cross the Mississippi, following up its valley, we observe that the ascent is rather more rapid than toward the west, as will be seen by the following list of elevations taken from General Humphreys' report on the Mississippi River:

	Above the sea-level.
	Feet.
Mouth of Sandy Lake River	1,253
Mouth of Swan River	1,290
Head Falls of Peckagama	1,340
Mouth of Leech Lake River	1,356
Entrance to Lake Cass	1,402
Entrance to Lake Traverse	1,456
Itasca Lake	1,575
Utmost sources of the Mississippi	1,680

As a matter of course, before we pass the divide in this direction a still higher point will be reached, although there is no marked ridge separating this basin from that north of it.

If we pass westward to Red River we find the elevation, where the road crosses it, but 900 feet above the level of the sea; and as we move northward along its course it gradually descends, until, at Pembina, the altitude, according to the railroad-surveys, is but 792 feet above the sea. It is therefore evident that in passing from the basin of the Upper Mississippi into Red River Valley we have descended to a general level about 400 feet lower, and in doing this have passed over a broad rim from 100 to 300 feet higher than the upper plateau.

What the vertical topography is northeast from the sources of the Mississippi, I am unable to say; but, as the waters of that section flow northward and eastward into another basin, it is evident the descent is in that direction, and the list of heights along Namenkan and Rainy Lake Rivers, from Lake Superior to the Lake of the Woods, as given in part below from the geological report of Mr. Hind, will show at least the amount of this descent to that line or water-level. As a matter of course, there is some kind of a divide between these two basins, but those who have passed over it at different points say that as a general thing it is an imperceptible swell; in some places it is marked by low ridges, which separate the numerous marshes of this portion of Minnesota. The prominent ridge marked in some maps as running eastward from the southern margin of Red Lake is wholly imaginary.

The following list of elevations along the Nameukan and Rainy Lake Rivers, taken from the geological report of Mr. Hind, gives us the slope of the main channel of this northern international basin, and is very important in this connection, although part of the link between it and the Mississippi Basin is wanting:

Stations.	Distance from Lake Superior.	Height above the sea.
	Miles.	*Feet.*
Mouth of Nameukan River	233	1,117
Grand Falls Portage	245	1,082
Lake Nameukan	257	1,044
Rainy Lake	301	1,035
Manitou Rapids	336	996
Lake of the Woods	453	977
ALONG WINNIPEG RIVER TO LAKE WINNIPEG.		
Grande Décharge	487	950
De l'Île Portage	510	901
Roche Brûlée Portage	544	843
Otter Falls	560	810
Bonnet Lake	585	744
Big Bonnet Portage	590	689
Fort Alexander	614	628
Lake Winnipeg	657	628

I regret that this line cannot be extended eastward direct from Rainy Lake to Lake Superior; but I have been unable to find any record, if one was ever made. Yet from this list, imperfect as it is, we learn some important facts, among which the following may be mentioned as of special interest in the present examination: That the divide between Lake Superior and Rainy Lake, which here is directed northeast, maintains an elevation equal to that immediately west of Duluth. It is true that, at the point where Mr. Hind struck the channel, the elevation was a little less than that immediately back of Duluth, but the rest of the table as given in his work, but not quoted here, shows that at a short distance northeast of that point the altitude is 1,300 to 1,400 feet above the sea. And, as Owen asserts in his Geological Survey of Wisconsin, Iowa, and Minnesota, the bordering rim of the immediate Lake Superior Basin increases in height toward the northeast.

A second fact we learn from this list is that the slope of the Winnipeg Basin along this line is tolerably rapid toward the northwest, reaching at Lake Winnipeg a level only 28 feet above that of Lake Superior. It shows also that Rainy Lake is fully 600 feet lower than the extreme source of the Mississippi and the Lake of the Woods 700 feet lower.

The elevation of Red Lake may have been ascertained, but if it has I have been unable to find the record; yet I think we have good reason to infer that it is less than that given for the source of the Mississippi. It is drained into Red River at a point where the elevation is only about 850 feet above the sea; the length of Red Lake River, by which its waters are carried off, is probably not more than one hundred miles, twenty-five or thirty of which are through the remarkably flat valley of Red River, and, so far as I can learn, the rest is without any considerable falls. I allude thus particularly to the elevation of this lake as it will assist us in determining the height of the rim of the Mississippi Basin on the northwest, and the character of the descent to the Red River Basin in that direction. By bringing together these facts we are enabled to form a tolerably correct idea of the configuration and elevation of the northern, northeastern, and northwestern boundary of the plateau of the Upper Mississippi Basin.

The line of the Saint Paul and Pacific Railroad to Breckenridge, although presenting a less rapid ascent while passing through the timber-strip—some fifty miles in width—reaches an average of 1,100 feet above the sea when we arrive at the prairie-belt which forms the divide; but when we arrive at Breckenridge, near the head of Red River, we have again descended to 953 feet above the sea and are only 50 feet higher than at Moorehead. If, instead of following the railroad-line, we move up the valley of the Minnesota River to its source in Big Stone Lake, cross over to Lake Traverse, and pass northward down Red River, we find a very remarkable channel, which reaches at no point an elevation of more than 960 or 970 feet above the sea-level, or about 280 or 290 above the Mississippi at Saint Paul. This immense furrow, connecting the drainage of Hudson Bay with that of the Gulf of Mexico, reaching at no point an elevation of 1,000 feet above the sea, possesses great interest in the study of the physical geography and surface-geology of the Northwest. Here, in all probability, will be found the key to the last act in the great geological drama of this section, and here undoubtedly will be found the last traces of the union of the arctic and tropic oceans across the bosom of the continent. It was here the waves of these two great seas gave their parting kiss before their long separation. But it is not my intention to dwell on this interesting topic; this is the work of the geologist who delights to dwell in the fading scenes of the far distant past. My business is with the present features, and the object I have now in view is the dull and prosy one of conveying an idea of the topography of the region drained by the headwaters of the great father of waters, our own noble Mississippi.

It is evident, therefore, from what has been said and from the lists of elevations given, that these waters are gathered from a moderately elevated and segregated plateau, whose border, starting from the vicinity of Lake Superior, sweeps around northwest until it approaches the valley of Red River, attaining its maximum altitude in the direction of Red Lake; thence bending south it fades away in the rolling prairies as it approaches the channel of the Minnesota River. Rising from 300 to 1,000 feet above the surrounding regions it slopes southward and from the east and west sides, especially the latter, inwardly toward the central channel.

As before remarked, in traveling westward from Lake Superior to the Missouri River, although we may, as a general rule, find a very great uniformity in altitude, we shall, on the other hand, find very strong contrasts in regard to the character and covering of the surface, and also marked climatic differences. Leaving the last until the subject of climate is introduced, I will call attention here to the other differences which are important items in making up our estimate of the agricultural resources.

This basin, as a whole, differs very materially from the regions farther west in the fact that the larger portion is covered with forests, the western and more elevated portions alone consisting of prairies. The ninety-fifth meridian corresponds very nearly with the division between the two portions, although there are west of this line some scattering oak-groves, and immediately east of it a few isolated prairies of small extent. The entire portion of the State east and northeast of the Mississippi and for a short distance west of it, north of Saint Paul, is covered almost entirely with pine and tamarack forests. And within this pine-covered area is found another very marked distinction from the section west of Red River. And I call special attention to these differences between Minnesota and Dakota, for the reason that, when we come to examine the climate, especially the rain-fall, we shall find a difference scarcely to be expected. The northeastern part of the State may be characterized as the region of swamps and bogs. A strip of some fifteen or twenty miles in width around the western end of the lake—which is required to reach the summit of the bluff—and which is rapidly ascending and mostly rugged, as a matter of course is well drained; but as soon as we pass beyond this limit we enter upon a succes ion of bogs and swamps separated by low ridges a few feet in height, which continue until we come near to the Mississippi, and are, in fact, repeated for a short distance west of it at some points. These ridges, which appear to be composed entirely of drift-material similar in character and color to the underlying or neighboring rocks, seem to have a general north and south or northeast and southwest direction. This parallelism of even these small swells between the boggy flats is but a repetition on a small scale of a remarkable feature of this part of the Northwest to which I have already alluded in speaking of the course of the rivers. Owen calls special attention to it in his report on the geology of this region as follows, (chapter iv, p. 333:)

> As what I conceive to have been great valleys in the rocky strata of large portions of Wisconsin and Minnesota have been filled up, and the country, in a great measure, leveled by the accumulation of immense deposits of drift, it is not possible to determine, with anything like accuracy, the width of the original valleys, nor the exact lines of the anticlinal axis separating them; but the distances from one synclinal line to another may be ascertained now, with as much precision as the linear surveys of that region, together with the draughts of the principal streams in the unsurveyed portions of the Territory, by members of the geological corps, will permit. Thus, from the valley of Chippewa River, at the mouth of Manidowish to that of the Upper Saint Croix, in a direct line and at right angles to the course of the valleys, is about sixty miles; and from the valley of the Saint Croix to that in which the Mississippi flows, between the outlet of Sandy Lake and the mouth of Crow Wing River, in the same direction across the strike of the valleys, is about sixty-two miles; and from this portion of the valley of the Mississippi to the next parallel valley—in which Leech Lake is situated—is about fifty miles; and from the valley of Leech Lake to the next great parallel valley northwest of it—the one in which Red Lake lies—is about sixty-eight miles; showing a remarkable degree of uniformity in the undulations of the crust of the earth throughout a very extensive region of country. * * There are three great systems of valleys in the Northwest, besides numerous subordinate ones, the valleys of each system preserving a very uniform degree of parallelism with one another and with the smaller valleys between the anticlinal axes.

He then proceeds to enumerate the various valleys of these systems by the names of the rivers occupying them, showing this parallelism to prevail to such an extent, not only in regard to the larger valleys and streams, but even in respect to the numerous smaller water-courses and valleys, as to make it evident that it arises from some law connected with the geological forces and structure. He gives it as his opinion that the great structural features of the country are due to subterranean movements, acting at different periods on an immense extent of the crust of the earth and with great uniformity during each epoch, and not to local disturbances only or to mere alterations of the surface from glacial or diluvial action, however much these agencies may have altered the face of the country.

This may be, and doubtless is, true in regard to the direction of the larger divides and valleys, but it will scarcely apply to the small ridges which separate the bogs and swamps of Northeastern Minnesota or the smaller parallel ridges of Dakota and Nebraska. Water alone, or water and wind were certainly the forces that formed these; perhaps glacial action may have played a part in originally outlining them.

Leaving the northeastern part of the State and moving westward across the Mississippi toward the opposite boundary of the basin, we observe a very marked and important change in regard to the surface-covering. The pines with their dark-green foliage and the gloomy tamarack gradually disappear, and for some distance we pass through groves of deciduous trees, chiefly oak, with some intermixture of elm and ash. About the ninety-fifth meridian we emerge upon the open, rolling prairies; yet for some distance the rounded hillocks are often covered with open groves of oak, and the little intervening basins are occupied by clear, limpid lakes, presenting a charming landscape. Here perhaps will be found some of the most beautiful spots in the State—and by "here" I intend that strip running from Red Lake south, including Becker and Otter Tail counties and following the divide between the basins—the green, grassy sward covering the gently-rounded knolls and gradual slopes and carpeting the surface amid the open oak-groves, where the trees appear as regularly distanced as though they had been planted by the hand of man. At the foot of almost every slope is a beautiful, clear lakelet, filled with finny tribes. We could scarcely imagine a scene more charming.

It is a singular fact that the entire surface of this western prairie-divide, which separates the Upper Mississippi Basin from the valley of Red River and from the upper part of Minnesota River Valley, is dotted with innumerable lakes of small size, many of which are without any visible outlets. If we examine a good, late map of the State, made on a scale of sufficient size, we shall find an immense circlet of these lakes extending from Saint Paul northwest and then north and northeast, to the source of the Mississippi, following, as a general rule, the more elevated portions of the country and the divides between the streams; it is said that not less than ten thousand of these lakes are to be found in the State. Why are these found so generally on the divides and the higher ground? What connection is there between the two? These are interesting questions, to which I may hereafter recur either in this or a future report, for it is evident that the existence of these lakes in this position has an important bearing upon the hygrometric condition of the atmosphere and the amount of the rain-fall in this portion of the country.

Continuing our course westward along the same line upon which we originally started, we next pass down a gentle slope of some 400 feet descent into the broad valley of Red River. This valley, or rather plain, for such it really is, extends northward from Lake Traverse to Lake Winnipeg, having an average width of thirty or thirty-five miles, one uniform level scarcely interrupted by a swell or depression, save the channels cut by the tributaries, which enter almost at regular intervals. There is perhaps no place on the continent that so fully meets our idea of a "flat" or "dead-level" country as this valley. Professor Owen has truly remarked that "nothing, however, but personal observation can convey to the mind the singular effect produced by this dead-level plain. The line of the horizon is so perfectly straight that it might serve the purpose of astronomical observation for determining the altitude of the heavenly bodies. While standing on this great savanna, straining my eyes in quest of some object more prominent than a blade of grass, it occurred to me that there is probably no spot on the globe more suitable than this on which to measure a degree of latitude." It is only personal observation that can convey to the mind the effect of this singular feature; even the gentle slopes, which border it, appear in the distance as abrupt bluffs when we gaze at them across this level surface.

The Saint Paul and Pacific Railroad, which runs diagonally across it for forty miles, during this distance is without a curve, a fill, or a cut, save what is necessary to remove the sod. It is one immense meadow of tall, waving grass, interrupted every twelve or fifteen miles by a narrow fringe of trees, chiefly oak, that lines the bank of some tributary which flows into it from the east or west. The descent of the stream northward, counting along a direct line, is about one foot to the mile, but if we follow its windings the fall will be less than this amount.

Passing westward beyond this valley we observe a very distinct change in the scenery. Here the treeless plains spread out before us in long, rolling swells, in that peculiar and somewhat semi-gloomy grandeur which belongs alone to the great trans-Mississippi plains, of which this is a part. The surface gradually ascends and becomes more undulating, broken into long, low, rounded ridges, smooth, grassy knolls and hillocks, furrowed here and there by the narrow, deep cañon-like valley of some stream, or by a dry *coulée*, which marks the pathway of some ancient creek or river. Instead of the forests of the eastern basin, or the tall, waving grass of Red River Valley, we now see the low, pale-green sward, or, as we move farther into the interior, the short bunch-grass, which formed the favorite food of the immense herds of buffaloes and antelopes that once roamed over these plains. Here and there we see a lake amid the somewhat barren surroundings, but the white incrustations on the bowlders which line its shores tell us too truly, what our taste confirms, that its waters are brackish, mostly unfit for the use of man or beast; a few fresh-water lakes are found, but these are rare. Another feature, which causes us to have doubtful forebodings of the distant future, is the frequency of what are significantly termed "dry lakes." These are the dry and parched basins where but a comparatively few years past lakes existed, not in the distant geological past, but in several instances within the memory of those now living. The surface of the country between the valley of Red River, on the east, and Missouri River, on the west, may be described, in general terms, as consisting of high, rolling prairies, intersected by the valleys of a few streams which run south. But this general contour is interrupted by two elevated plateaus, which stand high above the general level as monuments reared by the vast aquatic forces of the past, as if to give us some idea of their stupendous power. The smaller of these elevated plains, the Coteau des Prairies, extends from a point about forty miles west of the north end of Lake Traverse, latitude 46° and longitude 97° 30′, southward, expanding and somewhat dividing toward its southern extremity. The western arm of this southern extension encroaches close upon James River Valley, about latitude 44° 15′, where it ends; the other arm reaches southeast, passing down on the east side of the head-waters of Big Sioux, and gradually fades out in the southwest corner of Minnesota. The elevation of its surface averages nearly 2,000 feet above the level of the sea, varying from 1,860 feet to 2,046 feet, showing a rise above the plains east of it of about 800 feet and above the valley west of it of 700 feet.

The other plateau is the Coteau of the Missouri. This hugs the valley and follows the course of the Missouri northward from Fort Sully to the great bend of the river near the mouth of the Yellowstone. Here it recedes and extends in a northwest direction into British Possessions, where it gradually fades out and is lost. It varies in width from thirty to fifty miles and in height from 1,800 to 2,200 feet above the sea; but the surface is more irregular than that of the other coteau, portions of it rising as much as 200 feet above the general average. The general elevation corresponds very closely with that of the Coteau des Prairies, showing very clearly some relation between the origin of the two. On each are numerous small lakes, mostly impregnated more or less with saline matter, and at many points on each bowlders are quite plenty. So much so is this the case with the Coteau of the Missouri that Mr. Skinner remarks, in regard to the section where his line crossed it, that "it is very stony." This elevated plain will furnish us with the explanation of the great bend of the Missouri in the northwest part of Dakota, and its direction southeast from that point.

Pembina Mountain, which is situated within the belt now under consideration, and near the international boundary-line, is nothing more than an elevated plateau, similar in character to those already described, but much smaller.

I may remark here that the country northward, even as far as the Saskatchewan, along this meridional belt, preserves about the same character that we see exhibited in Dakota. I was at first under the impression that when we entered the valley of the Assiniboine we would find a section supplied with more moisture and ranker vegetation than further south, but from information received from persons who have long lived in that region I am satisfied it is but a repetition of the type we see along the northern border of Dakota.

Recurring again to the vertical topography, I would call attention to the fact that after we leave the valleys of Red and Minnesota Rivers we notice a gradual westward ascent, and in order to obtain a correct idea of these slopes I estimate by the lowest water-levels, whenever these can be obtained, and where they are wanting I use the lowest land-levels, or such as represent the average elevations of extensive plains or valleys. Following this rule we find that the ascent along the Northern Pacific Railroad, west from Red River to the Missouri River, averages a little over 4 feet to the mile. From Lake Traverse to the Missouri River, at Fort Sully, the average ascent is not more than 2 feet to the mile, and from the bend of Minnesota River to the Missouri, at the mouth of Big Sioux, it is not more than 1½ feet to the mile; but in this case the land ascent, until we reach Le Mars, is about 2 feet to the mile.

The plains immediately east of Cheyenne River, and between it and James River, and west of the latter to the Coteau of the Missouri, have an average elevation of about 1,450 feet above the sea, and from 90 to 150 feet above the streams which traverse this region.

Devil's Lake appears to be situated on a plateau or swell forming the divide between the Cheyenne River and the northern tributaries of Red River.

It has an elevation of 1,467 feet above the sea, or about 100 or 150 feet above the level of Cheyenne River at the point immediately opposite. But it is a general rule, as I have before stated, that the lakes in the prairie-portion of the Northwest are situated on the divides between the streams. Lake Eckelson, on the line of the Northern Pacific, between Cheyenne and James Rivers, has an elevation of 1,418 feet above the sea—very nearly the same as Devil's Lake—188 feet above Cheyenne River, and 25 feet above James River.

The leading ridges and land-swells, so far as my observations in the southern and northern part of the Territory have extended, appear to run nearly north and south, the direction being slightly west of north and east of south. But, as will be seen by reference to a map of the country, this corresponds with the general direction of the streams; and, as the drainage is southward from latitude 48°, we may infer that there is a gradual descent southward as well as eastward. No sufficient data have yet been obtained for determining accurately the rate of this descent to the south, yet we may approximate to it from the following items: James River, at the crossing of the Northern Pacific, (latitude

46° 52′,) is 1,393 feet above the sea, and at the point where Mr. Skinner's line crossed it—about latitude 45° 28′—it is 1,267 feet above the sea. This would give an average descent along this valley of a little less than 1 foot to the mile. Missouri River, at Fort Union, has an elevation of 1,970 feet; at the mouth of Heart River, 1,700 feet, and at Fort Sully, 1,398 feet. Using these figures and calculating the distance moved directly south, we find the descent to be about 2 feet to the mile, or 140 feet to the degree of latitude. These figures would indicate that the elevation of the river at Yankton is about 1,050 feet above the sea; but this estimate is probably a little too low, as the rate of descent doubtless decreases as we move eastward and probably as we move southward; 1,130 feet would likely be nearer the correct figure.

Another point in regard to the level of these leading streams worthy of consideration is the difference between them at the same latitude. At latitude 46° 50′ the Missouri is 1,700 feet above the sea; the James, 1,393; and Red River, 900. At latitude 45° 30′ the Missouri is (about) 1,510, while James River is but 1,260; yet the difference in longitude between the two is about the same at this lower point that it was at the upper, each having moved eastward, in this distance, about half a degree.

Passing west of the Missouri we have only to look at the map to learn the direction of the descent, all the tributaries which flow into it below the Little Missouri, as has before been stated, having an almost directly eastern course; but sufficient data have not been obtained to give the vertical topography of this western section.

If we enlarge our area, and include all north of Kansas River and west of the Mississippi as far as the one hundred and first meridian, and compare the elevations of points corresponding in longitude along the different lines running west from the Mississippi, we will obtain a pretty correct idea of the topography of the Northwest, as estimated from the lower or water levels. It is true that this will not enable us to form any idea of the higher intermediate points or the surface-contour, but knowing, as we do, that there are no elevated ridges, no prominent peaks or rugged portions, the general slopes form the most important topographical feature.

First. Along the line of the Northern Pacific Railroad, which corresponds very nearly with the forty-seventh parallel of latitude: the Mississippi at Brainard, 1,205; Red River at Moorhead, 903; James River at the crossing, 1,393; and the Missouri, at the mouth of Heart River, 1,700 feet above the level of the sea.

Secondly. Along a line running from Saint Paul, by way of Lake Traverse to Fort Sully, which, though bending considerably, we may consider as corresponding with the forty-fifth parallel of latitude: the Mississippi at Saint Paul, 680; Lake Traverse, 960; James River, at the point where Mr. Skinner crossed it, 1,260; Missouri River, at Fort Sully, 1,398.

Thirdly. Along a line from Davenport, by way of Omaha and the Union Pacific Railroad, corresponding very nearly with the forty-first parallel: the Mississippi, at Davenport, 528; the Missouri, at Omaha, 966; Lone Tree, on the line of the Union Pacific, 1,686; and North Platte Station, on the same line, 2,789.

Fourthly. On a line running from Saint Louis westward along the Kansas Pacific Railroad, and corresponding with the thirty-ninth parallel: the Mississippi, at Saint Louis, 375; State-line, at the mouth of Kansas River, 648; Fort Harker, on the Kansas Pacific, 1,484; and Buffalo, on the same line, 2,678.

The following data may be added as corresponding with the forty-third parallel: the Mississippi, at Dubuque, 580; the Missouri, at Sioux City, 1,093.

By selecting in succession the corresponding elevation from these different lines, we will obtain the vertical topography along four different meridians, beginning in each case at the north and running south, one or two additional numbers being introduced where it is possible to extend the line.

The line of the Mississippi.—Rainy Lake, 1,035; the divide between the Rainy Lake and Mississippi Basins, (about) 1,700; Leech Lake, 1,330; Brainard, 1,205; Saint Paul, 680; Dubuque, 580; Davenport, 5[illegible]8; Saint Louis, 375.

Along a line corresponding very nearly with the ninety-sixth meridian.—Pembina, 790; Moorhead, 903; Lake Traverse, 966; Sioux City, 1,093; Omaha, 966; mouth of Kansas River, 648.

Along or near the ninety-eighth meridian.—Devil's Lake, 1,467; James River, at the North Pacific crossing, 1,393; same river, at Skinner's crossing, 1,260; the Missouri, at Yankton, (about) 1,130; Lone Tree, on the Union Pacific road, 1,636; Fort Harker, on the Kansas Pacific road, 1,484.

Along or near the one hundred and first meridian.—The Missouri, at the mouth of Heart River, 1,700; the same river, at Fort Sully, 1,398; North Platte station, on the Union Pacific road, 2,789; Buffalo station, on the Kansas Pacific road, 2,678.

It is apparent from these figures that the plain or plateau from which the Upper Mississippi gathers its waters is elevated considerably above the region north and northwest of it, and that it is separated from the western plains of Dakota and Southwestern Minnesota by the much lower valleys of Red and Minnesota Rivers.

In passing south along the ninety-sixth meridian, which corresponds very nearly with the line of Red River, after passing Lake Traverse, we do not again descend to the same level until we reach Omaha, on the Missouri River, showing that the waters of the Big Sioux are gathered from a plain elevated considerably above the level of Lake Traverse. It is therefore evident, as heretofore stated, that there is a broad and somewhat elevated swell extending southeast from the Coteau des Prairies, which, though spreading out into broad and apparently level prairies, continues for a considerable distance into Northwestern Iowa.

Another, and perhaps the most important, fact, learned from the figures along these north and south lines is that the plains of Nebraska and Kansas, after we have passed a short distance into the interior, are more elevated, and more rapidly ascending (westward) than any portion of Dakota east or northeast of the Missouri; in other words, that as we move northward—say, for example, along the one hundred and first meridian—we descend, and this descent continues far into the British Possessions; not that it is by any means uniform, but that as we pass from one plain to another, or from one basin to another, we descend, as a general rule.

MINNESOTA.

As before indicated, this State consists of two districts differing widely in regard to the covering and character of the surface, and also with respect to their agricultural resources. The northeastern portion, embracing probably one-third of the entire area, being covered almost entirely with coniferous forests, is partially interrupted by bogs and marshes. When the land in this part of the State has been denuded somewhat of its forest-covering, and shall be urgently demanded for agricultural purposes, a large portion of this marshy section may, and probably will, be rendered suitable for tillage by an extensive system of drainage; but this, to be successful, will require a large expenditure of labor and money, and will only be done when it shall have been deprived of its valuable covering of timber and after the more inviting agricultural regions to the west shall have been fully occupied. Notwithstanding the somewhat forbidding aspect of this section to the eye of the farmer who is seeking a home in the West, yet it is not impossible that the day may come when this, having been thoroughly drained, will be considered the richest agricultural portion of the State; such, at least, is the opinion of some, even among those who have no personal interest in the matter. Its chief value now is its timber; but this is by no means a small item, the lumbering interest being one of the most important of the State. The sections drained by the head-waters of the Mississippi and Saint Croix, as well as the regions bordering Lake Superior, are clothed with immense forests, chiefly of pine. Although the timber of these forests is very valuable, it must not be supposed that the whole of this area is uniformly covered with timber that is valuable. As a general rule, so far as my observations and information extend, the swamps and marshes are generally covered by tamarack, of but little value for any other purpose than fuel or fencing, and wholly unfit for lumber. The pine, as a general rule, is confined to the intervening low ridges and swells in the marshy sections, the more broken areas around the lake, and the lighter, sandy soils of the valleys of the streams.

On the west side of the Mississippi there is a tolerably broad and lengthy belt of timber, extending from Crow Wing River southward to within some sixty or seventy-five miles of the southern boundary of the State, consisting of deciduous trees, chiefly oak and elm, with an intermixture of ash and maple. This forest-strip covers one of the richest bodies of land in the State, the soil being a dark, rich loam, heavily mixed with vegetable mold, and reminding one much of the richest bottoms in the State of Missouri. This belt of timber is called the "Big Woods," and is about one hundred miles in length and forty miles wide.

The following statement of the lumbering operations for 1869 and 1870 will give some idea of the extent of this business in Minnesota, to which if we add that of Wisconsin, (which is probably equal in amount to that of Minnesota,) we will be able to arrive at an approximate estimate of the lumber interests west of Lake Michigan:

	1869.	1870.
Saint Croix, feet of logs scaled	158,382,454	191,677,776
Mississippi, feet of logs scaled	92,709,030	121,438,640
Total of these two districts	251,091,484	313,116,416
Of the total log-crop of 1870, there were sent to market unmanufactured, feet		137,177,431
Sent to market as manufactured lumber, feet		175,938,985

The western and southwestern portion of the State, as heretofore stated, consists almost wholly of undulating prairies, until we reach the flat and broad valley of Red River.

In order to convey as correct an idea as possible of the northern and western portions of the State, (I omit the southeastern portion, as it is so well known that any description of it is wholly unnecessary,) so far as relates to the soil and agricultural resources, I cannot do better than insert the notes taken while passing along the leading railroad-lines.

And, first, I insert the few notes taken along the line from Saint Paul to Duluth.

For several miles out of Saint Paul until after we have passed a short distance beyond White Bear Lake, the country is rolling and slightly broken, and, where not in cultivation, is covered with oak-groves, mostly bushes near the city, but increasing in size after we have advanced some distance into the country. The surface of the country here appears to be knotted and pitted, thus affording basins for the numerous little lakes found in the northern part of this (Ramsey) county, and in fact over a considerable area in this part of the State. After passing White Bear Lake a slight change commences; the conifers begin to appear, especially in the low and swampy spots; the surface becomes more level, and the aspen (*Populus tremuloides*) appears in frequent groves, its white bark forming a strong contrast with the dark pines. About North Branch the country is quite level, and is covered with a pretty heavy growth of oak, which at a distance resembles the post-oak, (*Q. obtusiloba.*) The soil here also is very good, having a better appearance than that previously passed over. Much of the surface between Wyoming Station and this point is marshy, but we should bear in mind the fact that the past season, when I visited this section, was more than usually wet. From North Branch to Rush City the surface is level and rather wet, the soil rich, and the timber heavy, consisting chiefly of oak, elm, maple, and ash. Occasionally a hickory and butternut are seen, but these are rare. Conifers, in the swamps, are chiefly tamarack or black larch, (*Larix Americana*,) balsam-fir, (*Abies Balsamea*,) &c.

From Pine City, on Snake River, northward, the pine-forests prevail, and the surface of the country is more or less damp and swampy. At Kettle River we begin to meet with the low, rounded drift-ridges, the soil consisting of a reddish sandy clay, intermixed with small red bowlders; in many places the sand appears to be the chief ingredient. At this point, and also at several points along the Northern Pacific, we met with the wild strawberry in fruit, (July 3–10.)

As we approached the junction with the Northern Pacific we were met by a cold northern mist, that compelled us to draw on our overcoats and made fire very comfortable. From here to Duluth we descend the rugged bluff that surrounds Lake Superior; in going twenty miles we make a descent of nearly 600 feet. The dark waters of Saint Louis River rush down to our right over the ragged rocks with a deafening roar, plunging and dashing themselves into foam as they leap from ledge to ledge or drive through the narrow rugged gorges, presenting a scene of wildness and grandeur. Whether it will ever be utilized or not is more than I can say, yet it is true that here is an immense water-power.

It is scarcely within the scope of my duties to speak of the prospects of any town or city in a commercial point of view, but as Duluth is destined to be the chief port of the western end of Lake Superior, and as a matter of course the principal shipping-point of Minnesota, so far as lake-transit is concerned, a few remarks in regard to it may not be out of place here.

Although it will labor under some material disadvantages, yet it is destined to make a place of considerable importance. Its disadvantages are as follows: The climate can by no means be called a favorable one, although what I saw could scarcely be taken as a fair sample of summer weather. The winters, as I understand by those who have visited this point in search of health, are by no means as harsh and severe as we might suppose; but the spring is unpleasant, and the weather during this part of the year disagreeable. The second disadvantage is the fact that it cannot be said to have any surrounding farming-land to give it a local trade depending on agriculture. Thirdly, the shipping-season is short, closing rather too early to allow time to gather in the crops from the distant sections, where they are somewhat late.

Its advantages in part are as follows: It is the extreme western lake-point of the Northwest, which is a very important item; it is the nearest point of water-communication with the ocean for a very large area of country, viz, Minnesota, Dakota, and the grain-districts of British America northwest of the lakes; it has most excellent water-power close at hand, in the Saint Louis River; being the only important lake-port of Minnesota, it must necessarily have the influence and sympathy of that rapidly-growing State; and, finally, it is the eastern terminus of the great northern Trans-Continental Railway, which must make it an important point. These are important advantages, which must, in spite of the disadvantages under which it labors, ultimately make a city of considerable size, and, so long as this line of road controls the trade of Manitoba and other portions of Western British America, give it an international character.

The following notes relate to the country along the Northern Pacific line:

After leaving the junction, as we move westward, we enter a long stretch of marshy lands, covered chiefly by forests of pine and tamarack, and this continues, with but little variation, until we reach Aiken. Here we notice a change in the surface and character of the land; the soil also shows a variation from that eastward. The surface becomes slightly undulating, the sub soil more sandy and mixed with gravel; oak also begins to make its appearance; and although there is occasionally a swamp, yet the country westward from here to Brainard may be fairly classed as agricultural. The timber between these points is chiefly pine; yet there is a slight intermixture of oak, elm, and aspen, and occasionally an ash. A short distance before reaching Brainard we enter upon a sandy level, which continues to the Mississippi, and is repeated for some distance on the west side. The soil here, notwithstanding its sandy character, is rich and productive, and will doubtless produce heavy crops of cereals. The Mississippi cuts its way through this level in a deep channel like a large canal, without low bottoms. After crossing to the west side we pass for some distance over a sandy level covered with an open pine-forest; in a few miles the soil gradually changes to a darker hue, and we occasionally meet with wet and marshy spots, in which the ominous tamarack makes its appearance. Occasional broad low ridges now begin to be seen, clothed with deciduous trees, chiefly oak, elm, ash, and bass-wood; the soil is good, and, with the exception of a few points, will make excellent farming-lands. After leaving the sandy region the soil is mixed with clay and gravel. A short distance east of Wadena the surface becomes slightly undulating and somewhat destitute of timber, being partially covered with oak-bushes, which fade out as we enter upon the prairie-region; the surface-soil is quite rich.

From Leaf River westward, for some fifteen or twenty miles, we pass through a section alternating with low, broad ridges, and wet, narrow bottoms or "slashes," the ridges being composed almost wholly of gravel, though the surface-soil is a rich mold, and mostly covered with mixed timber, including an occasional large pine; but this tree is now rapidly disappearing as we move westward. As we approach Hobart Station we enter upon a beautiful undulating prairie, with a dark, rich surface-soil, but I noticed here that it is underlaid with a heavy gravel-deposit, which even a single furrow of the plow exposes to view. As we move on the surface becomes slightly more rolling, not broken, but gracefully rounded into hillocks, ridges, and valleys, with here and there groves of oaks on the hillocks and along the banks of the streams. We are now in that section which I have heretofore spoken of as being the prettiest portion of the State, a description of which need not be repeated here. This beautiful undulating prairie-belt, with its green sward, occasional oak groves, (but these gradually disappear after we pass Detroit Lake,) and numerous clear lakelets continue until we begin to descend the divide into the valley of Red River. The soil is a rich, dark loam; the subsoil appears to be composed generally of gravel and clay, with a marly appearance, mixed with bowlders, the former decreasing and the latter increasing—in proportion—as we move westward. The bowlders are mostly gray or red granite, though some of other rocks were seen.

I may remark, in passing, that I noticed the cuts through this hilly portion very carefully, to see if there was any evidence of stratified rocks or rocks of any kind in position; but no sign of such rocks were seen. At some points there are large accumulations of bowlders, but all these hills and the entire surface-material for a considerable depth are evidently drift.

The descent to the valley of Red River is very gradual along the line of the road, but from the valley it is very apparent, rising up in the form of a sloping bluff. It is unnecessary to repeat the description of this valley; the surface-soil is black muck some 4 to 6 feet deep, the first 2 feet being filled with a matted mass of grass-roots; the subsoil, as will be seen from the following record of the boring for an Artesian well at Fargo, is blue clay, which is very tenacious. The margins of the streams in this valley are lined with a narrow strip of timber, chiefly oak, with some elm.

The following is the record of the boring of the Artesian well at Fargo, so far as it had penetrated at the time I last visited that point, (September 3, 1872:)

	Feet.
Soil	3
White and yellow (or drab) clay	50
Fine dark clay	42
Small stone and gravel	10
Hard clay ("hard pan") mixed with gravel and bowlders	115
Soft, dark-blue shale	32
Coarse sand-rock	6
Soapstone	4

After piercing the sand-rock water rose to within some 10 or 12 feet of the surface, with an apparently good supply. The depth of the well at that time was 262 feet, and the boring had stopped with little prospect then of being continued, as Mr. Barker, superintendent of the work, thought it useless to go farther, it being his opinion that the next rock will be the igneous or metamorphic. As will be seen from this, one drawback in this rich valley is the difficulty of obtaining a supply of water.

The next line passed over in Minnesota was that leading from Saint Paul to Breckenridge—a branch of the Saint Paul and Pacific—a distance of two hundred and seventeen miles. The following is an abstract of the notes taken at the time I passed over this road:

From Saint Paul to Lake Minnetonka the land is rolling and somewhat broken and sparsely covered with small oaks. There are here, as on the east side, a number of small lakes, but I noticed several small basins which appear to have contained formerly small lakes, but which are now only empty basins. After we pass this point the country is less hilly, though still slightly rolling; the soil is generally rich and quite fertile; the forests are heavy, and timber large, chiefly oak, elm, and ash, with some maple and aspen. Of the oak there are two or three species, among which I noticed what I supposed to be the burr-oak or over-cup (*Q. macrocarpa*) and the scarlet oak, (*Q. coccinea*;) but I may have been mistaken as to the species. As I have heretofore remarked, this timber-section has a very dark, rich soil, very little of it being interrupted by swamps or too wet for cultivation. I noticed here both white and red clover growing luxuriantly. The few swampy flats seen were generally clothed with the gloomy tamarack. These characteristics continue until we come near to Darwin, where we enter upon a somewhat open country, having a prairie-like appearance, though we have not yet emerged upon the true prairies. The surface-soil is still dark and rich, and the surface slightly undulating, but the subsoil where exposed begins to show a heavy intermixture of gravel. At Darwin, or rather a short distance beyond it, we enter upon the prairies, though a considerable body of timber can still be seen to the north. The surface here is somewhat undulating, but less broken than at the corresponding point on the Northern Pacific line; there are also here scattered over the country numerous small lakes, indicating an approach to the divide between basins. The subsoil is still gravelly, but this character appears to be gradually disappearing as we move westward. When we reach Morris we enter upon a level plain, which continues without interruption to Red River; it is, in fact, an expansion of the valley of that river, and as far north and south as the eye can reach the same unvarying level is seen; and here for forty miles is a line of railroad as straight horizontally and vertically as possible to make it, without a cut or fill worthy of mentioning. The soil is much the same as at Glyndon, on the Northern Pacific; in fact, there is but little variation in the character of this valley its entire length. I am satisfied that along the Saint Paul and Pacific Railroad nine-tenths of the land can be cultivated and will yield abundant crops of such cereals as are adapted to the climate. And I may be allowed to digress here for a moment to give an idea of the future prospects of this road from the grain-trade.

Take the length in round numbers at two hundred miles and a strip twenty miles wide, giving an area of four hundred square miles, or 2,560,000 acres; deduct one-fifth as unfit for cultivation, and suppose one-half of the remainder to be annually planted in wheat, 1,024,000 acres, at 17 bushels to the acre, (the average yield in Minnesota,) amounts to 17,408,000 bushels. Allowing 400 bushels to the car, it would take 43,520 cars, or six trains per day of 24 cars to the train, (300 days in the year,) to move this immense yield of but a twenty-mile strip of country. As a matter of course, it is not probable that this proportion of the land will ever be cultivated in small grain, but certainly these figures do not overestimate its capability, and give us an idea of the bread-producing resources of this portion of the West. It is true the ratio assumed will not apply generally, but with a moderate deduction it will apply to the western half of Minnesota, the greater portion of Iowa, a considerable area in Southeastern Dakota, and Eastern Nebraska.

I should have stated that at Morris, on this line, there is a flowing well of good water. The well was being dug for ordinary purposes, and had reached a depth of about 30 feet, when suddenly the water broke in upon the workmen, who escaped with difficulty. The water rose rapidly to the surface and has been flowing freely ever since that time.

If we follow a line from Saint Paul to the southwest corner of the State we find the country somewhat similar to that toward Breckenridge. It is broken and timbered until we reach Crystal Lake, rather more so than toward the northwest. This strip of timber belongs to the Big Woods, and consists of deciduous trees, such as oak, elm, ash, &c. After passing this point we enter upon a beautiful undulating prairie-section, devoid of timber, except the little strips along the banks of the streams, which continues to and beyond the southwestern border of the State. The soil is of an excellent quality, and the subsoil is generally more or less mixed with a kind of finely-comminuted marl, though at some points it is composed in great part of clay. There are some small, clear lakes, but the surface is seldom marshy, the entire area as a general thing being susceptible of cultivation.

The following statistics, taken from the "Statistics of Minnesota for 1870," published by authority of the State, will give an idea of the amount and character of its agricultural products:

CROPS OF 1869.

Product.	Acres cultivated.	Bushels produced.
Wheat	1,006,007	17,660,467
Oats	278,487	10,510,969
Corn	147,587	4,519,120
Barley	35,201	938,466
Rye	4,632	75,628
Buckwheat	3,023	51,025
Potatoes	21,156	1,580,431
Beans	1,910	29,002

Sorghum, gallons	35,144	Cheese, pounds	321,969
Maple-sugar, pounds	205,702	Apple-trees growing	316,552
Maple-syrup, gallons	14,815	Apple-trees in bearing	20,800
Honey, pounds	93,651	Bushels of apples produced	9,932
Hay, wild, tons	532,183	Quarts of strawberries grown	148,024
Hay, cultivated, tons	69,129	Timothy-seed, bushels	2,279
Hops, pounds	283,335	Flax, pounds of fiber	15,106
Wool, pounds	382,902	Flaxseed, bushels	7,801
Butter, pounds	6,552,455		

Average yield of field-crops per acre.

	Bushels.		Bushels.
Wheat	17.55	Rye	16.32
Oats	37.74	Potatoes	74.70
Corn	30.62	Buckwheat	16.83
Barley	26.92	Beans	15.17

It is not probable that any considerable progress will be made in fruit-growing, as it is evident that the climate is too rigorous for the profitable growing of any varieties except the most hardy small fruits, as strawberries, currants, gooseberries, &c.

As before stated, the consideration of the climate is reserved for a future report, which will be devoted to this subject.

DAKOTA.

This Territory has been so recently settled, except a small section in the southeast corner, that but little can be said as to its agricultural prospects, save what we can infer from an inspection of its surface and soil, added to the slight knowledge we possess of its climate. And here the last item becomes important in this estimate, as it is known that the line of sufficient rain-fall is found within its borders.

It possesses, probably, the smallest amount of timber of any State or Territory in the Union, the forests bearing a ratio of not more than 3 to 5 per cent. to the entire area, and even this ratio is obtained by adding the amount supposed to be in that part of the Black Hills within its boundary.

With the exception of the west side of Red River Valley and the surface of the coteaus, the whole of that portion east of the Missouri (which is the only part I shall allude to here) consists of elevated, undulating prairies, very similar in character to the plains of the central and western portions of Nebraska and Kansas. The streams, as a general thing, run through deep and narrow valleys, having but a small amount of water in them, and the fall being insufficient to carry the water upon the bordering uplands; hence, as a rule, in the northern and central portion, if the rain-fall should prove insufficient for agricultural purposes, there is but little hope of redeeming any portion by irrigation, except the narrow valleys which the streams traverse.

As a general rule the soil is good, and where there is a sufficiency of moisture there is no reason why good crops cannot be raised; but I have very strong doubts on this point, except for the southeast portion and a narrow belt along the eastern border.

The following notes, taken down while crossing from Fargo, on Red River, to James River, along the line of the Northern Pacific Railroad, will convey, I believe, a fair and correct idea of this section of the Territory, the fact being borne in mind that 1872 was a more than usually wet season.

For about eighteen or twenty miles the surface is very flat, being the west half of Red River Valley, and corresponding in appearance with that on the east side. The soil is also very similar to that on the east side, the only difference noted being that here, after leaving the river for a short distance, it becomes more or less impregnated with alkali, which is quite apparent where the sod has been turned or a cut made; yet I do not think this is sufficient in quantity to injure any of the ordinary crops, for I have learned from my observations in Colorado and Utah to look upon the presence of a moderate quantity of alkali in the soil with much less serious apprehensions than formerly.

Passing westward beyond the valley we gradually rise to an undulating prairie, which becomes more rolling and slightly broken until we reach the second crossing of Cheyenne River. Although this section is evidently drier and not so rich as the Red River Valley, yet I think experiment will show that it is tolerably good agricultural land and that the amount of moisture is sufficient for ordinary crops. But already this troublesome question makes its appearance; already we see the grass growing much shorter and beginning to assume that peculiar character so well known on the western plains. Still I think this strip as far as the second crossing of the Cheyenne may be properly classed with the lands suitable for farming purposes. The valley of the Cheyenne is quite narrow, affording but a small amount of tillable land and a very narrow strip of timber. After passing this valley there is a considerable rise before reaching the general prairie-level beyond. I notice here, where the railroad-cuts have exposed the subsoil, that it is chiefly, I might say entirely, compact drab clay, of considerable depth. The surface of the country on the west side is undulating, dotted here and there with lakes, most of which are strongly alkaline or saline, their pebbly shores being frosted over with the alkaline deposit. Lake Eckelson, which is some six or eight miles long, and from one-fourth of a mile to one mile wide, is the largest in this immediate section; its waters are brackish, apparently more saline than alkaline.

Here we also meet with a phenomenon which leaves a very unfavorable impression upon the mind in regard to the climate in this section. I allude to what are called "dry lakes," the dry basins where lakes formerly existed, but which have in a few years past dried up from some cause not yet fully explained. As I have before stated, the fact should be borne in mind that 1872—the time of my visit to this region—was unusually wet. I mean by this expression simply to state that the amount of rain which fell during the spring and summer was more than the average amount.

Not only did I find these dry lakes entirely devoid of water, but the surface of the sediment which had been deposited by the water was dry and powdery and strongly alkaline. Even the lakes which contain water appear to be getting lower and lower, if we judge by the water-lines along the shores. And this calls to mind another fact bearing upon the condition of the climate, indicated by the facts stated, and that is that all through this section of country I noticed numerous evidences of former swampy spots where the grass still is more luxuriant than that surrounding it, but the water has disappeared from the surface. For some time I supposed that these were points where water accumulated and remained longest in the spring of the year; although this explanation will suffice for the condition of many, yet there are some things connected therewith which I can only explain by the supposition that they are gradually growing drier.

After passing Lake Eckelson the surface of the country, although gradually ascending, is tolerable level until we reach the large *coulée* where there appear to be two depressions or broad ravines running north and south, with an intervening ridge. Perhaps no better illustration of the Arabian *wady* is to be found on the western continent than these *coulées*. This very broad, dry ravine was evidently once the channel of a considerable stream, the shiftings and fluctuations of which may yet be detected; why is it no more filled with water? Beyond this the surface is slightly undulating, but somewhat more in the terrace-form to and west of James River until we reach the coteau of the Missouri. The valley of the James is narrow, not more than from one-half to one mile wide, with very little timber of any kind. The surface of the coteau is very irregular, being broken into ridges and hillocks, with here and there an occasional small lake; and from the best information I could obtain it appears to be true, although strange, that there is generally no difficulty in obtaining good water on this elevated plateau by digging wells to a moderate depth. I know this to be true in regard to some of the elevated plains in the southern part of the Territory. The section where the greatest difficulty is experienced in obtaining water appears to be in Red River Valley and those areas underlaid by the heavy clay deposits.

Although the country west of the second crossing of the Cheyenne is well adapted to grazing and pastoral pursuits, yet I am satisfied that the average rain-fall is not sufficient for profitable agricultural operations. There may be seasons when the supply may be sufficient to produce moderately good crops of the cereals, but I think these will form the exceptions instead of the rule. It is true no sufficient experiments have been made to test this question, and it is due to the welfare of the Territory and those who are largely interested in this matter that I should state that my opinion is not based upon direct experiments in this immediate section, and that the soil as a general thing is good; also that it is very probable the bottom-lands along the streams will form an exception to this rule. I should also state that Mr. Roberts, the chief engineer of the Northern Pacific Railroad, expresses a somewhat more favorable opinion in regard to this section. He may be right and I may be wrong; I only give my opinion, which is based on certain evidences which will be more fully set forth in my report on the climatology of the West.

I was informed by a gentleman who was for three years connected with the Indian agency at Fort Totten, on Devil's Lake, that the surrounding country there consists of undulating prairies, much the same as found at the same longitude farther south along the line of the North Pacific, but that the lower lands immediately around the lake he thinks will, as a general thing, produce crops without irrigation, and that he founds his belief on some experiments which were made there.

I have been able to learn very little in regard to that portion of Dakota south of the Northern Pacific road until we approach the southeastern extremity. This section has seldom been traversed with a view of studying its agricultural resources; yet from the little I could learn with reference to it, I am satisfied that there is a gradual improvement southward. The valley of James River, south of 45° 30′, gradually expands and gives evidence of a greater degree of moisture. Even the southern portion of the Coteau of the Prairies will in all probability prove productive and adapted to agriculture, notwithstanding its isolated elevation. I know from personal observation that the section drained by the Big Sioux is one of the most desirable and beautiful portions of Dakota, almost every acre here being susceptible of profitable cultivation. And in order to give something like a correct idea of this portion of the Territory, I will copy my notes taken while crossing from Yankton to Sioux Falls.

After leaving the immediate bottoms of James River, we ascended some 60 or 70 feet to the upper or general prairie-level, where the surface is quite undulating, not broken, but interrupted by long, rounded swells, with a dark, rich soil, thickly covered with a heavy growth of luxuriant grass, but entirely treeless. Such is the general character for twelve miles; I might add that most of this distance there appears to be an ascending grade. Here we reach a small stream called Clay Creek, which runs through a deep, narrow valley, its pathway marked by a few scattering bushes or trees. Beyond this we cross a broad, rounded ridge for some eight or ten miles, the soil and covering being similar to those already described; and I may state here, in regard to this ridge, that which applies to all the principal ridges in this part of the Territory, its direction is nearly north and south, running a little west of north and east of south. Descending from this to Swan Lake, we enter upon a broad, level prairie, which, beginning in the vicinity of Turnersville, continues eastward to Sioux River, a distance of some twenty-five miles. Although I call this a level prairie, I do not intend thereby to convey the idea that it is a "dead-level" flat such as Red River Valley, for such is not the case, but the undulations are slight, and, although sufficient for drainage, are scarcely noticed by the eye. The soil and grass are similar throughout the entire route, but running water—a stream of any kind—is wholly wanting on this level prairie-belt, save that at Turnersville, and the entire region is timberless.

It is apparent from these notes that there is a great sameness throughout this portion of the Territory; and any attempt to give a description of one part as contrasted with another would be useless, as there are no differences of any importance in an agricultural point of view, with the single exception of the contrast between the Missouri bottoms and the upland prairies. And here the only difference is that the former is flat, the soil deeper and darker, being mixed with a larger proportion of vegetable mold, and partially supplied with timber, chiefly cotton-wood groves.

The following description of Union County, (the southeast county of the Territory,) taken from "The Outlines of History of the Territory of Dakota," by James S. Foster, I found to be quite correct, and as it will apply pretty generally to the counties along the Missouri in this part of the Territory, I insert it here:

> The surface of Union County resembles that of any of the Missouri River counties. It has, however, more bottom-lands than any other county. The south half is level bottom-lands, only a few feet above the high-water mark of the Missouri River; the north half is rolling prairie, elevated about 20 to 50 feet above the bottom-lands. The bottoms are perfectly level and very smooth, presenting no obstacles to machine farming. The uplands are generally undulating, presenting to the eye a beautiful landscape. The soil of the bottoms is a dark, sandy loam, mixed with a large proportion of vegetable mold. These bottoms are vast natural meadows, producing an abundant growth of excellent grass, frequently yielding over three tons to the acre. The uplands also afford an excellent quality of nutritious grass, but not so luxuriant in growth as that of the bottoms. The latter produce excellent crops of corn, wheat, oats, and vegetables, but the uplands, although capable of producing all kinds of grain and vegetables, are pre-eminent for wheat, thirty bushels to the acre being an ordinary yield. Along the Missouri, in the southern portion of the county, are large bodies of heavy cotton-wood timber; there are also considerable bodies of timber skirting the Big Sioux.

The surface and soil of Clay County resemble those of Union; the surface of Yankton and Bon Homme Counties is rather more rolling, with less bottom-land, otherwise similar to Union. From the mouth of the Sioux River to Vermillion River, the bottom or immediate valley of the Missouri is chiefly on the Dakota side, and varies in width from five to twelve miles. At Vermillion the bluffs—which form the escarpment of the upper level or plateau—approach very near the river. Beyond this the bottom again suddenly expands, and continues until we reach the vicinity of Yankton, varying in width from five to ten or twelve miles. I was somewhat surprised to find this part of the Territory as well settled as it is, a large portion of the bottoms and a part of the upper prairie lands being already under cultivation. At the time of my first visit, judging by the state of the crops, the season really appeared to be more advanced here than in Northern Iowa, owing, I suppose, to the warm nature of the soil, which here is generally underlaid with a heavy deposit of yellow, sandy marl (loëss) which contains a large amount of the mineral elements of fertility. There appears to be but little difficulty in obtaining water on the uplands by means of wells, and the comparative elevation does not appear to make very great difference in the depth.

The farmers here have very wisely adopted the plan of planting out forest-trees as one of the first things they do after making a settlement, and notwithstanding all the wild theories which have been advanced, they have had the good common sense to select the native cotton-wood, which, in five years from planting, (not seeding,) will commence affording fuel for stoves. I noticed at several points thickets of the wild plum (probably *Prunus chicasa*) loaded with fruit; also many grape-vines (wild) in fruit.

One serious drawback in this section, which must be seriously felt as soon as the cotton-wood groves along the Missouri have been exhausted, is the deficiency in fuel and building-material. The latter want will be partially supplied when the railroads having connection with the timber-districts of Minnesota are extended into this regiom; but these will scarcely supply fuel at a rate that will meet the wants of the farmers. It is true that coal can be brought in, but this will be a heavy tax on the farmers of small means, who live far back on the prairies, and are exhausting all their means and energy to start a farm into active operation; yet this will probably be the only method of meeting this necessity, unless corn is used for fuel, or forest-trees are timely planted and in sufficient quantity. What is said here on this point also applies to portions of Nebraska, and to some extent to the southwest portion of Minnesota. I know there is in the mind of the farmer of the States who has labored hard through the hot days of summer in plowing his corn, and in the fall in gathering and garnering it, a very strong dislike to the idea of using it for fuel; but the true method of testing this question is to count the cost. If, for illustration, sixty bushels of corn in the ear—about thirty shelled—will equal, as fuel, one ton of coal, (I do not know that this amount is correct; it is but a guess,) will it pay to sell this corn at 20 cents per bushel (shelled measure) and buy coal at $8 or $9 per ton, besides the hauling to and from a depot? It is a simple question of figures and not of fancy, and it would be well if some one properly situated to do so would give us some practical information on this subject.

A kind of soft-chalk rock is found near Yankton, similar to that found in Nebraska and Kansas, which is used as a building-material. This can be easily cut into blocks of any shape desired, but there is some doubt about its durability, yet most of those who have tried it for a number of years say it stands the test of experiment.

In closing this brief account of the agricultural resources of Eastern Dakota, I should state that, after carefully weighing all the data I have been able to obtain, together with my own observations, I am satisfied that all west of James River Valley must be counted as in a district not sufficiently supplied with rain.

Taking all the records of the rain-fall which have been kept in the Territory for the five years from 1867 to 1871, inclusive, we find the average yearly amount to be only 14.09 inches, less than half that of Minnesota, Iowa, or Eastern Nebraska. This entire amount is not more than barely sufficient for the production of the cereals, and just so much as we take from this general average to increase the amount in the more favored sections, just in proportion do we lessen it in the others. And that this average is not far from correct is shown by the fact that there is no very great variation from it in either of the years included: 1867, 13.78 inches; 1868, 14.03 inches; 1869, 14.17 inches; 1870, 15.12 inches; 1871, 13.35 inches. The records, which are now being kept at Yankton, Fargo, and Pembina, will doubtless increase this average somewhat, but if an equal number of stations were made in the drier sections of the interior and west, I am satisfied there would be no increase. The meteorological data, therefore, so far as obtained, corroborate the opinion I have advanced on this subject.

NEBRASKA.

I regret that I am compelled by want of time to cut short my proposed account of the agricultural resources of this young State, which is so rapidly filling up and rising to importance and influence, and which the late census shows as standing at the head of the list, so far as the ratio of common-school education to the population is concerned.

During my examination of the central and southern sections in the summer of 1872, I found that in some respects I was compelled to change the opinion I had previously formed from hasty passages through the State. For example, I am now satisfied that Platte Valley can produce crops of the cereals without irrigation farther west than I had formerly supposed. Not that the amount of rain which falls on this valley is any greater than that which falls on the adjoining plains, but the moisture is longer retained; and, more than this, I strongly suspect that these valley-bottoms are largely underlaid with sand-deposit through which an underground river permeates. While I am of this opinion in regard to this great valley, on the other hand I am now pretty thoroughly convinced that the sufficient supply of rain on the upper plains does not extend as far west as I formerly supposed. For Southern Nebraska, I do not think this can safely be placed any farther west than Fort Kearney, except along the immediate valley of Republican Fork, and north of Platte this line will probably bend considerably east.

Notwithstanding it is doubtless true, as claimed by the residents, that the subsoil is well adapted to sustain droughts by its capability of absorbing moisture, yet it is also true that the evaporating power of the air is greater than is usually supposed. The records of the signal-station at Omaha show that on the 4th of April the difference between the wet and dry bulb was as much as 27°, which, considering the fact that this is on the bank of the Missouri River, the date early in the spring of a rather wet season, is very great and indicates a very dry atmosphere.

There is another thing in connection with this subject, which I think is true both of this State and Kansas; that is, that the amount of rain does not diminish so gradually as we go west as I had supposed, the supply in the eastern part of these States being almost equal to that of the States immediately east of them. For instance, the average of five years (1866–1870) in Nebraska was 31.47 inches, while that of Iowa was 40.65 inches; Kansas 40.98 inches, while that of Missouri was but 38.33 inches. But if we go westward to the middle of these States the precipitation will diminish to not more than half this amount. We should therefore bear in mind that these records which appear so favorable apply only to the eastern third of these States. Taking the average of all the stations in Nebraska for the years named, we find them to be as follows: 1866, 27.07 inches; 1867, 28.41 inches; 1868, 33.28 inches; 1869, 42.11 inches; 1870, 26.47 inches. This subject will be more fully discussed in my report on the climatology of the West.

The following answers to the inquiries contained in a circular sent out by the Secretary of the Interior, at the request of Dr. Hayden, is so full, and, as a general thing, so fair a statement in regard to the agricultural resources of southeastern Nebraska that I think it is proper that it should be inserted here. It is true it is from the land-office of the Burlington and Missouri River Railroad Company, who are deeply interested in sustaining the character of the lands in this section, yet, after a visit in person to the section described, I think I may safely state that it is correct. A few drawbacks are not mentioned, but I will allude to these, as they were not directly embraced in the questions propounded:

STATE OF NEBRASKA.

To the Secretary of the Interior, Washington, D. C.:

SIR: In accordance with the request contained in "Circular No. 1," addressed from the "Department of the Interior, Washington, D. C.," and dated "March 20, 1872," I have the honor to report on the description of land, climate, productions, and markets of a portion of the State of Nebraska. I answer the questions in the circular relating to this section of land, and the questions and answers I number consecutively.

BOUNDARIES.

The section of country to which this report applies lies between the Platte River on the north and the northern boundary of the State of Kansas on the south, and between the western bank of the Missouri River on the east and Fort Kearney on the west.

DESCRIPTION OF LAND.

Question 1. The relative proportion of mountain, valley, and plain of your section Proportion of timbered land and varieties of timber?

Answer. There are no mountains. The whole region forms a portion of the Trans-Missouri Prairie, which rises gradually from the Missouri Bluffs in long swells, every where available for cultivation. The rolling prairie offers no positive obstruction to the plow, and the broken prairie seldom. There is little or no timber in the section, except in the river-bottoms, where narrow strips of forest-trees are found. I here give a statement of

Elevation at the different stations along the Burlington and Missouri River Railroad, in Nebraska.

Stations.	Elevation in feet.	Stations.	Elevation in feet.
Plattsmouth	525	Crete	910
Omaha Junction	542.10	Dorchester	1042.65
Louisville	582.40	Fairmont	1198
South Bend	592.60	Grafton	1253.20
Ashland	643	Harvard	1356
Greenwood	682.10	Inland	1435
Waverly	677.80	Juniata	1526.40
Newton	692.60	Kenesaw	1605
Lincoln	704.90	Lowell	1627
Denton	788.80	Kearney Junction	1704
Highland	970		

Remarks.—Kearney Junction is above low water, Gulf of Mexico, 2,114 feet, and above Lincoln, (the State capital of Nebraska,) 1,000 feet. To each elevation add 410 feet to get the altitude above low water, Gulf of Mexico.

Question 2. What portion can be irrigated and rendered tillable, and what portion not irrigable is suitable for grazing? What are the methods of irrigation; how many times do you irrigate the different crops; what depth of water in inches is used during the season; what is your method of regulating the supply and price, and what the cost per acre of irrigation?

Answer. Irrigation is not required within the defined limits. The land, though devoid of forests, is not subject to destrutive droughts. During the agricultural months the rain-fall is sufficient for all the needs of the agriculturist, and it is regular. An average for five years is as follows: January, 1.24 inches; February, 2.35 inches; March, 1.75 inches; April, 2.98 inches; May, 4.71 inches; June, 5.43 inches; July, 3.40 inches, August, 3.20 inches; September, 3.49 inches; October, 2.41 inches; November, 1.24 inches, and December, 1.64 inches. Dividing the year into three portions, these figures give for the winter-months of January, February, and December an average total for the five years of 5.22 inches; for the spring and fall months of March, October, and November, an average total of 5.40 inches; and for the remaining six agricultural months, an average total for each year of 23.21 inches.* As the rain falls in largest and sufficient quantities exactly when it is most needed, the clouds themselves form a perfect system of irrigation. It is a fact that this section, as the whole State of Nebraska, receives a less amount of rain-fall than other places in the same latitude; but following a natural law, as settlement proceeds and trees are grown, (for which latter see answer to question 7,) the annual rain-fall will become increasingly larger, and the upper branches of the rivers and creeks—which are now dry, or partially dry, except during rains—will always have a flow of living water.† In order to furnish a correct account of the character of the country in this matter, it is necessary to add that the rich, black soil of the section rests on a subsoil of porous yellow clay. Moisture does not consolidate this subsoil into a mass, but water is received and held as it would be by a sponge. Thus the land is, as it were, scientifically underdrained; and the crops are duly fed, and able alike to resist drought or excessive rain.

Question 3. What varieties of grains, vegetables, fruits, and other crops have been tried, which have proved best adapted to your section, and the average yield per acre?

Answer. All cereals have been tried, and succeed perfectly; but wheat stands fore-

*The proper estimate is, from April to August, 19.72 inches.—T.

†This very general opinion is very doubtful, yet it is probably true that the distribution will be more equable and the amount more effective on vegetation.—T.

most, and in weight of crop this section only falls below California. Wheat grows well on the high and the low lands; and oats and barley yield abundantly, while maize is everywhere successful. Taking a period of five years, an average yield of wheat is found to be 17.70 bushels per acre; maize, 32.54 bushels; rye, 20.66 bushels; oats, 36.65 bushels; barley, 26.75 bushels; and buckwheat, 26.33 bushels. The wheat grown here retains its characteristics without deterioration for a longer period than in most parts of the country; but still it is desirable, now and again, to renew the seed. In view of this fact, the Burlington and Missouri River Railroad Company proposes to import from the old countries the best descriptions of seed for those among the purchasers of its lands who may desire new seed. Potatoes, sweet potatoes, turnips, beets, and all root-crops yield abundantly, the average production of potatoes for five years being 79.80 bushels per acre. The systematic culture of the sugar-beet would give an abundant supply of sugar. Sorghum is of free and rich growth; and an excellent sirup is manufactured from its juice, though the processes of manufacture are at present crude. Table-vegetables all grow freely; and the castor-bean finds the soil and climate suitable. For a few years past attention has been devoted to fruit-growing, and peach and apple orchards have been established in many parts of this section. At one time there were doubts whether fruit-culture would ever be sucessful here. These doubts were the offshoots of theories that had never been tested by experience; but now, and as the result of experience, they have been entirely dissipated. In three years young peach-trees come into bearing; and apple-trees in from four to five. One strong proof that fruit takes kindly to the Nebraska soil is that, at the exhibition in 1871 of the National Fruit-Growers' Association, the premium for fruit was awarded to the State of Nebraska, of which the section of country to which this report applies is one of the best parts. The grape is successful under proper conditions. The Missouri bluffs are similar in character to the loess of the Rhine banks, and throughout the broken prairie the culture of the grape can be profitably undertaken. Small fruits grow luxuriantly; and the wild strawberry and the raspberry of the timber-skirtings are of excellent flavor. Tobacco is grown to a small extent in the bottoms. The plant thrives, and the leaf comes to maturity. Flax has been grown in this section for seed; but both flax and hemp might be cultivated for manufacturing purposes. In a new country like this the manufacture of linen and agriculture might go hand in hand, provided immigrants who are accustomed to the twofold operation can be brought into the State, for to this day it remains a fact that hand-made linens can compete in the market with the productions of the power-loom.

Question 4. What kind of stock is best adapted to your section, cost of raising, value, &c.?

Answer. The raising of cattle has succeeded wherever tried. The native grasses which form the pasture of the buffalo and antelope are luxuriant. The blue-joint, which grows on the highlands, attains the height of six feet; and a grass locally called "tuley," which grows in the bottoms of the Missouri and the Platte, is equally rich. These are both excellent as feeding grasses; but there are many others, and most of the year there is pasture upon the prairie, for even after the slight frosts of the fall have browned the grasses they make good cattle-food until they are entirely shriveled in the dead winter. Hay is also readily cured and stacked. The winters, as a rule, are not long. Open weather continues to the end of November, and spring has fairly returned by the beginning of March. Cattle, therefore, can be kept in the open air for most of the year; and during ordinary years, with the exception a few weeks, all the year round. For these few weeks, however, shelter is needed; and when shelter is provided the worst winters experienced are not at all to be dreaded by the breeder. So far in the history of this country the stock-owner's worst enemy has been the carelessness induced by the general moderation of the winters. He comes to depend on the mildness of the season; and when a severe winter occurs, and he has not adequate shelter for his stock, loss ensues. The fault here indicated experience will correct. A good profit is made by purchasing Texan cattle and grazing them on the prairie for a season, before shipping to the eastern market. Cattled thus treated go to market in splendid condition. When cattle-breeding becomes one of the regular operations of the farmer, it is well to cross the Texan with the Durham. Horse-breeding will be one of the industries of the section. Except for the purposes of the farm not many horses have been raised; but qualified men are here and there turning their attention to the subject. The broken and rolling prairie, intersected by draws, (ravines,) is suitable for horse-breeding. As the land is not the best adapted for the plow, it is the cheapest of the lands in the section, though, as it is the most suitable for the stock-farm, it is the most valuable of all. In the draws water can always be found; and, from whatever quarter the wind blows, the animals can find shelter. It would be well, however, for the horse-breeder to plant willow in suitable places as wind-screens. Feed, in the shape of oats and corn, is readily raised. Sheep are valuable stock for these prairie-lands; and will make large returns as well in wool as meat. Good pasture is plentiful, and the sheep require no more than the most ordinary shepherding; but that they must have. The dry, open winters conduce to the health of the sheep, which are not found to be subject to much disease. The hog thrives, and with corn pleutiful, the "hog-crop" yields well. As a general remark, the cost of raising stock here is a minimum; and, as there is a command of markets, fair prices can be obtained.

Question 5. Time of planting the various crops; and time of harvesting?

Answer. Crops are of rapid growth, and rapid ripening. Spring-wheat is generally sown at the latter part of February, and corn is planted in April. Bnt corn may be planted much later; and in the land-office at Lincoln of the Burlington and Missouri River Railroad Company, there are now four heads of coru which weigh 3 pounds 2 ounces. These are average specimens of a crop plauted on the 27th of June, and harvested in perfect condition before frost. The ground for fall-wheat is prepared, and the seed sown, by the middle of Sepember.

Question 6. Character of your winters; amouut of snow and rain-fall?

Answer. Raiu-fall in the section is giveu in answer 1. The ordinary average winter extends over three months—December, January, and February; and the entire fall of snow does not exceed 10 inches. The heaviest snow-falls of which we have experience are from 4 to 5 inches.

Question 7. What has been done in the way of tree-planting, and varicties best adapted to your sectiou?

Answer. The annual prairie-fires have, as a rulc, prevented the growth of timber away from the raviues of water-conrses. In these ravincs, howcver, wood grows lnxnriantly; and the timber-skirtings of the rivers and creeks include cotton-wood, many varieties of oak, elm, white ash, hackberry—a trce resembling the ash, but not free in splitting—black walnut, coffee-tree, sycamore, aud wild plum. The wild grape-vine is also abundant. But for the fires, by natural processes, the prairies would be timbered, and in many bottom-lands, where for two or three years settlement has checked the fires, therc is ash and cotton-wood brush which, in due course, will become wood.* Planting is also proceeding, though not so rapidly as is to be desired. However, last year, (1871,) one farmer planted no fewer than 120,000 trees; aud very many farmers show a disposition to surround their homesteads with wiud-breaks. By an act approved February 12, 1869, the State of Nebraska exempts "from taxation of the property of each tax-payer who shall, within the State, plant and suitably cultivate one or more acres of forest-trees for timber, the sum of $100 annually for five years, for each acre so planted and cultivated," providcd the trees do not exceed 12 feet apart, and are kept in a healthy and growiug condition. Cotton-wood, which grows rapidly, is the favorite for groves; and the records show that these trees in ten years' growth have attained height varying from 25 to 50 fect, and circumference varying from 2 feet 5 inches to 4 feet. The Osage orange is preferred for fences and wind-breaks, though there are some planters who give choice to the honey-locust. Other suitable fence-plants, as the willow and whitethoru, are used, thongh more rarely. Induced thereto by the lack of timber, and the premium for its cultivation offered by the State, it is certain that the farmers of the section will more and more make the growth of wood an object. The Danish residents at Omaha have formed a tree-planting company; and this company iutends to plant 2,560 acres of suitable soil, within the limits of this section, in the southwestern corner of Adams County. The company proposes fruit (for which, by the act already quoted, property to the amount of $50 annually is exempted from taxation for five years, for each acre planted and cultivated) as well as forest tree culture. The frnit is to consist chiefly of grape-vines, peaches, and apples; and the forest trees principally of evergreens. The Burlingtou and Missouri River Railroad Compauy has now a contract out for the planting of twenty-seven miles of cuts on the north side of the railroad, from the Missouri River, at Plattsmouth, to Kearney Juuction.† Fronting the north, along these cnts, there will be seven rows of trees arranged thus: extreme north row, honey-locust; second row, cotton-wood aud willow; third row, maple, ash, and box-elder; fourth row, Norway spruce and Scotch fir; and the three inner rows, European larch. One main object of this planting is to furnish ties for the railroad; bnt it is also hoped that the operation will encourage settlers to imitate the example.

Question 8. What are the kinds and cost of fencing used on the prairies? What has been doue in the way of planting hedges?

Answer. This question is in great measure answered in the reply to question 7; but it may be stated that fencing is not a rapid process. When boards are used the work is costly, and therefore there is not much of that kind of fencing. Sod-fences occasionally occur, the sod being taken up ou breaking. A strong and durable fence can be constructed with this material, with no expense save that incurred in piling the sod in due form and order. This class of fence seems to be suited for partial use on the prai-

* I fonnd this to be true not only at points in Eastern Nebraska, but also in Southeastern Dakota, and in Minnesota, bnt it only applies to the rain-moistened districts, and sections but slightly grazed, for cattle, &c., are about as destructive to the young plants as fires.—T.

† The Northern Pacific Railroad is adopting the same plan.—T.

rie; but its value would be greatly increased if the wall were so built that it could be planted on the top with Osage orange. The honey-locust and the osage orange grow rapidly, and, if properly attended to, in four or five years they will make a fence that will turn cattle. The only cost of the live fence is the price of the seed and the labor. However, a settler frequently finds it necessary to obtain returns from his land before investing even the smallest amount of capital in any way but the most essential permanent improvements. Under these circumstances, the herd-law of Nebraska has a beneficial operation. The intent of this law is to fence crops from the cattle, and to fence stock within inclosures. The enactment provides, under penalty, that an owner of stock shall not allow his animals to trespass and commit damage on a neighbor's land. The result of this law is—as live fences have to grow and board-fences are expensive—that, when a locality is settled, the cattle are herded together under charge of men or boys who are paid for their labor from a fund jointly and proportionally subscribed by the stock-owners. While at pasture the herd is taken to the best feeding-grounds in the neighborhood. Every night the milchers are returned to the owners, the other cattle being corraled. The law is considered to work well. It prevents the necessity of fencing when a farmer could not well afford the cost; but it must also be added that it is a check on fencing when the work ought to be undertaken.

Question 9. Cost of getting stock and produce to market.

Answer. The local market for wool and beef is at the farmer's door, for the wholesale merchants of Chicago and Saint Louis collect produce by traveling agents. Whenever a district becomes sufficiently settled to support a town, one comes into being, in a conveniently central position, which depends for its trade on the surrounding country. Produce is, therefore, readily marketed, and the wants of the farm and the household supplied. As the country, however, becomes more thickly peopled, and its industry develops, the farmers and stock-raisers will probably deal more or less directly with the distant consuming markets. The way to Chicago and the eastern ports is opened by the Burlington and Missouri River Railroad, and westward by the Burlington Company and the Union Pacific Company. The Atchison and Nebraska Railroad strikes from the Missouri at Atchison, Kansas, and the Saint Joseph and Denver Railroad from the Missouri at Saint Joseph, Missouri. As the mineral resources of the Rocky Mountains are developed this section of country—Nebraska is the nearest agricultural State to the mountains—will find a profitable market there, while, by the Missouri and the Mississippi, the southern markets are open.

The drawbacks I alluded to are as follows: the difficulty in obtaining building materials and fuel, especially after you get west of Lincoln, for exactly the same remarks made in respect to Southeastern Dakota apply here. Another difficulty, though not a very serious one, is, that west of Crete wells must be sunk to a considerable depth—from 80 to 120 feet—to find water; and streams being scarce, it is difficult to obtain a supply of stock-water. A third drawback, which applies also with equal if not greater force to Dakota and Southwestern Minnesota, is the severity of the winter-storms. It is true these are not of very frequent occurrence, but when they do come, and few winters pass without one or more, they are very severe, and often occasion many hardships and much suffering, but experience will teach the settlers how to prepare for and protect themselves against these.

PART II.

SPECIAL REPORTS

ON

GEOLOGY AND PALEONTOLOGY.

LIGNITIC FORMATION AND FOSSIL FLORA.

BY LEO. LESQUEREUX.

COLUMBUS, OHIO, *March* 25, 1873.

DEAR SIR: According to the directions received from you, I spent the months of July and August in exploring, first, the plant-bearing Cretaceous strata of the Dakota Group, in the valley of the Saline River and on the Smoky Hill Fork of the Kansas; then the Lignitic formation of the Rocky Mountains, from Trinidad to Cheyenne, and along the Union Pacific Railroad to Evanston. You requested me to have these explorations especially directed in view of positively ascertaining the age of the Lignitic formations, either from data obtainable in collecting and examining fossil vegetable remains, or from any geological observations which I should be able to make.

The following report gives the details of these researches. Its divisions are marked by the nature of your instructions. The first part after recording the facts derived from explorations at different localities, discuss the age of the Lignitic in considering geological and paleontological evidence. The second part reviews what is as yet known on the formation of the lignite, the distribution of the lignitic basins, their productive capacity for combustible mineral, and the present application of the material. The third part enumerates the species of fossil-plants obtained in the explorations of this year, either by myself or other of your assistants, describes the new species, and compares their local distribution, &c.

On this last point my researches have been very successful. I obtained, from the Cretaceous and from the Lignitic, a large number of good specimens, which, selected in place and there compared, allowed me to fix more positively the characters of many species either not satisfactorily known or as yet undescribed. This work was rendered especially profitable by the assistance of Mr. L. Lesquereux, jr., who pursued the researches with scientific interest and unceasing energy, and who frequently discovered at remote or distant places the richest deposits of fossil vegetables.

Allow me, sir, to gratefully acknowledge the valuable assistance received from yourself in railroad passes, letters of introduction, &c., still more by information from your former reports, and also to mention the kind assistance offered everywhere to my explorations by the superintendents of mines, the engineers of railroads, the proprietors, &c., who generally manifested interest in my researches. At Fort Harker and Medicine Bow a generous hospitality was offered me by Lieutenant Edward Randall and Lieutenant Hall, commanding the stations. I am also indebted to Messrs. B. C. Smith and Eugene Ford for passes to Saint Louis, also to E. A. Ford for pass to Kansas City, and to Colonel Fisher for pass from Denver to Cheyenne.

Very respectfully, yours,

L. LESQUEREUX.

Professor F. V. HAYDEN,
United States Geologist, Washington, D. C

PART I.—DETAILS OF EXPLORATIONS IN THE LIGNITIC FORMATIONS OF THE ROCKY MOUNTAINS.

Before arriving at Denver, on the line of the Kansas Pacific Railroad, I had the opportunity of examining, at two different places, heaps of lignitic coal taken out of abandoned and closed shafts. The lignite appeared of very poor quality, had been taken from various depths, and little evidence on the age of the strata could be obtained from the mixed and mostly disintegrated materials scattered around near the mouth of the shafts. West of Denver, at Golden, Marshall's, &c., I became more intimately acquainted with the general features of the so-called western Lignitic formation. Afterward, from Denver, my explorations were pursued southward to Colorado Springs; then in the Arkansas Valley, and from Cañon City, along the base of the Rocky Mountains, to Trinidad and the Raton Mountains, in New Mexico. As it is at this last-named locality that I was for the first time able to see a well-exposed section of the whole formation, to study, therefore, its essential characters and the relative position of its more important members, I propose to begin, at the Raton Mountains, the descriptive narration of my researches, to pursue it hence northward to Denver and Cheyenne, and then along the Union Pacific Railroad to Evanston, where the explorations were discontinued. In following this plan some preliminary general conclusions may be taken from the data ascertained at the beginning, and may be used henceforth as points of comparison and reference for facts and observations obtained elsewhere, and which may afford confirmation or conflicting evidence.

§ 1. RATÓN MOUNTAINS.

The small town of Trinidad is pleasantly nestled on the south side and in the bottoms of the Purgatory River, which here runs eastward, to take farther east a more northerly course to the Arkansas River. Behind the town a series of round, more and more elevated hills cover the base of the highest peak of the Raton: Fisher's Peak, a dark basaltic or volcanic mass, which towers above the country at an altitude of about 2,000 feet. Opposite Trinidad, on the south side of the river, appears an extensive range of hills capped by thick, mostly perpendicular rocks of sandstone, overlying black soft shale, which descend in steep slopes to the plain. On the western side the Raton Creek, running north, passes through the hills in a narrow, pleasant, green valley, entering Purgatory River three miles above Trinidad.

In passing obliquely from the town to the Raton Valley, in a northwest direction, the stage-road gently ascends about 150 feet to a plateau which at first is seen formed, even at its surface, of the black shale No. 4 of the Cretaceous,* which here contains well-preserved, large, characteristic shells in ferruginous concretions. But soon the plain appears cut by undulations, which already, one mile from Trinidad, have their tops strewn with large broken flags of sandstone, over which no other trace of fossil remains but marine plants or fucoids are seen. A little farther from the town the same sandstone is in place, immediately and conformably overlying the black shale; and in entering the small valley of the Raton, the road curves around steep hills, whose base rests

* The divisions of the Cretaceous indicated in this report are those of Messrs. Meek and Hayden, marked in the general section of this formation in Dr. Hayden's report, 1870, page 87.

upon the fucoidal sandstone, and whose sides, exposed by denudation, are blackened by outcrops of coal at different altitudes. Here is the nearest place to the town where the coal is opened and sometimes worked in a very limited extent. These details render the locality easily recognizable.

A few sections of the Lignitic measures of the Raton Mountains have been given already from the hills along the creek.* They differ somewhat in the records of the distance and of the thickness of the lignite-beds, but the differences are easily accounted for by the great variety remarked, even at short distances, in the disposition of the strata of those Lignitic formations. They are, therefore, perfectly reliable, and it is merely to complete them that the two following ones are given here. They point out the exact relation of the Lignitic formation to the Cretaceous, and mark, besides, what I consider to be the essential character of a group of sandstone which separates these formations, and which, taken as yet as a kind of debatable ground, has been dubiously referred either to the Cretaceous or to the Tertiary. The first of these sections is taken along the small branch in whose banks the lignite-beds appear in succession down to the Raton Creek, and then following this creek to the Purgatory River, where the Cretaceous measures are exposed. It reads from top downward:

LIGNITIC.

	Ft.	in.
1. Sandstone and shale, covered with pines	60	0
2. Soft shale, alternating with soft clay, (soapstone)	35	0
3. Outcrop of lignite, indifferent	2	0
4. Soft-shale and fire-clay	26	0
5. Lignite outcrop, thin	1	0
6. Hard gray shale, with fossil plants at base†	30	0
7. Shaly hard sandstone, in bank	6	0
8. Soapstone shale	2	0
9. Lignite outcrop, good	2	0
10. Fire-clay and shale	36	0
11. Lignite, exposed	2	6
12. Fire-clay	6	0
13. Soft shale	30	0
14. Lignite, opened	4	0
15. Fire-clay	8	0
16. Ferruginous and shaly sandstone, covered	50	0
	300	6

SANDSTONE.

	Ft.	in.
17. Brown, reddish shaly sandstone, with *debris* of land-vegetables	37	0
18. Yellow shaly sandstone, full of fucoids	5	6
19. Ferruginous sandstone, barren	11	0
20. White compact sandstone, in bank and barren	28	0
21. Hard white sandstone, in bank, with fucoids	10	0
22. Soft white sandstone, with fucoids	32	0
23. Very hard block sandstone, barren	19	6
24. Ferruginous sandy shale, with fucoids	6	6
25. White sandstone, barren	5	6
26. Ferruginous sandy shale, with fucoids	8	0
27. Red shaly sandstone, with great abundance of fucoids	3	0
28. Hard white sandstone in bank, some fucoids	12	0
	178	0

* F. V. Hayden's Report of the United States Survey of Colorado and New Mexico, (1869,) pages 55 to 57; Notes on the Geology from Smoky Hills to Rio Grande, by T. S. Leconte, M. D., pp. 20 and 21.

† At a short distance the sandstone No. 7 takes the place of the shale-bearing plants.

This last stratum is underlaid by the Cretaceous black shale No. 4. In some places No. 27 is the last member of the section, and is, therefore, in immediate superposition to the black shale. From No. 17 to 28, and perhaps already from the upper member, which is covered, the whole measures form a single group of white or yellowish ferruginous sandstone-beds, separated by bands of hard laminated clay, mostly sandy or passing to sandstone, the whole measuring 178 feet. The characters of this group, as clearly recognized here, are as follows:

1st. Its general color is whitish gray, so white indeed, sometimes, that the lower strata, seen from a distance, appear like banks of limestone.

2d. Though generally hard, it weathers by exfoliation under atmospheric influences, and its banks are thus molded in round undulations; and, as it is locally hardened by ferruginous infiltrations, it is often too concretionary or grooved in cavities, so diversified in size and forms that sometimes the face of the cliffs shows like the details of a complicated architecture.

3d. It is entirely barren of remains of animals.

4th. On the contrary, from its lowest stratum to its upper part, it abounds in well-preserved remains of marine plants or fucoids, which, at some localities, are seen even in the sandstone over lignite-beds.

5th. In its upper part the sandstone or the shales of this group are mixed with broken *débris* of land-vegetation, with which also fucoidal remains are found more and more abundant in descending.

The disposition of the strata and their compounds is about the same on the other side of the Purgatory River, opposite Trinidad, where the section is from top downward:

		Feet.
1.	Hard ferruginous shaly sandstone with few remains of fucoids, but abundance of *debris* of land-plants	25
2.	Hard whitish sandstone, full of fucoids	57
3.	Shaly sandstone, with same abundance of fucoids	50
4.	Soft laminated ferruginous sandy clay, with fucoids	11
5.	Ferruginous shale, with fucoids	4
6.	White block-sandstone, barren	5
7.	White sandstone, with fucoids	22
8.	Ferruginous shaly sandstone, with fucoids	33
9.	Black shale of No. 4, Cretaceous	147
10.	Covered space, sandstone and shale to bed of river	153

In both these sections the remains of marine plants are remarked in most of the sandstone-strata and their intermediate clay-beds, and as abundant at the base as near the upper part. And in this last section they are seen mixed with fragments of land-plants, even to the top of the sandstone cut like a tower at the point of the highest hill facing Trinidad.

In passing from the black shale of the Cretaceous No. 4 to this group of sandstone-beds overlaying it, the difference in the characters is striking, not only in considering their compounds, but in the class of fossil remains which they contain, the traces of deep marine life predominating in the black shale, while here they have totally disappeared. The absence of the upper Cretaceous formation No. 5 might be taken into account for explaining this difference. We will see elsewhere that it is not the case, and that the upper Cretaceous sandstone-beds are as definitely characterized by their fossil remains as a deep marine formation as the second group No. 4. Now, in the sandstone above No. 4, marine life still marks its activity only by the abundant remains of fucoids, indicating by their growth a comparatively shallow water. They point out, therefore, to a slow upheaval of the bottom of the sea in which they appear to have lived; for their stems penetrate the sandstone in every direction. And this indication is still more manifest in the great abundance of *débris* of land-plants which seem as ground by the waves, thrown upon the shore and mixed in the sand with fucoidal remains. This slow upheaval, and its result in the formation of a new land, are read as in a book in the fossil remains of this group of sandstone, and every observer should forcibly admit that these memorials of old expose the beginning of a new era, or of what we call a new formation. This conclusion, however, can be warranted only if by further researches we recognize that this fucoidal sandstone is not a mere local formation; that it covers a wide area, preserves everywhere its relative position to the Cretaceous under it, and to the lignitic beds above, and has always the same characters either in its compounds or in its fossil remains.

That this sandstone forms all over and around the Raton Mountains the base of what is called the Lignitic formation, and that it there overlies the black shale No. 4, has been remarked by all the geologists who have explored the country. Dr. F. V. Hayden describes it briefly but very exactly in his section* as "*a massive, heavy-bedded sandstone, yellowish gray, (or whitish,) rather concretionary in structure, and weathering by exfoliation, over Cretaceous shales with Inoceramus and Ostrea,*" this last bed remarked elsewhere as Cretaceous No. 4. Nothing is said of the characters of its remains. But the specimens of fossil-plants gathered at the Raton Mountains by Dr. Hayden and his party, some of them marked: from the sandstone below the coal, bear fucoidal plants, representing the species of *Halymenites*, which, by the abundance of its remains, appears essentially characteristic of the marine flora of that period. Dr. Hayden still remarks it toward the southern end of the Raton Pass, where the Lignitic formation, 100 to 150 feet thick, containing two or three small seams of coal, rests immediately upon an irregular bed of alternate thin layers of mud, sandstone, and clay, which he calls beds of passage between the Cretaceous and the Tertiary of that region. Dr. John Leconte, considering the same strata as Cretaceous, mentions them in his report† as continuing southward of the Raton along the base of the Rocky Mountains, "*forming like an immense terrace, which extends as far south as the valley of the Tonejo, and perhaps even to the north bank of the Cimarron.*" They are evidently the same sandstone-beds as those of the Raton Mountains; for the same geologist remarks that they were observed by him northward from Trinidad and far toward the Arkansas. Indeed, from this place northward to the base of the Spanish Peak, these sandstone-beds, always with the same characters and the same thickness as marked for the eight first members of my second section, 207 feet, and always immediately over the Cretaceous No. 4, form like an immense terrace perpendicularly, cut like a wall facing east, high above the plain. They support the lignitic beds which still tower above them, either ascending in steep declivities from the top of the perpendicular sandstone, or receding at some distance where they have been more deeply sapped by erosion. "*This abrupt front,*" says Dr. Hayden, "*seems to form a sort of shore-line of a wonderful basin, as if a body of water had swept along and washed against the high bluffs, as along some large river.*"‡ The stage-road from Trinidad to Pueblo follows the base of the cliffs for thirty-two miles; and, from each station, a geologist has convenient opportunity for the exploration of these re-

*Report 1869, page 57.
† Notes on Geology, &c., loc. cit., pp. 22 and 23.
‡ Dr. F. V. Hayden's Report, 1869, p. 53.

markable hills, and for the study of the distribution of their geological strata and of their characters. South of Trinidad the lignitic measures have been followed nearly without interruption to the Maxwell estate,* about fifty miles. As it is not as yet ascertained, however, how far they go to the west, the area which they cover at and around the Raton Mountains cannot be positively marked. It is not exaggeration to estimate it at a few hundred, say six to eight hundred square miles. Besides this, the same formation is reported farther south, near and around Santa Fé; in the Gallisteo Valley; along the mountains to Albuquerque, and in the valley of the Rio Grande as far south as Fort Craig. Everywhere, with a single exception, which shall be considered hereafter, these lignitic measures have exposed, by their relative position, by the absence of animal remains in the thick beds of sandstone which indicate their base and constitute their foundation, by the homology of their marine and land flora, as recognized in the remains of fossil-plants which they contain in abundance, all the characters indicated above as authorizing, if generally marked, the separation of this group from the Cretaceous formation.

§ 2. The Arkansas Valley from Pueblo to Cañon City.

From Pueblo to Cañon City, forty-five miles, the stage-road follows a broad valley, closed on the south side by the Greenhorn Mountains, on the north side by the Rim Range of the Colorado Mountains, over which towers Pike's Peak, whose summit is visible all the time. The whole valley is essentially Cretaceous; all the eminences, either near the borders or in the middle, are hills of this formation, molded by the erosions of the Arkansas River, which has dug numerous beds in this soft material. The borders of its present bed, like those of its old ones, where the road sometimes meanders, as in a labyrinth, are picturesquely marked by rocks of diversified forms, resembling monuments built by the hand of man, towers, columns, ruins, &c., often strewn around in confusion. On the south side of the river, however, about fifteen miles before reaching Cañon City, the aspect of the country is modified by the appearance of a group of hills of the Lignitic, filling the space from the base of the Greenhorn Mountains to the borders of the river, three to four miles in width. The whole area covered here by the Lignitic is, from the report of Mr. Neilson Clark, civil engineer and superintendent of the mines, about thirty-three square miles.† The lower strata, overlying the sandstone, rise abruptly about 50 feet above the Arkansas River, forming a kind of narrow plateau, over which the hills of the Upper Lignitic rise up to about 500 feet. The whole thickness of the lignite-bearing strata is estimated, in the journal quoted above, at about 600 feet. The following section is taken on the land of the Central Colorado Improvement Company, where coal-beds are already now extensively worked.‡ It is written from bottom upward :

Underlying the bottom sand-rock is a thick bed of clay, interlaid with seams of sand-rock, whose thickness cannot be less than 200 feet.

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* Dr. F. V. Hayden's Report, 1869, p. 57.

† Engineering and Mining Journal, November 12, 1872. I owe also to Mr. Clark, who had the kindness to take me to the mines, the details of the following section, and other valuable information.

‡ Details on the lignite, its comparative value, thickness, &c., are given in a separate chapter.

		Ft.	In.
1.	Bottom sand-rock grayish-yellow, filled with concretions of red sandstone, stratified with red sandstone, decomposes easily into yellowish-white sand, with little grit, (exfoliating)	195	0
2.	Brown, very soft shale, (soapstone)	2	0
3.	Coal	1	8
4.	Brown (chocolate-colored) very soft shale, (soapstone)	2	0
5.	Coal, separating in blocks by cleavage	4	2
6.	Brown, very soft shale, (like No. 4)	8	0
7.	Coal ... 1 foot to	1	4
8.	Shale	0	10
9.	Clay	2	6
10.	Coal	0	10
11.	Shale, with thin layers of argillaceous carbonate of iron	9	0
12.	Sand-rock	7	0
13.	Shale	3	0
14.	Sand-rock	33	0
15.	Shale, with thin layers of carbonate of iron	8	0
16.	Coal	2	2
17.	Slate	14	0
18.	Sand-rock	2	0
19.	Shale	2	0
20.	Coal	1	8
21.	Rock and shale	12	0
22.	Coal	2	8
23.	Rock and brown shale	25	0
24.	Coal	1	1
25.	Brown shale	1	10
26.	Sand-rock	22	10
27.	Slate	0	6
28.	Coal, (river-seam)	3	8
29.	Shale	10	0

Then follows some 200 feet of sand-rock, containing three seams of coal, varying from 10 to 20 inches, one of which yields pieces of coke. On the edge of the basin, the coal-bearing strata are few in number; toward the center they increase in number, high bluffs continually appearing until, over the center of the basin, we find the highest geological rocks of the region.

Mr. Clark still remarks:

But in regard to the formation of the coal the regularity of the strata is wonderful. It is true that, toward the north, the seams of coal are thinner, and the sandstone much thicker, than to the south; true, also, that at times the parting of the seams, mostly of clay, varies somewhat in thickness, but over the whole extent of the basin, some thirty-three square miles from outcrop to outcrop, the dip is conformable to the center with a few unimportant exceptions, and the thicknss of the seams and the sand-rocks varies regularly.

Mr. Clark's section has been carefully made from data obtained in mapping and surveying the whole extent of this lignitic basin. I therefore consider it as a favor to have the privilege of substituting it for my own, not only on account of its being more detailed, but because it affords opportunity to consider here, as at the Raton Mountains, the essential characters of the Lignitic from observations presented under different points of view.

In the above section it is easy to recognize from its composition, its color, its mode of disaggregation, the sandstone No. 1, about 200 feet thick, as the equivalent of the lower fucoidal sandstone of the Lignitic of the Raton Mountains. The essential character taken from its remains is not mentioned. But I had full opportunity to remark it, not only in the lower beds under the coal worked by the Improvement Company, but also where the same sandstone is exposed, together with the upper Cretaceous strata, in the middle of the valley, half way between Pueblo and Cañon City. In my examination of the strata overlying the lignite of the same basin, I found not only a number of dicotyledonous leaves in the shaly sandstone, but in the intermediate beds of hard sand-rock too, many remains of fucoidal plants, especially of the species which, so easily recognized by its tuberculate surface, appears to be the most common one, and the more characteristic too of the Lignitic. This is a proof that the eocenic character of this formation is not limited to its base, and that the lower sandstone, together with the beds of lignite, are of the same formation; that, indeed, as it will be seen elsewhere, the lower sandstone sometimes includes in its divisions beds of lignite to its base.*

Can we here determine the upper part or the end of this formation? At the Raton its lower stage is especially formed. I could see there nothing in ascending the highest hills or slopes covering the volcanic central group which indicated any change in the characters of the strata. But near the center of the Lignitic of the Arkansas Valley, the formation is covered with high hills, and the 200 feet of lignite-bearing measures above those marked in the section are overlaid by beds of coarse grit, mostly conglomerate sandstone, which I consider as the closing strata of the Eocene-Lignitic period. For this, as for the great sandstone of the base, we have to see if these upper conglomerate strata have been observed elsewhere and in circumstances which may prove their immediate connection with the Lignitic. Here the 200 feet of measures under them are formed by an alternance of beds of soft clay or soapstone, with an abundance of silicified wood, beds of lignite, (the outcrop of one near the top indicating at least two feet,) beds of clay, which become hard, uninterrupted, blackened by carbonaceous matter; and over them, in immediate superposition, ferruginous conglomerate sandstone separated by bands of soft-grained sand-rock in a thickness of about 75 feet. No trace of organic remains are found in this top sandstone. I found fucoidal plants mixed with broken remains of Cyperaceæ as high as 300 feet below the top.

Three miles northeast of Cañon City I had opportunity of examining the formation which underlies No. 1 of Mr. Clark's section. It is a compound of thin beds of yellow, compact, sandy clay, separated by thin layers of coarse materials or of sandstone. It contains animal remains only, large scales of fishes and shells of Cretaceous characters overlying the black shale No. 4, in a thickness of about 40 feet. What there remains of this upper group of the Cretaceous is not much, the materials being too soft, and having been swept away by erosion. But there is enough left to show at once the great difference existing in the compounds and nature of the strata of this Cretaceous upper formation, and of those of the lignitic sandstone, which here is immediately above. The superposition is seen, as remarked above, in the Arkansas Valley, on the banks of a creek on the stage-road midway between Pueblo and Cañon City.

All this is not new. The same yellow, arenaceous clays of No. 5 in the Arkansas Valley are already exactly characterized and reported by Dr. Hayden,† who marks, too, their succession in ascending as "passing up into a somewhat extensive series of what I call mud-beds, composed of thin layers of clay and mud sandstones, with all kinds of mud-markings, sort of transition beds or beds of passage. In the upper portion of these layers I found an imperfect specimen of *Inoceramus*. This group of beds is from 50 to 100 feet in thickness. Resting upon them is a thick bed of rusty-yellow sandstone, which I regard as the lower bed of the Tertiary deposits," &c. These mud-beds, with all kinds of mud-

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* Dr. Hayden has, from five miles south of Trinidad, specimens of the same plants labeled, *"From the sandstone above the coal."*

† Dr. F. V. Hayden's Report, 1869, p. 50.

markings, appear to belong to the lower part of the fucoidal sandstone, the remains of marine plants often resembling mud-marks of various kinds. The presence of a specimen of *Inoceramus* in the upper part of the strata is an apparent contradiction to this conclusion. The matter is left aside for future discussion.

§ 3. COLORADO SPRINGS TO DENVER.

From Pueblo northward no trace of the Lignitic is seen along the mountains till near the southern base of a range of hills, the Colorado Pinery, which, in its eastern course, at right angles from the primitive mountains, forms the divide of the waters between the Arkansas and the Platte Rivers.

The succession of the Cretaceous strata is clearly marked on the banks of Monument Creek. In following it up from Colorado Springs the formation can be studied to the top of the black shale No. 4, and above this to a bed of brownish sandstone, separated from the black shale by thin layers of *Tuten clay* and soapstone, where the last remains of Cretaceous animals, especially fragments of *Baculites*, are still abundant. Over this is the sandstone, barren of any kind of remains, overlaid in the banks of the creek by a bed of fire-clay, or very soft chocolate-colored shale, which marks the base of the following section at low-water level of the creek:

	Feet.
1. Brown laminated fire-clay, or chocolate-colored soft shale, a compound of remains of rootlets and leaves and branches of undeterminable conifers	2
2. Coal, soft, disaggregating under atmospheric influence	2
3. Chocolate-colored clay-shale, like No. 1, with a still greater proportion of vegetable *debris*	6
4. Soft, yellowish, coarse sandstone in bank	8
5. Clay, shale, and shaly sandstone covered slope	130
6. Soft, laminated clay, interlaid by bands of limonite iron ore, thin lignite seams, and fossil-wood	88
7. Lignitic black clay, in banks	32
8. Fine-grained conglomerate	112
9. Fine-grained sandstone	4
10. Coarse conglomerate	7
11. Sandstone	3
12. Ferruginous hard conglomerate	32
	426

The soft, chocolate-colored, laminated clay, Nos. 1 and 3 of this section, has here the same composition, color, and characters as the clay under and above the coal-beds of the Raton Mountains and of the Arkansas Valley. Indeed, I have seen it the same, more or less darkly colored by bitumen, however, in connection with coal-beds, over the whole area of the Lignitic which has been passed in my exploration. This clay takes the place of the fire-clay so generally underlying the coal-beds of the Carboniferous measures, where, as in the Lignitic, it forms, besides the floor, some bands, clay-partings, separating coal-strata, and soft shale overlying them. It has also been formed in the same way by immersed fresh-water plants, or true water-plants like *Characeæ*, by the innumerable divisions of the roots of trees living along or within the swamps, and by the *débris* of the trees, which appear to have been mostly conifers. The fragments entering into the composition of this clay-shale are much more divided and obscured by maceration than the remains preserved in sandstone or sandy shale, and, except for a few branches of conifers, I have not yet been able to determine any of them in a satisfactory manner.

The sandstone over the Gehrung coal, No. 4 of the section, is by its appearance, its mode of weathering by effoliation, &c., the equivalent of the lignitic fucoidal sandstone. On the south side of the river, where the coal is opened, it does not contain fossil remains of any kind, and is comparatively thin. But on the other side, its thickness increases to about 75 feet, and it has some remains of fucoids, and a thin bed of coal, (6 inches,) a mere streak in the sandstone. In its upper part, this sandstone, ferruginous and shaly, contains a quantity of dicotyledonous leaves, *Populus*, *Platanus*, &c., with large fragments of *Sabal* leaves, all species which, by identity with some found at the Raton and in the Arkansas Valley, do not leave any doubt about the contemporaneity of these Lignitic measures.

By far the most interesting member of the section at Gehrung's is the conglomerate formation at the top. These rocks are a compound of small grains or pebbles, mostly of white quartz, and of silex of various colors, varying in size, at least for the largest proportion, from that of a pea to that of the head of a pin. Pebbles as large as a walnut are still abundant; the largest, like the first, are rare, and especially found within the layers of the top. This formation, 150 feet thick at least, is conformable to the strata overlying the coal of the base of the section, and here, as it will be still seen at other places, it overlies immediately thick banks of soft, laminated, bituminous, black clay. The materials forming this conglomerate are cemented together by a thin coating of carbonate of lime, which easily disaggregates under atmospheric influence, except in the upper stratum, where the cement has been hardened by ferruginous infiltration. Its greater resistance has then locally preserved the whole mass from destruction. These conglomerate cliffs, which, from the hotel of Colorado Springs, arrest the view to the west, appearing like high bluffs of white sandstone, are evidently the mere vestiges of an extensive formation, originally covering the base of the mountains from the Arkansas River, extending far inland to the east. For hundreds of miles the ground of Colorado Territory is formed by its *debris*. They have given to the soil that apparent sterility of surface which is so remarkably changed into fertility by the culture of the substratum composed of softer-grained materials and lime. Nearer to and along the base of the Colorado Pinery, whose Lignitic hills have escaped destruction by the upheaval of the ridge, these conglomerates, still detached from the common mass, and molded into the most diversified forms by disintegration, have scattered columns, pinnacles, round towers, and cupolas over a wide area, the far-famed Monument Park.

I have not had opportunity to examine the highest ridges of this Colorado Pinery, whose southern base is about five miles from Colorado Springs, and on the other side descends to five miles south of the South Platte. Dr. F. V. Hayden, who has surveyed the formation, considers it as Upper Miocene (?) (modern Tertiary deposits) comparing it to a group of rocks which covers the country from Fort Bridger to Weber Cañon, and also to a series of sands and sandstones along the Gallisteo Creek below Sante Fé, the Gallisteo group.* We shall have opportunity to see this formation again, and to consider its age with more details. Here, as at other localities, it is conformable to the Lignitic, which reappears on the northern side of the ridge, along Cherry Creek and other branches emptying into the Platte. No beds of Lignite are as yet reported along this slope; but the clay-beds have, as on the other side, an abundance of silicified wood. I have seen many fine specimens of it in

* Dr. F. V. Hayden's Report, 1869, p. 40.

the cabinet of Mr. Byers,* the redacteur of the Denver City News, and since my return have read in the same journal the description of a fossil-tree found at Cherry Creek, which, had I read it while at Denver, would have induced me to visit the place and ascertain the exactness of assertions scarcely credible. This reported fossil *palm*-tree, which is hollow, measures at its base 22 feet in diameter, and 20 feet from base the diameter is still 15 feet. This is nearly equal to the size of the largest *sequoia* or giant tree of California. Such a size cannot be supposed, at least not for palm-trees. Whatever it may be of this discovery, the abundance of fossil-wood indicates at Cherry Creek the same level as that of the beds of clay marked in the section of Gehrung's as No. 6. I believe that the lignite-beds underlie there these fossil-trees at a distance of 100 to 150 feet. Not far from this place, fourteen miles east of Denver, on the Kansas Pacific Railroad, a bed of lignite 8 feet thick was reached at 81 feet from the surface by a shaft, which is now closed, and whose section is worth future reference. I owe it to Mr. E. B. Mally, who superintended the work. The section is from top to bottom:

	Ft.	In.
1. Slaty clay	16	0
2. Sand	18	0
3. Yellow clay	5	0
4. Light-blue soapstone	6	0
5. Brown soapstone	2	0
6. Soapstone and clay	13	0
7. Drab soapstone	14	0
8. Dark-brown soapstone	2	0
9. Black slate, with veins of coal	5	6
10. Coal, wet and smutty	4	0
11. Coal, better	3	0
12. Black-clay parting	0	4
13. Coal	1	0
14. Soapstone, blue, brown, and black	24	7
15. Hard sand-rock	1	4
16. Spotted sand-rock	12	0
17. Very hard sand-rock	5	0
18. Soft, sandy clay	9	6
	142	3

The work was abandoned on account of the poor quality of the coal; but the section indicates the place of the bed, at the top of the great Lignitic or fucoidal sandstone under the series of beds of clay, soapstone, &c., as at Gehrung's and at the Raton Mountains.

§ 4. South Platte to Cheyenne.

From the mouth of Bear Creek into the Platte, a few miles west of Denver, the Lignitic formation, abutting against the Cretaceous and diversely thrown up by the upheaval of the primitive mountains, follows the base of these mountains in a nearly continuous belt to Cheyenne. Though generally covered by detritus, the basin is deeply cut by all the creeks descending to the plain—Clear, Ralston, Coal, Erie, Boulder, Thompson Creeks, and others—and the strata thus exposed can be studied in their relative position, their compounds, &c., at many places. This study is most interesting, but the same ground has been already surveyed by geologists of repute, Dr. F. V. Hayden, Dr. John Leconte, Mr. James T. Hodge, &c., who have given to their explorations more

* I owe to this gentleman valuable information on the distribution of the lignite-beds around Denvers.

time and experience than I had at my disposal. I shall therefore refer for details to the reports already published,* and restrict my observations to facts essentially connected with my line of researches—on the age of this Lignitic formation as indicated by vegetable remains.

Golden is on the banks of Clear Creek, at its outlet from a deep cañon, and in the middle of a narrow valley, shut up on the west by the slopes of the primitive rocks and on the east by a high wall, a trap-dike, which here follows the same trend as that of the mountain at a distance of one to one and one-half mile. As it is generally the case along the eastern base of the Rocky Mountains, the more recent formations have been thrown up and forward, and their edges upraised to a certain degree nearest to the uplift, and thus succeeding each other by hog-backs facing the mountains, they pass toward the plains in diminished degrees of dip, and soon take their original horizontal position.

At Golden, the Lignitic strata, compressed, as they are, between two walls of eruptive rocks, have been forced up on the western side in a nearly perpendicular position, while on the other they were thrown up at the same time by the basaltic dike, and thus folded or doubled against their faces in the same way as the measures of the anthracite basin of Pennsylvania have been so often compressed in multiple folds between the chains of the Alleghany Mountains. In that way the lowest strata of the Lignitic, which are nearly perpendicular, overlie the Upper Cretaceous strata, which, following the slope of the mountain's plunge, inclined in a less degree. The line of superposition of both formations is seen along a ditch opened for a canal of irrigation, about 200 feet from the tunnels made in a bank of clay which underlies the lower lignite-bed, and which is worked for pottery. These upper Cretaceous strata are seen in the same position, and exactly of the same nature as at Gehrung's: thin beds of soapstone, or laminated clay, with Cretaceous fossils, and above them the same kind of *Tuten-clay*, a few inches thick, under the lower sandstone of the Lignitic, which is there covered. The surface of the ridge formed by the upthrow is pierced by the edge of the perpendicular strata, especially of the hard sandstone, and there the characters of the lowest beds are recognized at many places as the same as those of the fucoidal sandstone of the Raton Mountains. At the cut made across the measures by Clear Creek, the lower sandstone appears proportionally thin, 10 to 20 feet. It is a white, soft-grained sandstone, hardened by metamorphism, containing, besides remains of decotyledonous leaves, some species of finely preserved fucoids; among them one species as yet undescribed and not seen elsewhere. In following the same sandstone to the south it is seen increasing in thickness, and near and under the Roe coal, five miles from Golden, it forms a high, isolated ridge, at least 200 feet thick, barren of any kind of remains, except some fucoids.

By its compound the alternance of its coarse-grained and soft-grained strata, these being often mere clay or mud beds, its characters appear the same as those of the lower Lignitic sandstone of the Raton Mountains. It has, too, broken, undeterminable fragments of wood, cyperaceæ, &c. Besides the species of fossil decotyledonous leaves found in the white sandstone of Golden, most of them homologous, or even identical with some species of the Raton and other localities, it has one of those very rare land-plants which have been described and recognized in Europe as pertaining as yet exclusively to the Eocene.†

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* Dr. F. V. Hayden, Silliman's Journal, March, 1868, pp. 101; Geological Report, 1869, pp. 29 to 37; Notes on Geology, &c., by Dr. Leconte, pp. 47 to 53; on the Tertiary Coal of the West, by James T. Hodge, in Hayden's Geological Report, 1870, pp. 318 to 329.

† See description of species for further details.

My researches at and around Golden have been rewarded by the discovery of the finest and best preserved specimens of fossil-leaves that have ever been found in this country, with the exception, perhaps, of those of Black Butte. They were obtained, 1st. From the hard white sandstone under and interlying the beds of coal, the white sandstone hardened by metamorphism as described above; 2d. From beds of white clay upheaved against the sides of the basaltic dike, a clay hard as silex from metamorphism, having mostly remains of palm-leaves; 3d. From three miles south of Golden, from a sandstone still upheaved near the tail of the dike, but scarcely changed by heat and easily cut in large pieces. These specimens should indicate a different degree of hardening by heat, according to distance from the granitic mountains on one side, and from the basaltic dike on the other. It is remarkable, however, that the lignite obtained from the mines at Golden, like this plant-bearing sandstone, scarcely bears any trace of the action of heat.

In following the narrow valley from Golden to Murphy's coal-beds, the same strata worked at both places have been traced all along in a distance of more than five miles. From Murphy's or Ralston Creek, the Lignitic is covered by *débris*, under which evidently the same formation is hidden, with the same kind of strata. For the lignite is worked at Leiden's, about two miles north of Murphy's, from same nearly vertical strata; and five miles farther north, the formation cut by Coal Creek exposes still the same Lignitic measures, now tending to their natural horizontal position by the disappearance of the basaltic dike. Still farther north, in the valley of Boulder Creek, at Marshall's, Wilson's, Brigg's, Erie, &c., the Lignitic exposes, by the number and thickness of its veins of coal and of its beds of sandstone, a fullness of development remarkable indeed, and scarcely seen elsewhere. From Golden to Marshall's I have not obtained any specimens of fossil-plants. A careful examination of the numerous beds of sandstone exposed there would have demanded much more time than I had at my disposal. At Marshall's, besides specimens of interesting dicotyledonous leaves, I found few fucoidal remains, the lower sandstone being there below the level of the country. The main coal, by the abundance of large trunks of half-carbonized, half-petrified wood, shows a character which is remarked, too, at the main coal of the Arkansas River on the land of the Colorado Improvement Company. At Erie, the Lignitic is worked as at Marshall's, near the level of thecountry, and therefore no sandstone is exposed. In the shaly, sandy clay overlying the coal, I found only remains of dicotyledonous leaves and palms.

The continuity of the Lignitic formation is still traced farther north by Dr. Hayden, who, in his report of 1869, indicates a bed of coal opened and wrought to some extent, twenty miles south of Cheyenne. The section of the locality, as given on page 17, positively marks the position of this Lignitic as above a massive sandstone 50 feet thick overlying Cretaceous No. 5; and the same section, too, identifies some of the strata with those of Marshall's and of Black Butte by beds or aggregations of oyster-shells, *Ostrea subtrigonalis?* curiously represented by homologous or identical species at about the same horizon at these named localities. I believe that farther north, to Cheyenne, the same formations are still present, only hidden by the mass of detritus brought over them from the mountains.

Around Cheyenne the predominant formation is a thick bed or a succession of beds of conglomerate sandstone of the same composition and in the same position as the conglomerate of Gehrung's or of Monument Park in Colorado. It here overlies, as at Gehrung's, thick beds of black bituminous clay 15 to 20 feet thick, as exposed to the level of the creek. The difference in the compounds of these conglomerate strata is merely in the larger size of the pebbles, which at Cheyenne vary from the size of a pea to that of the head, and in the presence of thin beds of fresh-water limestone, resembling tufa, which are seen here and there, of very limited extent, similar in composition to the calcareous clay-beds at the base of the Green River group. I found in these conglomerates two pieces of fossil-bones, the only traces of fossil-remains which I was able to recognize in this peculiar formation. Though I cannot positively say as yet if it closes the Lignitic period, and is therefore a member of this formation, its peculiar identity of position and of composition is worth remarking. A boring of a few hundred feet at Cheyenne would settle the question and show if, as I believe it, the Lignitic beds may be found there at a depth of 200 to 300 feet. Anyhow, all what we have seen as yet tends to confirm the statement already made by Dr. Hayden in 1868, (Silliman's Journal,) "*that all the lignite Tertiary beds of the West are but fragments of one great basin, interrupted here and there by upheaval of mountain chains, or concealed by the deposition of newer formations.*"

§ 5. Cheyenne to Carbon Station.

Along the Union Pacific Railroad, from Cheyenne up the Laramie Plains, the country has been explored by Dr. Hayden, who, in his report, (1870,) describes the passage from the primitive rocks, and marks further upon the plateau the re-appearance of the Cretaceous, its continuity and its limits to the West. A number of specimens sent to me in former years for examination, being labeled as from Rock Creek and Medicine Bow, I expected to find at these localities, at least some isolated basins of the Lignitic. This indication was a mistake; for, indeed, the Cretaceous strata are continuous along the railroad to four miles west of Medicine Bow, where they are seen abruptly passing under thick strata of the Lignitic barren sandstone. Though I did not find any fossil-plants at Rock Creek, my visit there afforded me a good opportunity of studying in the country around, the upper groups of the Cretaceous, and therefore of remarking at short distances the essential differences in the characters of both the upper Cretaceous sandstone and the Lignitic sandstone over it. Besides, the great quantity of remains of invertebrate animals, especially abundant in the upper Cretaceous, all representing deep marine species characteristic of the formation—*Ammonites*, *Scaphytes*, and *Baculites*, &c.—the matter itself, a kind of sandy calcareous shale, appears at first sight far different from that of the fucoidal sandstone. The color of the first is dark-brown or yellowish-brown, the texture finer-grained, mixed in some places with calcareous infiltrations; the banks, when exposed along the creeks or cut by erosion, do not weather in round, concretionary forms. They break in large cubic pieces, or separate in shaly layers, forming, by disintegration, heaps of broken fossil-shells, of angular fragments of rocks and of dust rather than sand. At Medicine Bow, the line of connection of both formations is perhaps more difficult to fix than at other localities, the fucoidal sandstone here being mostly barren of remains of marine plants. But from its base to its top, in a thickness of perhaps 200 feet, it is barren, too, of any remains of animals, while here and there, branches of fucoids appear, as thrown by the waves, being generally mixed with fragments of wood and stems of dicotyledonous plants. From the cut of the railroad west of Medicine Bow, where this sandstone is seen overlying the Cretaceous, and where two, fine mineral springs come out from its base, it is continuous to Carbon in repeated and deeper undulations, forming basins, which at this place and around, contain the upper Lignitic formation with remarkably thick beds of combustible mineral. The coal is mined at Carbon Station by a shaft descending through the following strata:

	Feet.
1. Shale, clay, and sandstone, at top	35
2. Ferruginous shale, with dicotyledonous leaves	3
3. Clay, shale, and sandstone, with the plants at top	18
4. Coal, (main)	9
5. Fire-clay and shale, with dicotyledonous plants	20
6. Coal	4
7. Fire-clay and shale	8
8. Coal	4
	*101

In following the railroad to about one mile west of Carbon, the upper coal is seen exposed in a cut, under a thick layer of compact, gritty sandstone, resembling the millstone-grit or the Mahoning sandstone of the Carboniferous formations, not only by its composition, but by the quantity of pieces of wood or streaks of coal mixed with it at its base. The wood is either petrified (not silicified) or transformed into coal, forming irregular thin layers which pass into the sandstone in various directions, sometimes ascending nearly vertically one or two feet high, and abruptly disappearing. This bank, too, has in some irregular small cavities pebbles of sandstone; even fragments of rolled wood transformed into coal, indicating its formation as that of a beach where the waves brought with the sand and imbedded into it materials of various kinds. Above this sandstone are beds of fire-clay with silicified wood, overlaid by thick layers of sandy shale, with fossil-leaves of dicotyledonous species, the whole topped by another thick stratum of coarse conglomerate sandstone. In the rubbish along the railroad I found one specimen of fucoid. I should have liked to examine the country with more details, especially in order to compare the distribution and the composition of this upper conglomerate sandstone with that of the upper member of the Lignitic of Colorado, and thus to possibly recognize an analogy of formation. But my attention was claimed by the examination of fossil-plants found at Carbon in great quantity, and my whole time had to be gvein to their study. These plants are obtained from two horizons: No. 2 and No. 5 of the section, separated by 35 to 40 feet of measures.

§ 6. Carbon to Black Butte Station.

From Carbon westward the country and its geological characters and modifications have been, too, so exactly and minutely described by Dr. Hayden in the same report of 1870, pp. 134 to 140, that, besides my paleontological researches, I had, in following the railroad to Evanston, little else to do but to record by comparison the exactness of the geological facts and descriptions already published. It was the case at Rawling's Station, the first place where I stopped, after passing Carbon, to examine what had been indicated to me by Mr. William Cleburn, civil engineer of the railroad, as "peculiar rocks, containing an immense quantity of fucoids," which, from description, I supposed might indicate

* For the communication of this section and other valuable information, my thanks are given to Mr. J. Williams, the able superintendent of the Carbon mines.

perhaps the presence of the Lignitic at that locality. These rocks, a kind of siliceous, reddish-brown sandstone, hardened by metamorphism, are exposed in a thickness of 200 to 300 feet in bluffs on both sides of the railroad, half a mile west of the station. They overlie the upturned edges of granitic rocks, which come to the surface one mile farther north, and, indeed, they contain an immense abundance and variety of fucoids, without any traces of animal remains. I have never seen plants of this kind filling rocks in such quantity, except in some ferruginous shale of the Devonian of Ohio, or in some groups of the Silurian of New York and Pennsylvania, the Trenton and the Clinton groups.

These marine plants belong to types far different from those of the fucoids of the Tertiary. This is immediately recognized, especially in their large size, as remarkable as the quantity of their remains. Some branches or trunks measure more than half a foot in diameter, while their ramifications, filling the rocks and crossing the layers in every direction, cover large surfaces by a confused mass of filaments. They look like heaps of sea-weed crushed, flattened, and petrified at the same time. The large-sized trunks of these plants are generally found near the base of the formation, or in close proximity to the granite rocks, while at a higher level the shales are mostly covered with small species, perhaps mere branches of the large ones. Some of these, as far as they can be recognized, are referable to *Chondrites antiquus*, Sternb; *Buthotrephis succulosus* and *B. flexuosus*, Hall, all species of the Silurian. But, as said above, they are mixed in such a way that the ascertaining of their specific characters would demand much time for a careful study, which can be made only in place, small broken specimens being useless for that purpose. But if even I had been able to determine specifically a number of these plants, our acquaintance with the fucoids of the old formations is as yet too limited to afford reliable points of comparison, and therefore it would not be possible to refer those of Rawlings to a peculiar division of the Silurian. That they belong to the Silurian epoch is all that can be ascertained, and thus the opinion of Dr. Hayden on the age of these fucoidal rocks is corroborated by paleontological evidence.

The same kind of fucoidal remains are seen also, but far less abundant, in the red rocks overlying the primitive formations in Colorado; as, for example, in passing up Glen Eyrie from what is called the Garden of the Gods. These plants may be remarked in the fragments strewn along the borders of the run. The formation is evidently older than that of the upturned red rocks which form the inclosure and the monuments of the garden. In these I did not find any fossil remains of any kind at this locality; but near Cañon City, from the upturned ridge of red and white sandstone from under which the soda-springs gurgle out, and which, from their position, are referable to the same formation, I obtained a few fruits of the genus *Trigonocarpum*. With some rare fragments of *Calamites*, recognized too in these rocks, they would indicate their age as true Carboniferous or Lower Permian. In crossing this ridge along Oil Creek, east of Cañon City, the underlying strata from which the bitumen there percolates, mixed with the water, are mostly beds of black shale, which appear referable to the Devonian, at least from the analogy of their compound and color. I do not know that any kind of fossil has been remarked in connection with them, and this, too, is a point of analogy with our oil-bearing Devonian black shales, so extensively developed from Arkansas to Pennsylvania, and recognized everywhere by their geological position and the large proportion of bitumen which they contain, though mostly barren of fossil remains.

From Rawlings, still on the line of the Union Pacific Railroad, the Lignitic formation soon comes up, bordering the belt of the Cretaceous which passes southward, and at Separation, ten miles west, a bed of coal, reported 11 feet thick, has been opened and then abandoned for a time on account of the difficulty of mining it, and of its distance from the railroad. At Creston, fourteen miles farther west, no coal has been found exposed, but a bed of lignite has been passed by a boring at 83 feet from the surface. The coal is reported 4 feet thick and of good quality. Here the strata are nearly horizontal, and it is probably the same bed which thirteen miles farther west, at Washakie Station, is indicated by a boring as being 3½ feet thick at 120 feet from the surface. As Washakie Station is 333 feet lower than Creston, this difference, with that of the distance from the surface to the coal, would indicate a dip to the west of about 30 feet per mile. The records of this last boring, which I owe to the kindness of Mr. John Denover, station-agent, further indicate a stratum of red paint 20 inches thick at 180 feet, and then a succession of beds of soapstone alternating with beds of white sandstone to 675 feet, where water was obtained. The beds here called soapstone did offer to the bore as much resistance as, if not more than, white sandstone. Though no positive evidence can be drawn from these records, it appears, however, that the thick formation of white sandstone, interlaid by beds of hard clay-shale, represents the sandstone formation of the Lower Lignitic. Generally springs, mostly of mineral water, flow out at its base, near its line of superposition to the compact and impermeable clay-beds and black shale of the Upper Cretaceous.*

§ 7. Black Butte to Rock Spring.

In following the railroad from Black Butte westward, the Lignitic formation, already seen at the surface of the country from below Bitter Creek Station, forms an irregularly broken ridge, whose general dip toward the east is varied by low undulations. In that way the measures slowly ascend to Point of Rocks, where they overlie the black shale of the Cretaceous No. 4, there constituting the axis of an anticlinal, which is cut, below Point of Rocks, by the meanders of Bitter Creek. The counterface of the axis appears westward in corresponding strata after passing Saltwell Valley, and hence the dip to the west brings to the surface the upper strata of the Lignitic at Rock Spring. The section of the measures is perfectly clear and exposed in its whole length. At Point of Rocks, and near the highest part of the anticlinal axis, the Cretaceous strata are exposed 80 feet in thickness, immediately and conformably overlaid by 185 feet of the Lignitic sandstone which from its base bears fucoidal remains. It has moreover the composition, mode of disintegrations, &c., remarked already in the same formations at the Raton. East of the station, 25 feet above the base of this sandstone, there is a bed of coal 8 feet thick. Farther east, at Hallville, a Lignitic bed, overlaid by shales where are imbedded a quantity of fossil-shells, is worked near the level of the valley at a short distance from the railroad. At Black Buttes a bed of lignite is worked, too, above the Eocene sandstone, as indicated by the following section taken from the railroad, half a mile east of the station:

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* For further details on the geology of that barren and wild country, see Dr. F. V. Hayden's Report, 1870, pp. 139, 140

From base upward:

	Ft.	In.
1. White sandstone concretionary, weathering in cavities, with abundance of fucoids	118	0
2. Shale and fire-clay	16	0
3. Coal	4	0
4. Black, soft laminated shale	10	0
5. Fire-clay, gray and chocolate colored	5	0
6. Coal, (main)	8	0
7. Argillaceous and sandy yellowish shale, with a quantity of dicotyledonous leaves	10	9
8. Coal-streak	0	3
9. Argillaceous shale and clay	7	0
10. Shaly sandstone, often ferruginous	10	0

Above this, and on the other side of the hills toward the station, the sandstone with the characters indicated for No. 1 of the section, ascends to the level of this section, does not contain any coal, and is overlaid still by about 50 feet of measures, mostly shale clay-beds, with fossil-shells mixed with plants. There is, too, a stratum of ashes or baked clay, where bones of a Saurian, shells, dicotyledonous and Sabal leaves are mixed in a confused mass.* Though the best parts of the Saurian had been taken out already, I got some specimens bearing on the same pieces, fragments of bones, shells, and fossil-leaves. About at the same level, and a few hundred yards northwest, the top hills are composed of baked red shale, where specimens of dicotyledonous leaves and small shells are also found mixed together. In the strata marked on the section, other kinds of remains, too, have to be mentioned. The sandstone No. 1 of the above section has fucoidal remains beautifully preserved. One specimen of *Halimenetes* is seen in an erect position unfolding its branches about 10 feet high, with a stem more than 1 inch wide, as clearly defined upon the vertical face of the sandstone as if painted there by hand. It is upon a large detached block quite near the mine on the side of the railroad. The sandstone itself, full of round concretions varying from the size of an egg to that of the head, is molded and dug by weathering in still more diversified and remarkable forms than the same sandstone at the Raton Mountains.† In the hills facing the depot, its walls are dug into a multitude of niches of every size and form, which the children of the station use as store-rooms for play, and where they expose, as in cabinets or shops, the various and curiously molded concretions found around in the sand. And above the main coal, too, the shale of the stratum marked No. 7 of the section has the best-preserved specimens of fossil-leaves found as yet in the Tertiary formations of ours, and this in profusion. Indeed the whole country at and around Black Butte offers rich mines of interesting and valuable materials for the study of the geologist and paleontologist.

At Rock Spring, as said above, the upper strata of the same formation come to the surface, and there a splendid bed of lignite 8 to 9 feet thick has been worked for a long time, from just above thick banks of white fucoidal sandstone. In this sandstone the remains of marine plants are as numerous as at Black Buttes, and as well preserved, too. This sandstone, from the section given below, is, with its alternate beds of hardened clay shale, about 100 feet thick. Most of its strata are

* A large Dinosaurian discovered by Professor B. F. Meek, and dug out in pieces by Professor E. D. Cope. American Journal of Science and Arts, December, 1872, p. 489.

† For more details on this sandstone, on the geological direction of the strata, on the distribution of coal-beds, &c., from Black Buttes to Rock Springs, see Dr. F. V. Hayden's Report, 1870, pp. 140–142.

exposed in the hills southeast of the station. Some of them have a few fossil dicotyledonous leaves. They overlie the bed of coal marked 4 feet in the section, the Van Dyke bed, which is opened and worked near the railroad, two miles east of Rock Springs.

When I passed Rock Spring a boring for an artesian well was still in progress and had already reached 1,180 feet. Mr. Frank F. Phelps, to whom I am indebted for many kind offices and valuable information, gave me the following records of this boring. Though the nature of the strata separating coal-beds is not marked, some interesting deductions may be furnished to discussion by the succession of the measures.

At 7 feet from surface, after passing sandy soil and black shale:

	Ft.	In.
1. Main coal	8	0
At 117 feet, after beds of hard sandstone, shaly sandstone, and soapstone, intercalated:		
2. Coal worked two miles east	4	0
3. At 149 feet, coal	3	4
4. At 268 feet, coal	5	5
5. At 324 feet, coal	3	0
6. At 353 feet, coal	2	6
7. At 377 feet, coal	2	1
8. At 420 feet, coal	3	0
9. At 447 feet, coal	1	8
10. At 476 feet, coal	2	6
11. At 485 feet, coal	2	0
12. At 577 feet, coal	2	6
13. At 606 feet, coal	3	0
14. At 640 feet, coal	1	8
15. At 668 feet, coal	1	8
16. At 728 feet, coal	2	0

Between all these coal-banks the strata passed through were constantly soapstone and sandstone; the soapstone looking like blue fire-clay, but more difficult to pass with the bore than the sandstone. From 780 to 1,180 feet, the depth reached when I was there, the strata are merely white sandstone, alternating with shale.

This record seems to show an extraordinary or abnormal development of lignite-strata. We have here sixteen beds of this coal, measuring in the whole 48 feet in thickness, in little more 700 feet of measures. This, however, is not different from what has been seen elsewhere already, in some exposures of the upper Lignitic formations. The section at Marshall's, as published in Dr. F. V. Hayden's Report, (1869,) pp. 29 and 30, marks eleven beds of lignite, which, taken all together, measure 63 feet, and this in less than 600 feet, of strata, overlying the lower sandstone and exposed above surface. There is merely at Rock Springs an increased thickness of the sandstone-beds, which is normal, and is easily understood in considering the mode and development of the Lignitic formation.

From Rock Springs to the base of the hills north of the station, six to seven miles distant, the bottom of the valley is nearly flat, bordered by low ridges of shaly sandstone, passing to mere hillocks, and then to sand and clay detritus from the northern, hills which overlie here the Lignitic. They belong to the Green River Group of Hayden, and appear indeed to form a distinct, well-characterized division of the Tertiary. My purpose in visiting these hills was first to see a remarkable stratum, mere compound of shells glued together by ferruginous and calcareous clay, the whole mass mostly silicified. These molluscs, generally small, appear fresh-water species, and of more recent types than those which I had found in the black shale over the main coal of Rock Springs.

But I was especially anxious to ascertain if the conglomerate formation, remarked at the other localities, had here left some traces as indication of its superposition to the upper Lignitic strata. Nothing like it is seen either at the top of the hillocks or in the broad bottoms of the valley in crossing it northward in a direct line from Rock Springs. Near this station only, the top sandstone is, here and there, strewn with loose pieces of silicified and finely opalized wood; but I have seen no pebbles with them. This exploration, however, was too rapid and superficial to afford positive evidence. It should be repeated under more favorable circumstances, and pursued in different directions, especially toward the upper end of the valley.

§ 8. Green River Station.

All that can be said in a general way on the succession and the compounds of the strata of the Green River group is already published in the reports. As I shall have, however, to remark upon the composition of the numerous beds of bituminous shale of this formation in examining the value of the combustible mineral of the Lignitic, and also to consider the relation of the fossil-plants which have been found in some of its strata, it is convenient to have for future reference a detailed section of the measures. The following is taken from near Green River Station, where the succession of strata is clearly seen and exposed in a comparatively great thickness. This section is from top of Pilot Hill downward.

		Feet.
1.	Hard, red ferruginous sandstone in layers	50
2.	Shaly, reddish, laminated argillaceous sandstone, with abundant remains of fishes	55
3.	Black bituminous calcareous shale	7
4.	Red shaly sandstone	5
5.	Black bituminous shale, with remains of fishes	5
6.	Hard, shaly, argillaceous sandstone	7
7.	Black bituminous shale in bank	25
8.	Calcareous thin beds of shale and black bituminous layers alternating	70
9.	Soft, white, calcareous shale	5
10.	Hard, white, calcareous shale	5
11.	Bituminous shale and remains of fishes	5
12.	White, soft, calcareous shale	15
13.	Shaly yellow sandstone	13
14.	Clay shale, topped by half a foot of bituminous shale	20
15.	White calcareous shale, interlaid by green sand	72
16.	Bituminous black shale	2
17.	Argillaceous shale	33
18.	Sandstone shale	15
19.	Soft, laminated clay shale	17
20.	Shaly sandstone	5
21.	Soft calcareous shale	20
22.	Harder laminated shale, mixed beds	22
23.	Hard calcareous rock	5
24.	Soft shale and white clay	25
25.	Covered space to bed of river	45
		548

This section indicates a thickness of about 40 feet of bituminous matter distributed in thin beds, besides the 70 feet thick bed No. 8, composed of alternate layers of calcareous and bituminous shales. All these shales are more or less impregnated by bitumen, and sometimes so much charged with it that it percolates through rocks of sandstone under them. As atmospheric action vaporizes and dissolves the bitumen, the exposed faces of the strata are generally whitish, and do not show on the outside the appearance of their composition. But when cut into a few feet deep, the shale are found as hard and as black as cannel-coal, breaking in even fracture without marks of lamination. This has caused a great deal of useless researches, borings, and tunnelings, from unreliable reports on the presence of true coal at various localities around Green River Station. From my own exploration of these formations, I am satisfied that they do not have any bed of true lignite. The shales are, however, valuable, and may yield by distillation an amount of bitumen large enough to be remunerative, when this matter becomes available to some purpose in the distant localities where it is found. This bitumen appears to be essentially the result of the decomposition of animal matter. I have looked in vain in the shales for remains of vegetables. In the lowest stratum only, No. 16 of the section, I have found an obscure impression resembling a leaf of grass or a narrow flattened stem, rather referable to some fresh-water plant than to a marine vegetable. From the thinness of the strata of the Green River group, their extreme diversity, their multiplication, and their compounds, they seem to be the result of deposits in shallow lakes where materials were originated and mixed. These lakes were inhabited by a prodigious quantity of fishes, which, destroyed at repeated periods by drought, have partly furnished the bitumen to the shales where their skeletons are preserved. Whenever I had time to search for them, I have scarcely failed to find traces of fish-remains in the numerous beds of bituminous shale which I have examined. It is probably to the periodical drain or desiccation of these lakes, to repeated variations of level in these fresh-water basins, that is due the absence of beds of lignite; these changes having prevented the heaping, preservation, and slow maceration of vegetables, which are obtainable only under the permanent influence of water. The alternations of submersion and drougth, on the contrary, cause a total decomposition of vegetable remains resulting in the formation of mud and clay. Even animal remains, especially small mollusks, are affected and soon destroyed under the same influence. The records attest that in Denmark, some shallow lakes have been thus filled in four years with two feet of calcareous clay by the decomposition of *Characeae* and thin-shelled *Cyclas* and *Physas*. Fossil dicotyledonous leaves have been found in yellow clay shales, near Green River Station, and have been already described. As yet, remains of this kind appear very rare in this formation.

§ 9. EVANSTON.

A good description, with fine sections of the lignite-beds of this locality, has been given by Mr. A. C. Peale, in Dr. F. V. Hayden's last report, (1871,) p. 194. I have nothing to add to the observations most carefully made and to the details given on this remarkable deposit of combustible mineral, but wish only to make a few remarks on the distribution of the strata overlying the lignite-beds, especially in regard to the conglomerate formation which tops the hills. The sections of Mr. Peale go to the top of the upper coal-bed. From this, in ascending order, the following strata are exposed in the hill above the works of the Wyoming Coal Company:

	Feet.
1. Argillaceous shale, with ferruginous concretions	96
2. Shaly sandstone, sometimes in banks and very hard, with fossil dicotyledonous leaves	11
3. Alternating beds of shale and shaly sandstone	106
4. Sandstone in bank	11
5. Shale and clay banks, mostly clay-covered	145
6. Bituminous clay	10
7. Conglomerate, lower bank	27
8. Fine-grained sandstone, with thin layers of coarse-grained sandstone	32
9. Conglomerate, topped with coarse sandstone	37
10. Hard, yellow, fine-grained micaceous sandstone	32
11. Conglomerate to top	40
	547

In these 547 feet of measures above the coal, the upper part, mostly conglomerate strata alternating with sandstone, is 168 feet. Comparing this section to that of Colorado Springs, above the Gehrung coal, where the same kind of conglomerate tops the Lignitic formation, we cannot but find a remarkable analogy, not to say identity, between both. At Colorado the conglomerate, as should be expected from the greater distance to the point where the materials have originated, is composed of smaller pebbles. The thickness of the same measures is, too, reduced by erosion. But the relation and alternance of the strata is similar. The same can be said of the Upper Lignitic of Cañon City and of other localities reported by Dr. Hayden. From this, and also from the conformability of these conglomerate beds with those of the Lignitic which they overlie, I am disposed to consider them as of the same age and as marking the close of the Lignitic group. The conformability of the strata is especially remarkable at Evanston, and easily recognized along the hills facing the river, cut nearly vertically and sloping northeast by a dip of about 10°. If, as it has been supposed, this conglomerate formation was more recent and had covered Tertiary strata of different groups, this alternance of conglomerate with sandstone strata, in perfect concordance to the soft bituminous clay-beds which they overlie, is unexplainable. Further evidence, however, will be afforded on this important question. The amount of materials brought up for this formation is beyond computation. They not only form the essential compounds of hills over wide areas, but their *debris* covers the plains for hundreds of miles around the nuclei which now stand as mere dwindled monuments of a wide-spread, as yet inexplicable agency. The pebbles composing the conglomerate of Evanston vary in size from that of a pea to that of the head; the most common are as large as the fist. They are all rounded, without exception true pebbles, as if they had been rolled by water for a long time. As at the other places where they have been remarked, they are of the same materials as those which now compose the mountain-ridges of the vicinity, and are glued together by a kind of calcareous cement, hardened locally by ferruginous infiltrations.

Dicotyledonous fossil-plants are found in quantity in a bituminous shale overlying the upper coal of Evanston, and, too, in the sandstones marked on the sections Nos. 2, 3, 4. This sandstone is hard and compact enough at some places to afford good building-materials. On one of the blocks used for construction at the mines I saw a well-preserved leaf of a *Populus*, larger than any as yet found of this genus, in a fossil state. It measured more than 6 inches in length without the petiole. In the shale above the coal, the leaves are crowded, heaped upon another, and though well preserved by a thin incrustation of coal upon their surface, they are rarely isolated, and their nervation, too, being scarcely distinct, their determination is difficult and somewhat uncertain. I did not find at Evanston any fucoidal remains. The specimens obtained by Dr. Peale, however, have, in a hard, gray sandstone, two branches of a fucoid, (*Halimenites major*,) labeled from that locality.

§ 10. COALVILLE, UTAH.

This place is known to me only from descriptions given by Dr. Hayden, Mr. Hodge, and other explorers. No fossil remains of land-plants have as yet been obtained from strata in connection with the Lignitic beds. Judging from the relative disposition of the coal-beds, their thickness and their chemical compounds,* I have been disposed to consider them as equivalent to those of Evanston. Professor B. F. Meek's observations, however, as published in this report, indicate for the geology of Coalville a series of Lignitic strata with intermediate beds, clay and sandstone, bearing remains of evidently Cretaceous animal species, therefore tending to refer the whole series to Cretaceous. Except the fucoid species, abundantly found at Coalville by the same observer, we have no botanical evidence to bear upon the question of the age of these strata. I believe, nevertheless, that this case is of the same nature as that of Black Butte, where Cretaceous animal fossils are found hundreds of feet higher in the measures than thick beds of lignite, immediately overlaid by shale-bearing remains of plants positively of Tertiary age. Facts of this kind have to be judged from a general point of view, in considering the evidence of general relation. For, indeed, in a formation like the Lignitic, which may be called a formation of transition, the evidence given by vegetable and animal paleontology, or by land and marine remains, can but disagree sometimes.

THE WESTERN LIGNITIC FORMATION CONSIDERED AS EOCENE.

Dr. Hayden in his reports has constantly alluded to the Lignitic group, especially to the barren sandstone underlying it, as to beds of passage or of transition between the Cretaceous and the Tertiary, often mentioning them as *Eocene*. No formation is exclusively limited in its characters, at least not in those which are supplied by fossil remains. On this account, every geological division might be considered as being a transition, and this is especially the case for the strata intermediate between a marine and a land formation; as, for example, in the Carboniferous epoch, to which our Lignitic has so many points of similarity. Devonian animal fossils ascend to the Subcarboniferous, or even to the true Carboniferous measures, which have also species of invertebrate animals characteristic of the Permian; and the plants which have entered into the composition of the coal are found already, some of them at least, in the Middle Devonian, the Hamilton period; while the most common species of ferns, even of *Sigillaria* of the Carboniferous, have left traces of their presence high up in the Permian. The same might be remarked on every other artificial group, which geologists have to fix for convenience and better understanding. The discussion, therefore, on the age of the formation called Eocene, and now under consideration, should not admit as evidence isolated facts in contradiction to the persistence of general characters observed over wide areas, in great thickness of strata, and which give to the whole a kind of

* Mr. Hodge's paper in Dr. Hayden's Report, 1870, p. 321.

homogeneity in correlation with the forces which have, at the same time, modified the surface of our earth. The Upper Cretaceous, from indications of the remains of a deep marine fauna, is positively characterized as a deep marine formation. Immediately over it, the sandstone shows in its remains the result of the upheaval of a wide surface, exposed to shallow marine action, as indicated by fucoidal life. The upheaval continuing, this area is brought out of marine influence to be exposed to that of the atmosphere. It is a new land, cut in basins of various size, where fresh water is by and by substituted to brine, where vegetable life of another character appears, where swamps are filling with clay by floating plants, where peat-bogs in their growth form deposits of combustible matter, &c. To suppose that the marine action is totally banished from such a land would demand the absurd admission of an absolutely flat surface. Of course estuaries penetrate into it at many places; their waters feeding marine species, brackish shells; their bayous inhabited by Saurians, and their remains are mixed with leaves of the trees growing on the borders and preserved together in a fossil state, without impairing the true character of the formation by what paleontology considers as types of different ages. The surface of the Eocene sandstone, before its separation from marine influence, was of course uneven. This sandstone has therefore the general characters of the Eocene, while in some troughs, Cretaceous species, still living in deep water, may have left their remains in the sand. Even if these remains were numerous, their presence does not change the age of the formation. But on this subject, and in comparing our Eocene sandstone to the other groups established by geology, we find, in its abrupt and permanent separation from the Cretaceous, its lithological compounds, its total barrenness from animal remains, at least generally, and the homogeneity of its flora, reliable and constant characters better defined than in any geological division admitted by science. This sandstone formation is inexplicable. It can be compared to nothing but to the millstone-grit of the Carboniferous epoch. How to explain why, at once, animal life seems to disappear from the bottom of the sea, to be superseded by marine vegetation? May this change have been caused, perhaps, by a rapid increase of temperature of the water brought up by the force acting to the upraising of the bottom into land, and afterward into chains of mountains?

Though it may be this change is evident and proves the geological discrimination of the Eocene sandstone from the Cretaceous, a separation the more remarkable that, from numerous observations, this sandstone is reported constantly conformable to the Upper Cretaceous beds. As Dr. Hayden remarks in his description of the Lignitic group of Nebraska,* "When we bear in mind the fact that wherever this formation has been seen in contact with the latest Cretaceous beds, the two have been found to be conformable, however great the upheavals and distortions may be, while at the junction there seems to be a complete mingling of sediments, one is strongly impressed with the probability that no important member of either system is wanting between them."

This intimate connection of two sandstones of different ages appears to be of frequent occurrence along the Pacific shores, and to have caused some difference of opinion, and some confusion too, in reference to the age of these strata. Professor Gab, in a very valuable paleontological document, published in vol. 3 of the Proceedings of the California

* Geological report on the explorations of the Yellowstone and Missouri Rivers, 1859 and 1860, p. 30.

Academy, page 305, remarks, on the lower sandstone, "that it has often been considered as Eocene, but that it is proved to be of Cretaceous age by the large number of Cretaceous species which it contains, these already resembling Tertiary types." He adds, however, that these Upper Cretaceous strata are "*everywhere overlaid by an immense deposit of non-fossiliferous sandstone.*" It is this last non-fossiliferous sandstone which belongs to the Eocene. It has in California the same characters which mark it on the eastern side of the Rocky Mountains. Professor Gab has found fucoidal remains in it. It has been seen all over California at the base of the Coast Range, and I believe that the lignite-beds from Oregon southward, even from Vancouver's Island, will be recognized in the Eocene, formed as at other localities, either near the base or within or above the sandstone.* The objections against the Tertiary age of the Lignitic are partly answered by these remarks. They have, however, to be considered in detail.

To my knowledge only two specimens of Cretaceous fossil have been as yet found in the Eocene sandstone of the Rocky Mountains and in strata overlying it, south of Golden. One specimen of *badly* preserved *Inoceramus* was seen at or near the base of the Eocene sandstone, by Dr. F. V. Hayden, and still another *badly* preserved specimen of the same genus was found by Dr. John Leconte in a bed of sandstone, overlying the Lignitic beds of the Raton. It is useless to argue on the chances which may have brought these remains at the places where they have been found. These cases are exceptional and unimportant. Large companies of explorers have passed the same localities without discovering any other marine fossil mollusk in these strata, and I have myself carefully searched the indicated stations with the same result. It is otherwise, however, with the beds of oyster and other shells remarked in great abundance from Rock Springs to Black Butte, where, too, the bones of a large *Dinosaurian* were found mixed with fossil-shells and dicotyledonous leaves, and which have served as authority to many geologists for their opinion on the Cretaceous age of the strata.† The opinion of Professor Meek on this subject is especially to be considered, as he has not only given much time and care to the determination of the fossil-shells, and has himself visited the localities, but is so cautious and careful in coming to his conclusions that they merit full confidence. Now, in a letter on this subject, the celebrated professor remarks: "Looking on these invertebrate remains alone and aside of all other facts, I could scarcely doubt from their affinities that they are Eocene—Lower Eocene. You see there are none of the characteristic Cretaceous genera of mollusks among them—no *Inoceramus*, no *Ammonites*, no *Scaphites*, no *Baculites*, not a trace of any of the long list of Cretaceous or older genera, which might be mentioned, while a majority of the forms are most nearly allied to the Eocene types, *specifically*." Against this evidence Professor Meek remarks on the relation of shells of the same kind found at Coalville and at Bear River, *below evident Cretaceous species*.

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* In a late paper, Professor Dawson, of Montreal, considers the fossil plants of Vancouver's Island as Tertiary. I already came to the same conclusion after the examination of the fossil plants of Dr. T. Evans, as published in American Journal of Science and Arts, vol. XXVII, May, 1859, page 362. This opinion was controverted afterward by Dr. Newberry, who referred the Lignitic formation of Vancouver to the Cretaceous, on account of the presence of Cretaceous fossil animal remains in strata above the coal. My remarks on Blockbutte, Coalville, &c., are apparently applicable to Vancouver also.

†American Journal of Science and Arts, December, 1872, p. 489.

To my opinion, this fact is of great weight in discussing the question of the age of these formations. For the presence of deep marine species in strata overlying remains of more recent ones indicates a local subsidence which should be considered as an exceptional case, unimportant indeed in comparison to the persistence of general characters. Beds of lignite of Eocene age may have been formed at a higher level or before this supposed local subsidence. And, of course, as resulting from it and from a subsequent upheaval, fucoidal remains mixed with Cretaceous shells; and Cretaceous saurian bones, too, with brackish mollusks and dicotyledonous leaves of the Eocene, would be in a position, if not exactly normal, at least easily explainable.

Professor F. B. Meek's letter furnishes another point of evidence on the same question, in his remarks on a peculiar species of plant which he describes, and of which he sent me numerous specimens. It is that fucoidal plant, *Halimenites*, which has been mentioned already as one of the essential characteristic species of the Eocene. He writes that he found it at Coalville, at least 1,000 feet below well-marked Cretaceous beds; that it ranges also through most of the Cretaceous beds of Bear River, and through the whole of the Bitter Creek series, nearly up to the Black Butte bone-level; that he saw it too at Carbon and in the Cretaceous beds of Fort Steele. The range of this species is indeed from the base of the Lignitic to its upper strata, those of Carbon and of Evanston, and, therefore, we have at Bear Creek and Coalville shallow marine plants and lignite-beds under Cretaceous remains. These last characteristic documents, or the remains of Cretaceous age, are local, merely in isolated patches; the others are recognized over the whole extent and the whole thickness of the Lignitic formations. The question is, therefore, reduced to this: Shall we admit as Cretaceous all these land formations bearing from top to bottom evident Eocene characters, on account of some isolated Cretaceous deposits locally spread over them; or shall we consider the whole as presenting general characters positive enough to force its separation into a new group and call it Eocene? In this case we should have to consider the abnormal disposition of Cretaceous remains as resulting from local disturbances which are observable everywhere in this central basin, both by repeated undulations, pierced here and there by eruptive rocks, bearing irrevocable marks of the diversified action of the forces which have modified its surface.

As I have not visited the localities, Bear River and Coal Creek, where the abnormal distribution of the strata has been remarked, the above arguments may be considered objectionable. But how can we dispose of an evidence, forced by comparison between our Eocene strata and those of the Carboniferous epoch, where, as remarked before, we recognize facts similar to those now under discussion? We do not and cannot call the coal measures either Devonian or Permian, on account of some fossils mixed in their strata, and identical to species of these different formations. Would it be rational to admit that the Eocene shells and Eocene plants under the strata bearing Cretaceous fossil-remains may be so-called Eocene colonies, decended into the Cretaceous, that the lignite-beds underlying them represent an escaped member of the Eocene, bearing, as it does, in its flora, its compounds, &c., Eocene characters; and that these Eocene members have become of Cretaceous age by the only reason that some Cretaceous fossils are seen over them? As legitimate would it be, I think, to admit our present epoch as Cretaceous from the animals of Cretaceous types brought up by deep soundings from the bottom of our seas. But this subject has to be considered under another point of view.

That the great Lignitic formation of the West belongs to a land formation cannot be denied, and is denied by none. It is, therefore, to the materials preserved from the land that we have especially to look, as most reliable records for the history of this geological division.

GENERAL CHARACTERS OF THE FLORA OF THE AMERICAN EOCENE.

Before entering into this subject, a few words must be said in defense of the above assertion, which assumes, for vegetable paleontology, an importance too generally contested, at least on this side of the Atlantic.

The first specimens of fossil-plants from the Cretaceous of the West were discovered by Dr. F. V. Hayden in 1855. They represented dicotyledonous leaves, mostly different from the species as yet published or known from the Cretaceous of Europe. In order to fix, if possible, their relation of age, sketches of a few of these leaves were sent to Professor O. Heer, the most reliable authority for the determination of the vegetable remains of the recent formations. The celebrated professor referred these Cretaceous plants to the Miocene. This error has been unjustly considered and remarked upon as invalidating the evidence of botanical paleontology in relation to the distribution of geological groups.

The cause of the error was essentially in the insufficiency of the materials furnished for examination. The mere outlines of leaves rarely give reliable characters for the determination of fossil-plants. The nervation has especially to be considered, and this essential character is not marked upon mere sketches of leaves, or can be correctly copied only by botanists of experience. A proof that Professor Heer did not get sufficient materials to enlighten his examination is, that Professor Newberry, who had opportunity to see the specimens, recognized at once, from the study of their nervation, the character of *Credneria*, or of a Cretaceous type, in a leaf considered by Heer as a *Populus*. In both genera the leaves have the same form, but the difference of nervation is recognized at first sight. Could the celebrated professor of Switzerland have made the mistake if the specimens had been submitted to him? But even if the materials obtained for comparison had been sufficient, it is questionable if a European paleontologist should not have been misled in considering the general characters of our Cretaceous flora, and therefore forced to admit the same conclusions. For nothing at all was then known of our Eocene flora, and the essential types of the Miocene of Switzerland, like those of our Cretaceous flora, have a greater analogy to those of our present arborescent vegetation, than to those of our Eocene. This, of course, could but lead to the conclusion that both are representative of a same formation. This cause of error does not exist now. We have got materials abundant enough to afford reliable points of comparison. More than two thousand specimens have been examined from one Eocene strata, and a comparative large number, too, from the Cretaceous. The data exposed by the determination of the species are certainly as reliable as those which may be offered by animal paleontology. A few of these data have to be recorded here, though already partly considered in a former report.

Not a single leaf has as yet been found in our Eocene identical with a Cretaceous species. The genera especially represented in the Cretaceous are: *Sassafras*, *Credneria*, *Platanus*, *Salix*, *Liquidamber*, *Quercus*, *Populites*, *Liriodendron*, *Proteoides*, *Dombeiopsis*, *Acer*, and *Juglans*. We can dispose at once of the genus *Proteoides* on account of its as yet unknown affinity. It has been referred, as its name indicates it, to

Australian types, but from analogy I doubt if we may ascertain the presence of any of these types even in our oldest floras. Now, we have in our Cretaceous, as more easily recognized by their likeness to living species, leaves of *Sassafras* and of *Liriodendron*, the tulip-tree. If I should judge by the profusion of leaves of *Sassafras* which I have seen in the shale of the Dakota group, in the valley of the Saline River, and around Fort Harker, in Kansas, I would assert that more than two-thirds of the vegetation of this epoch did consist of species of this genus. But then, as now, however, related species appear to have lived in groups, perhaps over limited areas; for at other localities Dr. Hayden found especially leaves of *Liriodendron*, *Juglans*, and of *Platanus*, genera scarcely represented at Salina and Fort Harker. The groups may still differ elsewhere. The present remarks, however, must be limited to what is known, and *Sassafras* and *Liriodendron* have to be considered yet as the genera the most profusely represented in the flora of the Dakota group, even more, perhaps, than they are in that of the present time. The American Eocene has not yet shown any remains positively referable to these genera. I have described from specimens marked "*six miles above Spring Cañon*" the lower part of two leaves as, perhaps, referable each to one species of *Sassafras* and of *Liriodendron*; but such fragments cannot be taken into consideration for positive evidence in a comparison like this. They may represent leaves of different affinity. In the Miocene of Europe, per contra, the above genera are represented by a number of species. One of each, *Liriodendron* and *Sassafras*, are described from the Miocene flora of Greenland, and more from that of Germany and Italy.—The genus *Credneria*, or *Pterospermites*, appears to represent forms of leaves of a lost type. We have no representatives of it at our time, nor have any been seen in the Eocene. It has left its remains, however, in the Miocene of Greenland in four different species. Seeds, too, of undecided affinity are referred to *Pterospermites* from the Miocene of Oeningen. The Eocene species of *Platanus*, at least the three splendid species described by Dr. Newberry—*Platanus Haydenii*, *P. Raynoldsii*, *P. nobilis*—have no relation either to Miocene or Cretaceous types, which are mostly analogous to *Platanus aceroides*. This last species, however, like its relative, *P. Guillelmæ*, are as common in the upper American Eocene as the former ones are in the lower.—Of the species of *Salix* I have remarked already that they are more numerous in the Cretaceous than in the Eocene of ours. They re-appear more abundant in the Upper Tertiary groups of Green River.—*Liquidambar*, the sweet-gum, has one of its species in the Cretaceous. It has been described from one leaf only, but I have found recently a number of specimens of the same near Fort Harker. Our Eocene has nothing like it, while remains of one species, *Liquidambar europeum*, are found over the whole Miocene of the old continent, together with a large number of forms as yet doubtfully referable to this genus. Our Cretaceous leaf is, perhaps, of this kind, on account of the entire divisions of its leaves; but this does not change its affinity to Miocene forms of Europe. Massalongo, in his Flora-del-Senigalliese, has described and figured a *Liquidambar scarabellianum*, with the divisions of the leaves entire, a form much like that of our Cretaceous species, only smaller; and Unger, in Flora of Sotska, has named *Platanus sirii*, a leaf still more similar to ours. These leaves are considered by other authors as referable to the genus Acer. This does not make any difference. They represent a type of our Cretaceous and of the Miocene of Europe; as yet not seen in our Eocene.—It is the same with *Acer* (maple) and *Quercus*, (oak.) They are marked in our Cretaceous, the first by *Acer obtusilobum*, with characters of leaves seen again in the European Miocene, and at our present time on both continents; the second by a species related to some varieties of our chestnut-oak, and by two others comparable by the form of their entire leaves to our shingle-oak, (*Quercus imbricaria*, Michx.) Both these types are most common in the Miocene of Europe; but, like that of the Cretaceous maple, they have not as yet been observed in our Lignitic Eocene.—The leaves which I have considered as of a *Juglans*, and which Heer refers to *Populus*, *P. Debeyana*, are of uncertain affinity. Their analogy has not yet been recognized out of the Cretaceous.

I could pursue to some length the examination of analogies of this kind, which may be considered as negative characters of the American Eocene. Besides establishing the remarkable relation of the American Cretaceous flora with the Miocene flora of Europe and the present flora of this continent, they serve to prove the disconnection of our Eocene flora from that of our Cretaceous, indicating therefore truly separate formations.

The positive characters of the same Lignitic flora more forcibly still elicit the same conclusion. From the beginning, in the examination of the sandstone of the Raton, I have recorded the great amount of fucoidal remains in this sandstone, as an essential character of its Eocene age. The irregularity of distribution of marine vegetable remains in the geological groups has been remarked by every paleontologist. The oldest formation, the Silurian and the Devonian, have an abundance of them. The Carboniferous, except at its base, as also the Trias and the Permian, have scarcely any. In the Jurassic they begin to re-appear, and their number increases upward to their maximum degree of distribution in the Eocene. Thus, while ten species only are known from the Cretaceous, thirty-five species have been already described from the Eocene of Europe. In our Cretaceous measures a single species has as yet been found, and this from the Fort Benton Group, near Fort Harker. It seems identical with *Fucoides digitatus*, Brgt., but it is as yet uncertain to what section of marine vegetables this form is referable. I found it upon pieces of limestone covered with the species of large mollusks characteristic of this group. Referred by Brongniart to the *Dictyotites*, by Geinitz to the *Zonarites*, by Schimper to the *Jeanpaulia* of the *Marsileaceæ*, by Schenck to the *Ferns*, it is as yet impossible to mark its true affinity. It appears already in the Dias, as seen from Geinitz's description. Any how, it is of a character far different from any of those remarked in our Eocene fucoids. From its association with the mollusks of deep seas, it is clearly a deep marine species.

It is as yet too soon to enumerate, even approximately, the species of fucoids of the American Eocene. A few are described in this report. But by far the largest number is unknown, and will remain undescribed for a length of time, on account of the size and the inextricable embedding of the largest species with the sandstone. They have to be studied in place, represented in drawings, and their description can be made only from these representations.

The Eocene of Europe is, in Switzerland and Germany, a formation of an immense thickness of soft black shale generally hardened by metamorphism and sometimes transformed into valuable slates. It is the Flysch.* In this soft-grained material the small thread-like forms of marine weeds, or the *Confervites*, are mostly found. Our sandstone is too coarse for the preservation of such filaments; its marine flora, how-

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*Dale Owen, who studied it in Switzerland, compares it to the Mauvaises Terres, Report 6, page 203.

ever, has, by its remains, an analogy in that of the sandstone of the Eocene of Mount Bolca, where, as with us, the genera represented by thick coriaceous species, *Caulerpites*, *Delesserites*, *Halimenites*, *Munsteria*, and *Chondrites*, are predominant. Perhaps it will be observed that we cannot attach great importance to the distribution of vegetable remains whose forms multiply in proportion to their divisions and are generally indistinct, and whose law of distribution is so little fixed that species from distant formations are considered by some authors as identical; as, for example, *Fucoides Targioni* and *Fucoides antiquus*, quoted from the Cretaceous as well as from the Silurian and from the Devonian. It would be easy to prove that as fast as these deep marine plants become better studied, their characters are recognized and their specifications fixed, but this is out of the way of these researches. Some species of fucoids of our Eocene are perfectly distinct; their characters are as clearly marked as they could be for any dicotyledonous fossil-plants. These, therefore, may be compared to the Mount Bolca species, and, what is more to the point, their remains, from different localities of our Lignitic, afford, by identity or difference of characters, reliable indication of the relation of the strata. I have named already a large species of *Halimenites* whose stem and branches are covered with half-round tubercules, and which is recognized at first sight. It is represented in the Eocene flora of Europe by *Halimenites rectus* and *Halimenites minor*, both intimately related to the American species. And remains of this fucoid have been observed and specimens collected in our Lignitic formations from the base of the great sandstone to its top, even in sandstone-strata overlying the Lignitic beds everywhere over the whole area covered by this formation. Professor Meek has found fine specimens of it at Bear Creek, near Fort Steele and Coalville. I can really say that I have not explored any station of the Lignitic without recognizing this species, especially abundant at Black Buttes, where, as remarked already, splendid specimens of it are embedded in the sandstone underlying the main coal.

The genus *Delesseria*, in the order of the *Florideæ*, forms now by its numerous and beautiful species a predominent character of the marine flora of our temperate zone. Its distribution extends between 30° and 60° of latitude, north and south of the equator, remarkably coinciding with that of the Lignitic formation on this continent. The first representatives of this genus are positively recognized, in Europe at least, with the Eocene formation. Of the eight fossil species known till now and described by Schimper in his *Vegetable Paleontology*, the seven first ones, whose relation to this genus is uncontested, belong to the Eocene. The only species mentioned from the Cretaceous, *Delesseria Reichii*, Schimper, is like that *Fucoides digitatus*, Brgt., of doubtful affinity, being named at first, by Sternberg, *Haliserites*, and then considered by Rossmässler, Brown, &c., as a fern. From our Eocene sandstone eight species of marine plants only are described; of these three are true *Delesseria*—two from the Raton Mountains, the other from Golden.

Coming to the examination of land vegetation, we are met at once by the appearance in our Eocene measures of a class of plants, giving evidence of the age of these measures, fully as conclusive as that of the fucoids. It is that of the palms, of the section of the Sabal. Scarcely any trace of these vegetables has been remarked in the Upper Cretaceous of Europe. There they become somewhat conspicuous in the Eocene, but their largest development is with the Miocene. With us they appear immediately above the great Eocene sandstone, or in connection with every bed of lignite formed within this sandstone, and show by the profusion of their remains the remarkable place which they have in the distribution of the flora of the Eocene epoch. Their fossil remains are most abundant in the Lignitic of Fort Union, where the largest leaves of Sabal have as yet been observed. At the Raton a good half of the specimens represent fragments of leaves, of petioles, of fruits of this species. At Golden they are found in the same proportion, and at Black Butte splendid specimens of palms are mixed with dicotyledonous leaves in the shale overlying the main coal; while the bed with Saurian bones and shells, about 150 feet higher in the measures, has Sabal leaves, too, less abundant, however, than the shale of the main coal. At Evanston, in the under sandstone, a quantity of fruits referable to palm has been found, and remains of the same kind are a marked feature of the scanty flora as yet known from the Arkansas and Colorado Lignitic formation. It might be argued that if some remains of palms have been found in connection with strata recognized as Cretaceous, these plants might as well be admitted as characteristic of Cretaceous age in our Lignitic. I do not know of a single case positively ascertained of palm remains in the Cretaceous. But even if we had any, their abundant distribution in the vegetation of our Eocene is sufficient proof that this class of plants had already acquired at that epoch a remarkable development. Its origin may be discovered later by scarce remains in the Cretaceous; its preponderance in the vegetation of the Lignitic attests a more recent formation.*

The Tertiary groups of Europe are not as yet clearly limited. Many of the Lignitic strata which have furnished remains of fossil-plants to European paleontology were at first referred to the Eocene. Unger, for example, places in this formation the fossil-plants of Radoboj, in, Croatia, of Haering, in Tyrol, of Parshlung, of Sotzka, now referred to the Lower Miocene. Thus, too, the Bovey coal of England, which was considered contemporaneous to the Eocene of Wight, is now admitted as Miocene. The Tertiary deposits have been formed in basins of limited areas, and therefore the characters of their flora are not identical, even for contemporaneous deposits, on account of the diversity of the vegetation at various places and under various circumstances. This explains a difficulty of identification of strata which may be met perhaps in trying to circumscribe the upper limits of our Eocene. As yet, in this formation, homogeneity of the essential characters is recognized everywhere in its flora, and when it is compared with that of some locality positively ascertained as Eocene in Europe, it indicates, too, points of identity remarkable enough. Such is the flora of Mount Promina, where a fern found at Golden in splendid specimens is described by Professor Ettinghausen as *Sphenopteris eocenica.* In the same paper a species of *Myrica*, whose leaves appear to have been found in profusion at the same locality, is described and figured, indi-

* Vegetable paleontology has not any more recent and more positive records on this subject than those furnished by Schimper, (Veget. Pal., vol. ii, 1871.) This work describes twenty-four species of palms (fossil) in the three genera *Chamaerops*, *Sabal*, and *Flabellaria*, twelve of which are from the Miocene, ten from the Eocene, and two, *Flabellaria longirachis*, UNG., and *F. chamœropifolia*, GÖPP, from strata considered as Cretaceous. Of these two species, Schimper says that the first, from the length of its rachis, is evidently a type of a peculiar genus, and that the other, whose rachis is unknown, cannot, on that account, be positively referred to any type. The author still describes twenty-two species of palms in other genera, all from the Tertiary, mostly Eocene, and twenty-three known from stems only, and these, too, all Tertiary. Admitting all the references as exact, this makes sixty-seven species of palms described from the Tertiary, and two from the Cretaceous.

cating such affinity with leaves also very abundant at Black Butte, that it is as yet uncertain if the American form does not represent a mere variety of the same, differing only by the larger size of the leaves. We have at Golden *Quercus angustiloba*, Al. Br., described by Heer from the Bornstaedt Eocene, and in the flora of the same locality, as in that of Golden, a remarkable predominance of species of *Ficus* and of *Cinnamomum*, primitive types of the Tertiary of Europe. Some of these pass, with the Sabal species, into the Miocene; for, of course, the Tertiary formations, as land formations, removed from the influence of prolonged submersion in deep marine water, have, like the Carboniferous, a permanence of the types of their flora, marked by a number of species identical in the groups even of the more remote stations. This answers the observations made on the vegetable species already published in Dr. Hayden's reports, and which European authors are disposed to consider as Miocene, from the number of leaves of our Eocene flora, not only homologous, but identical, with Miocene species of Europe.

This comparison might be pursued farther and with more details. These remarks, however, cannot be indefinitely prolonged. Those who may desire to compare more precise points of correlation or of differences between the flora either of our Eocene and that of the Tertiary of Europe, or of the different strata of the Lignitic at various localities, will find sufficient materials for this task in the table of distribution which closes the descriptive part of the fossil flora of this report.

THE AMERICAN EOCENE IDENTICAL WITH THAT OF EUROPE BY GENERAL CHARACTERS.

I do not believe that the divisions of our geological groups have to be controlled by European classifications. It is advisable, however, especially on account of the diversity of the conclusions indicated by botanical and animal paleontology, to mention still a few points of analogy remarked in the distribution and composition of the Eocene of both continents.

The Flysh or Eocene of Switzerland is mostly a compound of shales, here and there interlaid by sandstone strata of great thickness and even passing locally to massive sandstone, where the slate-beds disappear. This formation extends all along the northern base of the Alpine chain in different degree of thickness, in proportion to the amount of denudation to which it has been exposed. It enters the valleys, especially borders them, in constant and immediate superposition to the Cretaceous. On the northern base of the same chain, it is present, too, in basins of limited extent, where the Upper Cretaceous strata have been left for its support. The various strata of this Eocene formation are, according to their vicinity to primitive rocks, changed by heat to a certain degree. And the top of these measures is *overlaid by a conglomeratic compound of materials derived from rocks of all the older formations, all rolled pebbles, and in pieces varying in size from that of a walnut to that of the fist.** In this formation, too, valuable beds of lignite are found; and these, though not as richly developed as in the Eocene of this continent, have sometimes a thickness of 6 feet, and have furnished combustible materials for a long time. The lignite of Niederhorn, 5,700 feet above the sea, has been worked since the former century, and is now used at Bern for the production of illuminating gas. The Eocene group

* Herr Urwelt der Schweitz, p. 241.

of the Paris basin has also some rich beds of lignite. Does not this read like a true epitome of the descriptions given of ourEocene?

This brings forward again what I consider the last unanswered question in relation to the distribution of the American Eocene. Its base is everywhere ascertained as immediately resting upon the Upper Cretaceous; the lower sandstone is recognized as either a massive homogeneous compound or as interlaid at different places by beds of lignite or of shale. The fossil flora, with some difference, has the same characters in the strata connected with these lignite-beds, at all the stations. The group is therefore satisfactorily limited so far, but where does it pass to a higher division of the Tertiary or to the Miocene? I have already remarked that I consider the conglomerate formation seen at Evanston and other localities as the upper beds of the Eocene. But I have not myself found any positive proof of this assertion, and as these conglomerates have been referred to different groups according to the strata which they appear to cover, the assertion is contestable. The observations, however, of Dr. Hayden, who, after years of careful field explorations, has become the true interpreter of the geology of the Rocky Mountains, will supply this last evidence. In beginning his description of the Green River Group, and in marking its superposition to the Eocene sandstone, he says:*

> This interesting valley (Henry's Fork) is filled with beds which show a perfect conformity. The first bed is a yellow-brown, rather fine-grained sandstone, dipping 75° a little west of north. Then comes a series of yellow and light-gray arenaceous or marly clays with beds of yellow-brown and light-gray sandstones projecting somewhat above the surface. Alternating with these layers of sandstone are quite thick beds of pudding-stone and conglomerate composed of round pebbles of all the older formations. These conglomerate beds are intercalated among the sandstone through 300 or 400 feet in thickness, and are probably of Upper Eocene age. Above them are at least 500 feet of sandstone which have a diminished dip 20° to 30°, and then pass up into the calcareous layers of the Middle Tertiary of Green River group.

The relative position of the conglomerate as underlying the Green River Group is thus positively ascertained. Comparing this with what has been described and marked in the sections of Evanston, Cheyenne, Gehrung's in Colorado, the lignite basin of the Arkansas Valley near Cañon City, the Santa Fé marls, the Gallisteo group, &c., such remarkable analogy is seen in the composition and geological distribution of these conglomerates that the unity and contemporaneity of the formation becomes evident. The upper part of the section of Evanston is a counterpart of that of the conglomerate-beds described above by Dr. Hayden. It is, indeed, reduced in thickness, as also in the size of the materials entered into its compound. But, as remarked already, this reduction is everywhere relative to the distance of the older rocks which have furnished the materials. And it ought to be so; for the formation is a kind of drift, spread over a wide area by water or by glacial agency, and of course the coarse and heaviest materials are found nearer their point of origin. It has been, but it cannot be, considered as a recent drift. I have seen no trace of recent glacial agency on this side of the Rocky Mountains, where, indeed, moraines, or heaps of materials transported by glaciers, would be, I think, a kind of anomaly. The glaciers have, like the peat-bogs, a development relative to atmospheric humidity. It is not the rain which increases the density of the snow, transforms it into névé and then into ice, but the fogs. Therefore, the eastern slopes of the Rocky Mountains have snow in their high, deep

* F. V. Hayden's Geological Report, 1870, p. 69.

gorges, but not glaciers. The case must have been far different at the Eocene time, where the great atmospheric humidity is manifested by the formation of the lignite-beds.

From these remarks, and as a short *résumé*, I am, I think, authorized to deduce the following conclusions: That the great Lignitic group must be considered as a whole and well-characterized formation, limited at its base by the fucoidal sandstone, at its top by the conglomerate beds; that, independent from the Cretaceous under it and from the Miocene above it, our Lignitic formations represent the American Eocene.

PART II.—THE LIGNITE; ITS FORMATION.

The greatest geologist of our time, Lyell, takes as a preamble of his *Principles* this admirable remark of Playfair:

> Amid all the revolutions of the globe, the economy of nature has been uniform, and her laws are the only things that have resisted the general movement. The rivers and the rocks, the seas and the continents, have been changed in all their parts; but the laws which direct those changes and the rules to which they are subject have remained invariably the same.

Certainly, every geologist is disposed to admit the exact truth of the above assertion; but how few of those who are called to teach geology are disposed to follow the advice implied in it and to begin their instructions in studying the changes and phenomena on which the present surface of our globe is dependent, and of which, too, it is, at least for a given time, the immediate result.

The want of precise information on actual phenomena, whose understanding is important for the pursuit of geological studies, is perhaps nowhere more evident than in considering how little the formation of our combustible minerals is understood. It is indeed generally believed, and rightly admitted now, that we have, in the peat-deposits of our time, a formation analogous to that of the coal, and that therefore we have only to study this present and active production of nature to be able to understand the origin of the deposits of combustible mineral of former epochs. But how to make this study? Nature's works are of such a complex immensity that, simple as they appear to the mere looker-on, a whole human life is often fully employed in the abortive trial of unraveling the details of one of its minutest productions. Peat-bogs are not a compound or a mere heap of dead matter, brought up like the mud and sand of the rivers by some appreciable force. That the peat has grown, and is still growing, in basins which it tends to fill up to a precise degree, is well known. But this general and vague assent of a truth says nothing on the mode of growing, on the materials which supply the compound, on the elements necessary to its preservation, on the influences affording those subsequent transformations by which nature secretly elaborates some apparently useless vegetable *débris*, restores them after a time as lignite, coal, anthracite, even diamond, all matters adapted to the wants of our civilization. All these questions, to be clearly understood, demand in botany, in chemistry, in physics of the earth, not mere notions, but an intimate acquaintance which, even for one of these specialties, cannot be obtained by a whole life of study. There is, however, another cause of the ignorance of the phenomena which accompany the formation of the peat-bogs of our time, and of the laws which promote it. Peat-bogs have nothing attractive, nothing which speaks at first to an imaginative mind, which charms it and tempts it to investigation. They are like cemeteries, mere resting-places for death. They have no life but vegetable life, which, in its luxuriance, is generally enveloped in a kind of repulsive gloom. At some open places the surface is covered by mere heaps of mosses, where deep-sinking footing makes each pace not only uncertain but startling and alarming as dangerous. At others the bogs are thickly interspersed by hillocks, which, formed on the roots of trees and bushes, hidden under a thick carpet of mosses, offer not only an insecure footing, but are separated by gulches full of stagnant, black, muddy water, where the prospect of a plunge is not pleasant indeed. At other places still the bogs are so thickly overgrown by trees and bushes that one has to use the hatchet to penetrate them. Through a narrow path, edged in that way by two walls of verdure, the perspective is so limited that every kind of research becomes nearly impossible. Or, also, the trees and bushes, some standing, some inclined or prostrated in every direction, form over the surface a kind of net, whose meshes are hidden by the vegetation of the mosses, of the ferns, &c. Those who have tried to cross a cedar-swamp will never try again the same mode of shortening their journey. It is the most difficult task to pierce through a few rods of such a swamp, either in walking along the prostrated, half-covered trunks, by fear of tumbling down into the dark intervals, or in searching a passage upon the surface by climbing and passing across the trunks or piercing under them through the wet curtains of rank vegetation pending from their sides. Moreover, many peat-bogs are not only of dangerous, but of impossible access. In the north of Europe, and in the south of our country, as, for example, in the swamps near the shores of the sea from New Jersey to Texas, the bog-vegetation often begins at the surface of the water, extends over wide areas, covering abysses of water and mud of various depths. At some places the vegetable carpet is strong enough to bear trees of large size; even railroads have been built upon such kind of floating land; at others the too thin carpet is split and rent by a little weight. When the naturalist is trying to visit such swamps, he does it at the peril of his life. Peat-bogs of this kind in Ireland, as in Denmark and Sweden, too, are crossed only by narrow paths indicated by poles. On dark nights, and in trying to follow them, many a wanderer, missing the way, has never been seen again. Some of these bogs are of such dangerous access that they are never spoken of by the inhabitants of the country but with a kind of dread. In Denmark, according to legendary records, a run upon the death-swamp was the penalty inflicted on great criminals, who rarely or ever traversed the bog, being generally ingulfed in the attempt. Though we may doubt the truth of this legend, it is, however, positive that a great quantity of implements, of weapons, of ornaments, even skulls, skeletons of inhabitants of former races, are found in bogs now emptied by hydraulic enginery and worked to the depth of 75 feet or more, in the north of Europe. The museum of Copenhagen has a number of large rooms filled merely by remains of this kind. And these are not the only forbidding features of the peat-bogs of our time, not all the visible phenomena which should demand investigation and study to enable a naturalist to understand some of the more marked characters of the formation of combustible deposits.

The peat results from the heaping of vegetables growing at the surface of the bogs; but as water is necessary for the preservation and transformation of the vegetable matter, and as peat does not grow always in basins, but often far above the reach of any water-level, where and how is the water procured? By the agency of a mere kind of moss, the *Sphagnum*, which acts like a vegetable sponge.

These mosses absorb water from their leaves, their branches, their stems, still more than from their roots; they live, therefore, from the humidity of the atmosphere when they cannot derive it from underlying basins of water. They always grow in compact masses, sometimes covering wide areas by their only vegetation. They grow, too, upon slopes, even steep ones, and thus in countries where the atmosphere is charged with a large proportion of humidity, they ascend from the base to the top of high mountains. It is the case in Ireland. The cone of the Brocken, too, so well known in the German legends of the Hartz Mountains, is not only surrounded at its base by deep peat-bogs, but the peat covers, at many places, the slopes of the cone to the tops of its rocks. Nobody would dare to attempt descending the cone on these apparently smooth slopes of the mountain, formed by a mere carpet of mosses which, passing from rock to rock, covers sink-holes of great depth between them. In our country, the same phenomenon is repeated in those naked places called glades, on the slopes of the Alleghany or of the Adirondack Mountains. They are openings like small prairies, in the middle of thick pine-forests. The fire has evidently not touched these places; a small spring has developed the vegetation of the spongy mosses. They have, by and by, invaded a larger space, preventing any other kind of vegetation but that of the bogs, even covering the dead trees falling upon them, and there we have deposits of peat upon slopes of the same degree as that of the forests around.

It would take a volume to describe in some detail and explain a few of the manifold appearances which the mere surface of a peat formation, even of small extent, offers for investigation. If one, for example, will take the trouble to traverse a peat-bog, even where its surface is flat and looks uniform, and where the dryness affords a somewhat solid footing, he cannot but remark this:

1st. The essential vegetable, the moss, (*Sphagnum*,) is not only spreading and covering the plane surface, but its tufts ascend all over the *debris* of wood, even the largest trees which have fallen upon the ground, and cover them. And when the swamp is in some places overgrown by bushes or conifers, as it is often the case, these mosses ascend against the trunks or above the roots, forming tufts, hillocks, around and upon them.

2d. This kind of moss, even in its more upraised and apparently dryest patches, is always full of water. Take a handful of it and press it; water will run out of it, not in mere drops, but in rills. This moss has the softness of a sponge, and is a sponge. If you want a proof of it, put this now well-compressed and apparently dry tuft in your pocket, and when at home expose it upon a dry plate to the atmosphere for one cloudy night, and in the morning, you may repeat the experiment, squeeze the moss, and find it as much saturated with water as it was when taken from the swamp.

3d. The vegetation, though most generally, if not always, intermixed with *Sphagnum*, is not continuous or uniform over extensive areas; here we find patches of mosses over which the cranberry and other creeping small bushes are in full bloom; there a group of shrubs; farther, a thick growth of tamaracks, in the north; in the south, the bald cypress and magnolia, or an impenetrable grove of canes; then apparently barren surface covered by shallow water or a thin crust of black mud, interspersed with tufts of hard sedges, rushes, &c.; thus a continual change caused by great diversity of a vegetation which, however, taken in its whole, forms an exclusive and limited group.

This much for mere surface appearances. The diversity becomes, however, far greater in penetrating nearer to the shore of the ocean, in those dismal swamps of the south where it is caused, not merely by the variety of the vegetation, but by modifications of level from the incessant action of the water, either in seeking an outlet, or by alternately invading low land or heaping upon it materials which raise it above the sea. Isolated lakes, like the Drummond Lakes, for example, are met with, which formerly were covered by forests, now sunk to the bottom, where, near the borders, the tops of trees, (*bald cypress*,) still standing, appear above the surface of the water, their trunks immersed 10 to 15 feet deep. A bed of mud is slowly deposited over this sunk forest, from particles of matter brought by water, while on the borders the floating vegetation of the peat, the *Sphagnum*,* especially, already begins preparing for the future a new bed of materials, which may be extended over the whole surface of the lake. Suppose a depression of this floating mass, and the bottom of the lake is then overlaid by two beds of combustible matter, separated by a bed of mud, while, on the borders, the peat of an uninterrupted growth has, of course, formed a single bed. This represents, if time enough is admitted, a bed of coal, compact or in one at some places, separated in two or more beds at some others. This division of the peat-beds by foreign matter, either deposited or brought up by the same agency, is remarked everywhere and often continuous and increasing in the same direction. Some of the lakes of Switzerland are separated by peat-bogs of great extent, some of them more than fifty square miles in area. In the middle of the greatest of these bogs the bed of peat is, on the eastern side, 8 to 10 feet thick, without parting, but toward the west it is horizontally divided in the middle by a streak of sand, which, for six miles farther, increases by degrees to 3 feet. In coming to the borders of the lake the lower bed of peat passes under the sandy bottom. In Holland, borings for water record one bed of peat farthest from the shores in coming nearer to them, proportionally to distance, two, three beds, or more, formed by superposition of sand and mud, causing temporary or permanent divisions of the original bed.

The same modifications are observable in the peat-deposits of this time, and their cause plainly exposed to the explorer in the swamps of this country nearer to the shores of the ocean. Here estuaries indenting the land form a true net-work of canals, lagoons, bayous, cut by narrow capes, islands of various size, some of them a mere mass of heaped vegetables, floating here and there. The lowlands are mostly overgrown with a luxuriant vegetation, affording materials for the growth of the peat; but in some localities these swamps are slowly invaded again by the sea, which has cut a channel through the beach somewhere near by and brings sand over them. By and by these peat-deposits will be buried apparently forever. But if a current or a storm, or some other casualty, closes the channel, the lagoon, protected against marine influence, becomes an inland lake with a permanent level, has its brine slowly changed into fresh water by the ingress of some river, and after a while the same kind of vegetation will re-appear over the lagoon and begin its productive work anew. There is along these low shores a perpetual contest for predominance between

* Species of *Sphagnum*, when growing in water, extend their filaments over the surface in continuous and innumerable ramifications, which soon form a net of floating vegetation, where other plants by and by take root and live. On a solid ground the same species grow in compact mass, all their stems erect, closely pressed together.

water and land; between the peat vegetation which tends to force back the sea in building its moors, as ramparts against invasion, and the marine force, searching an ingress, and in its charges scaling low walls to re-occupy or farther extend its domain for a while. This, of course, causes innumerable modifications of land-surface. The borings and shaftings around New Orleans record an alternance of forests, either prostrated or standing, of gravel, of mud-beds, of peat, &c., as a result of this conflict, which, of course, becomes still more active and varied near the mouth of our great rivers. The low bottom-lands of the Arkansas and Red Rivers at their entrance into the Mississippi show the same kind of alternance in their stratification. The cause is merely modified; inundations, especially, marking their active influence, instead of waves, tides, and currents.

What has been said, as yet, tends already to explain not only the cause of the multiplicity and variety of the deposits remarked in our Lignitic and coal measures, but also the differences observed and recorded by experiments or analyses in the compounds of the combustible minerals, not only at separate points of a same bed, but even on pieces cut from the same block of moderate size.

A perfect understanding, however, of the causes of all the differences noted above, and other phenomena as yet unexplained in the formation of coal and lignite, can be obtained only from the study of the materials which enter into the composition of a peat-bed, when seen on a bank exposed in a vertical section. Such an examination can rarely be made in this country, where the peat is as yet of comparatively little value, and where the rare diggings are made by enginery; heavy, sharpened cutting-shovels, or boxes, moved by steam, bringing out the matter from under water. The face of the banks is in that way constantly immersed. In Europe, even now, peat is worked from large banks isolated at first from the swamps and drained by canals. The matter is cut by hand from the top to the foot of the banks, and on these sections the difference in the compound resulting from variety of the vegetation of the surface may be comparatively studied both ways, either vertically for succession in time, or horizontally for distribution of a contemporaneous flora. The examination of such banks of peats shows at first that, even where the peat is older and more compact, one can recognize and often count from the top to the bottom the layers of vegetable matter which have been heaped each year for the constitution of the whole mass. Near the top the annual layers are spongy, irregular, thick, varying from one to three inches; by compression and decay they become thinner by degrees, and at the bottom are sometimes reduced to one-tenth of the thickness of the surface-layers. They show, too, irregularities resulting from the embedding of vegetables of large size. Generally, however, the general growth is not entirely stopped, even by prostrated forests. It is still indicated by thin layers marking the remains of the vegetation of the *Sphagnum*, and when, either at once or successively, the trunks of trees become embedded, there is for a while a kind of local confusion of the annual layers, till, the growth of mosses and small vegetables having filled the intervening spaces, the surface has become horizontal again and the layers distinctly marked on wider areas. Generally, vegetable remains after a few years are mostly rendered unrecognizable by compression and maceration, which change their color and modify their characters, and, of course, the older the peat-strata are the less their vegetable compounds become identifiable. Some kinds, however, escape disintegration for an immense space of time. These, like some species of mosses, of sedges, twigs of coniferous or species of the heath family, may be recognized from the surface to the lowest part of the banks of ancient beds of peat. I have many times seen strata composed essentially of the heath, (*Erica vulgaris*,) which enters often in great proportion into the formation of the peat in Europe, whose branches, with leaves still attached to them, were as identifiable as in their original form, and this under 10 to 12 feet of peat. In digging for the foundation of a state monument at Berlin, a thin bed of peat was exposed under 40 feet of drift-sand. This peat was a compound of mosses, which were so well preserved that the species could be recognized just as if the mosses had been recently taken out of the swamps. Professor Horton, attached to the geological survey of Ohio, found two identifiable specimens of mosses in a peat-deposit underlying clay-beds covered with drift.

The growth of the peat in basins full of water and from immersed vegetable, results from proceedings somewhat different, but not less admirably adapted by nature to the purposed end. All the basins where the peat is formed under water have a bottom of clay prepared in advance by some kinds of water-plants, *Confervæ*, which, living totally under water, out of atmospheric influence, are mere cellular plants, and by decomposition produce, like the infusoria and small mollusks which they feed, siliceous or clay deposits. To these capillary plants are often added the *Characeæ* and some species of mosses which, by peculiar and as yet unexplained structure, have the property of transforming and assimilating in their tissue the carbonic acid of the water into lime. It is only after the preparation of the clay bottom, and when the basin has been rendered impermeable, that water-plants of another kind begin their vegetation. The *Sphagnum* among them, the floating species of *Hypnum*, the *Thypha*, *Sparganium*, *Pond-weeds*, *Water-lilies*, all plants rooting in more or less deep water, but opening their leaves and flowers at or above the surface, and thus by atmospheric influence transforming the carbonic acid into fibrous tissue, and becoming woody plants fit for future use as combustible mineral. The *débris* of this vegetation are heaped every year and decay under water. These *débris*, generally more mixed, and mostly, too, partly decayed and bruised before submersion, form a more compact mass, without recognizable annual layers, and in time may be transformed into that coal named cannel.

Swamps of this kind, however, are not always continuous either in a vertical or horizontal direction. It happens in some countries that when peat formed by immersion of vegetables has been heaped up to the level of the water, the upper aquatic vegetation begins its work and builds, high above it, a deposit of peat, where the same phenomena, viz, distinct annual layers, &c., are remarked as in the emerged peat formation. On another side the subaquatic vegetation, and therefore the immersed formation of the peat, is sometimes in full activity over a swamp-surface, while at another place of the same swamp, the ground raised above water is covered by a cranberry-swamp or an emerged peat-bog. This is the case on some of the great swamps of North Ohio, and I still recollect with some kind of dismay, that twenty years ago, misled by vague informations, I waded in three feet of water over the surface of an immersed peat formation, so thickly overgrown by bulrushes (*Scirpus pungens*, *Scirpus validus*, *&c.*) that once within this kind of thicket I lost sight of the borders, already far away, and lost my direction, too. Searching there a way of egress for hours, I had full time to investigate that unpleasant side of the formation of the peat, till at last I came to the upper part of the same swamp, the cranberry-marsh which I was anxious to explore. The difference of compounds in some beds of coal which, sometimes, have layers of cannel-coal in the lower part, topped by bituminous coal; or which at one end are true cannel-coal in their whole thickness, passing to bituminous in following them to some other part of the same deposits, is explained by these remarks on the formation of our peat-bogs. We find, also, a remarkable identity of compound in the bottom clay of the coal and Lignitic beds, which, too, indicates by its remains the agency of plants of a same nature or of water-plants in its formation.

In comparing peat to coal, and judging from mere appearance, one finds at first a great difference between these combustible materials. But in following the intermediate grades which modify them according to age, the intervening links are found so intimately joined that it becomes impossible to separate them or to mark divisions from permanent characters. In ancient peat-bogs, the peat, especially near the bottom, becomes black, compact, intermixed by layers of crystalline, though still soft coaly matter, which only wants hardness to be comparable to true coal or even undistinguishable from it.* Passing from peat to what is called lignite, or to deposits of woody matter in formations older than ours, we find in these accumulations either beds of mosses of species still recognizable as analogous to those of our times, or heaps of trunks whose wood has still its color, its original structure, as it is seen in the present peat-bogs, but which has already become softened to the consistence of clay. Some older deposits have their woody remains, trunks, and branches, already blackened but still soft, being easily cut by shovels. Still farther into the divisions of time or of geologists, this wood, as at Golden, for example, is found hardened, carbonized-like, but preserving its original structure so distinctly that the concentric layers of branches are as distinct as in the wood of our forests. And in the same basin, or at the same horizon, as, for example, at the Raton, the combustible matter still called lignite has become, by its appearance, hardness, and chemical compound, undistinguishable from the coal of the Carboniferous measures.

Chemistry accounts for the differences remarked in the various degrees of decomposition of woody materials. It explains how the transformation of woody fibers into coal is the result of a retarded combustion by the slow combination of the oxygen of the atmosphere with the hydrogen of the plants, converting the woody fiber into carbon and increasing, proportionally to the duration of the process, the amount of fixed carbon. In this operation of nature the wood passes through all the stages of decomposition remarked in mineral combustible, from peat to anthracite, &c. In the lignite the work is only half done, as seen in consulting the numerous analyses given of this matter, which always indicate a proportion of carbon relative to that of water or of as yet unburned woody fibers. In some cases the slow maceration appears hastened to its completion by subterranean heat. How else would it be possible to explain the transformation of lignite into anthracite in close vicinity to basaltic dikes, as at the Raton Mountains and at Placiere Mountains, New Mexico, when the same beds, at a distance, retain still the appearance and chemical compounds of true lignite?

Nothing is more admirable in nature than the apparently simple process of the formations which have here been briefly reviewed. Nature disposes of the carbonic acid of the atmosphere and of its humidity for the food of the plants which, by a kind of digestion, elaborate it into woody fibers. Under peculiar times and circumstances, where these

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* The bottom of a peat-bog of Locle, Switzerland, is formed of layers of this substance already hardened and undistinguishable from lignite-coal.

woody materials are unavailable, it piles them into vast magazines, carefully prepared a long time in advance, for that purpose. And then, reversing its operation, slowly combining again the water and the carbonic acid of the wood, to return them to the atmosphere as new food for living plants, it constantly improves the value of the stored materials for a future contingency. Man now recognizes the end of this work, enjoys its results, and can but acknowledge in it the disposition of a wonderful Providence.

The first result of the decomposition of woody matter in basins prepared for the formation of the peat is the generation of an acid, (*acid ulmic*,) soluble in water, and especially marked by its antiseptic property. Water saturated with this acid not only retards indefinitely the decomposition of the wood immersed into it, but, under some circumstances, preserves for a length of time every kind of organic matter, even meat. The water does not receive from this compound any unpleasant taste or smell, nor any unwholesome influence. It is as palatable for drink as spring water, merely unattractive by its somewhat brownish color. Even it may be considered by its antiseptic property a preventive against fever and other epidemic diseases, or a remedy for every kind of diseases caused by putrid decomposition of tissue. Statistic tables have established this fact in Europe, that the average of human life is longer for the inhabitants of the peat-bogs or of the land bordering the formations of this kind. This water, too, does not enter into decomposition even when exposed to a high degree of continued heat. It has been carried for eighteen months or more in explorations of equatorial countries, preserving its purity to the end. From this it is easily understood how trees or fragments of wood, thrown down or strewn upon the bogs, become protected against decomposition by a thin carpet of mosses impregnated with such kind of water.

The ulmic acid, soluble in water, becomes fixed or solidified into a black resinous matter, by evaporation of the water, thus forming a proportion of the combustible part of the peat, and greatly increasing its value. The difference in the heating properties of the compound, when dried under atmospheric influence or by compression, is sometimes as high as one-fifth. The best peat, therefore, is that which, taken from the bogs by hand or by machinery, is kneaded till the whole has been rendered a homogeneous paste. The operation is performed in various ways, according to means and circumstances; by pounding with the feet, with wooden mallets, by mills, &c. The peat thus prepared is cut or molded in pieces of suitable size, left upon the ground till somewhat hardened, then dried by successive exposure of the faces to the atmosphere. Prepared in that way, the peat of the old bogs of our time is as good a combustible as hard wood.

The ulmic acid of the water of the bogs, antagonistic to some kind of vegetation, essentially favors the growth of plants of hard woody tissue. The flora of the peat-bogs is therefore exclusive and limited. It has mostly species with sharp-pointed narrow leaves—conifers, grasses, sedges, rushes, canes, mosses, and a few shrubs, dwarf-birch, cranberry, &c. The bladed form of the leaves appears especially appropriate to the absorption of atmospheric humidity, and by their multiple surfaces to the evaporation when superabundance of water demands it. The mosses have not as yet been observed in a fossil state, neither in the Carboniferous nor in the Lignitic formations. The first remains of this class appear in the Upper Tertiary, especially in the amber. But there is not a positive proof of their absence in older formations. Moreover, the peat-bogs of former epochs have apparently had for their growth other kinds of vegetables, possessing the same properties with the same mode of life. We do not know them as yet, for the vegetable remains fossilized in sand and clay beds seem to represent species of plants bordering the swamps, rather than the species which have contributed to their composition.

The evaporating and absorbing power of the plants of the bogs play another remarkable part in the economy of nature in moderating the extreme of temperature, especially greatly reducing the excess of cold. Everybody knows how even a thin fog prevents frost. The flora of our Lignitic, like that of the Coal epoch, has a number of species, whose affinity is with plants now considered as characteristic of a tropical or subtropical climate. It has been generally argued therefrom that at the time when our combustible minerals were in progress of formation the climate of our country was much warmer than it is now. From the examination of the first specimens of Tertiary fossil-plants found on this continent I was inclined to admit a same opinion; but the more I have studied the distribution of the plant of former epochs, comparing it with that of ours, the more I have been led to believe that the differences in the general characters of the vegetation, as indicated by fossil remains, result essentially from atmospheric humidity, rather than from temperature. In Ireland and in Scotland, near the mouth of the Firth and of the Clyde, as high as 57° of latitude, a limit corresponding on the American continent with North Labrador, the vegetation under a high degree of atmospheric humidity, already presents a tropical aspect. Tropical ferns, species of *Hymenophyllum* and *Trichomanes*, cover the rocks and the mossy trunks of the trees, mixed with European forms of ferns, which, by their luxuriance and size, recall the characters of the vegetation of the Southern Islands.* It has been remarked already that the coal and lignite beds proved for the time of their formation a far greater degree of atmospheric humidity than we have now. If a mere difference in the proportion of humidity can produce at our time a change in the character of the vegetation corresponding to that indicated by temperature in 25° of latitude, or the difference between the southern swamps of ours and those of Scotland, we can easily admit, as resulting from the same cause, the facies of the vegetation of Greenland at the Tertiary epoch. This flora, as we know it already, has a general relation and some identical species with that of our Lignitic deposits of the West.

These details, which indirectly throw light on the productive causes, the distribution, and the original composition of the lignite-beds, are sanctioned by the importance of a formation, justly considered as a most essential series of our American geology.

THE LIGNITIC CONSIDERED IN ITS APPLICABILITY.—AREAL DISTRIBUTION AND THICKNESS OF THE STRATA.

§ 1. THE NORTHERN LIGNITIC BASIN.

The formation to which the name of *Great Lignitic* is fittingly applied is for the first time noticed in Lewis's and Clarke's expedition to the Rocky Mountains, 1804:

> The coal or lignite was first observed twenty miles above the Mandan Village. The bluffs on each side of the Missouri are upward of 100 feet high, composed of sand and clay, with many horizontal strata of carbonated wood, resembling pit-coal, from 1 to

* Schimper, Vegetable Paleontology, vol. 1, p. 358.

5 feet each in thickness, and occurring at various elevations above the river. At fifty miles above the village, similar coal-seams were noted, but here they were observed to be on fire, emitting quantity of smoke, and a strong sulphurous smell. Further on the same sulphurous coal continued for eighty miles more; strata of coal, frequently in a state of combustion, appearing in all the exposed faces of the bluffs. The quality of the coal improved as the party advanced near the mouth of the White River, eighty-five miles farther, affording a hot and lasting fire, but emitting very little smoke or flame. Thence forty-seven miles to the Yellowstone River, and at a bluff eight miles up that stream, were several strata of coal. For fifty miles above the junction of the Yellowstone and the Missouri there were greater appearances of coal than had yet been seen, the seams being in some places 6 feet thick, and there were also strata of burnt earth, which were always on the same level with those of coal. The explorers had thus far traced this lignite formation along the banks of the Missouri for a distance of three hundred and thirty miles. The horizontal formation of clay, loam, and sand, with fragments of coal in the drift of the river, extended three hundred miles more to Muscle-shell River, or six hundred and twenty miles from the Mandan Village. Even above this point, washed coal continually appeared on the shores of the river and at Elk Rapids, eight hundred miles from Fort Mandan, the high bordering bluffs, were still composed of horizontal beds of clay, brown and white sand, soft, yellowish-white sandstone, hard, dark-brown freestone, and large, round, or kidney-shaped nodules of clay, iron ore. Coal, or carbonated wood, similar to that previously observed, was also seen, and was accompanied with burnt earth, probably the result of the spontaneous combustion of the coal, as was noticed for hundreds of miles below. After reaching the grand fork of the Missouri, and ascending two or three days' journey up Maria's River, northward, it was remarked that precisely the same geological character and coal-strata prevailed for more than sixty miles. So far, therefore, the exploring party had been traveling through or over a ligneous-deposit of singularly uniform character for no less than nine hundred and eighty miles, following the winding of the river. Pursuing the south fork toward the great falls of the Missouri, coal was still observed in bluffs of dark and yellow clay at a distance of two thousand four hundred and fifty-four miles up that mighty river, and it was not until near the base of the Rocky Mountains, and after one thousand miles of traveling across it, that this great region of coal-beds and lignites was passed.

On his return Captain Clarke descended the Yellowstone from about north latitude 45° to its mouth, 48° 20′, and everywhere found the same series of coal, and variously colored clays and soft sandstones, as was traversed in ascending the Missouri.

Below the Big Horn is a large stream falling in from the south, whose Indian name implies "The Coal Creek," from the great quantity of this mineral upon its border. The same coal series continued to the confluence of the Missouri, exhibiting uninterruptedly for seven hundred miles, in addition to the thousand previously traversed, the vast persistence of this formation. The enormous area of similar strata is further shown by the decoloration of all the tributaries that enter the Missouri from both the south and the north from the forty-second to the forty-ninth degree of north latitude.*

In 1832 Prince Maximilian, of Neuwied, passed up the Missouri River, and in the splendid record of his travels mentions the occurrence in numerous localities of thick beds of lignites.

Some more detailed information on the distribution of the lignite-beds of the Tertiary are given by Mr. E. Harris,† who accompanied Audubon up the Missouri to the mouth of the Yellowstone, in 1843. He counted, at one place, eight seams of coal between the river and the top of the bluff, their thickness varying from 6 inches to 4 feet.

In Dr. D. D. Owen's final report of a geological survey of Wisconsin, Iowa, and Minnesota, an account is given of Dr. John Evan's exploration of the Mauvaises Terres. He remarks, (p. 195:)

That below Fort Clarke the great lignitic formation first shows itself in the banks of the Missouri. It was traced to a point twenty miles below the Yellowstone. One of the thickest and most valuable beds of coal observed by Mr. Evans occurs near Fort Berthold, where it is from 4 to 6 feet thick.

In 1850 Mr. Thaddeus A. Culbertson visited the Upper Missouri to above Fort Union, noting the occurrence of lignite-beds at various localities.

Thus, at different times, the lignite-beds of the Upper Missouri and

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* R. C. Taylor, Statistics of Coal, p. 175.
† In Proceedings of the Acad. of Nat. Sci., Phil., May, 1845.

Yellowstone Rivers were remarked, but always in a general way, without giving any precise information concerning their age, their distribution, thickness, and compounds.

The same Lignitic formations were also described from the northwest of British America, with some more details; but these observations do not concern the present researches.

From the south, too, or from New Mexico, we have records of the presence of thick coal-beds "found in great abundance and of good quality between the placers in the Raton Mountains, and many other places."* And in the narrative of Lieutenant-Colonel Emory, coal is mentioned as occurring between Fort Bent, on the Arkansas River, and Sante Fé to the north and south of the Raton Pass. One bed seen to the northward, at Captain Sumner's camp, is described as an immense field, the seam which cropped out being 30 feet thick. Another noticed by Colonel Emory, was seen on the banks and near the head-waters of the Canadian River, about north latitude 36° 50′, on the 7th August, 1847.†

It is in the reports of Messrs. Meek and Hayden, and in the numerous papers which these gentlemen have published from 1857 to 1861, that we obtain the first positive data, not only on the geology and paleontology of the Lignitic formations of the north, but, also, on the distribution and value of their beds of combustible minerals. The proceedings of the Academy of Natural Sciences of Philadelphia, May, 1857, have a very interesting account of the Tertiary and Cretaceous of Nebraska, by Messrs. Meek and Hayden. The section, page 8, marks the relative position of eight beds of lignite underlaid by a compact sandstone 30 feet thick, which directly reposes upon No. 5 of the Cretaceous.

In the same year Dr. F. V. Hayden has a map with sections of the country bordering the Missouri River, accompanied by explanations and documents of the highest interest. This work embodies the results of three years' explorations by the author in the Northwest. It marks the outlines of the great Lignitic Tertiary at the south from the Upper Smoky Hill Fork of the Kansas River, to above White River, or the South Fork of the Cheyenne; and at the north on both sides of the Missouri River from below Fort Clarke to the Muscleshell River, the north limit marked by British America, and the southern by the head-waters of Cherry Creek and the Black Hills. The author estimates the area of this north basin at four hundred miles in length and one hundred and fifty miles in width, or at about sixty thousand square miles—an estimate which he rightly considers as too low. From this time to 1861 the papers of Messrs. Meek and Hayden, mostly relating to paleontology and geology, do not furnish any materials for this part of my researches.‡

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* In a letter of Don Manuel Alvarez, May, 1847, quoted by Taylor, *loc. cit.*

† R. C. Taylor's Statistics of Coal, p. 220.

‡ In order to show the amount of work performed at that time to prepare the knowledge which we have now obtained on the geology of the Western Territories, and to direct the researches of those who are interested in the subject, I give here a mere catalogue of the memoirs published by Messrs. Meek and Hayden, from 1857 to 1861:

May, 1857.—Proceedings Acad. Nat. Sci., Phil.: On the Tertiary and Cretaceous formations of Nebraska, &c. (F. B. Meek and F. V. Hayden.)

May, 1857.—*Loc. cit.*: Notes explanatory of a map and section illustrating the geological structure of the Upper Missouri, &c. (F. V. Hayden.)

June, 1857.—*Loc. cit.*: Notes on the geology of the Mauvaises Terres of White River, Nebraska. (F. V. Hayden.)

March, 1858.—Trans. Albany Inst.: Description of new organic remains from Northeastern Kansas Permian. (Meek and Hayden.)

The geological report of Dr. F. V. Hayden on the exploration of the Yellowstone and Missouri Rivers, under the direction of Captain Raynolds, (1859–'60,) published in 1869, gives besides the details on the geology of the country, some interesting data on the distribution of the lignite-beds. The more important are as follows:

In the great Lignitic group of Fort Union, local deposits of lignite as marked in general section of the rocks of Nebraska, p. 29. In section 2, from the Black Hills to the Yellowstone River, eight beds of impure lignite varying in thickness from 3 inches to 3, 4, and 5 feet. Sections 3 and 4 have two beds of impure lignite with only one bed of lignite more or less pure, divided by layers of clay. Section 5, p. 52, on Powder River, indicates on a thickness of 356 feet of strata, thirteen beds of lignite mostly thin and clayey; one of them, however, No. 11, is 7 feet thick and quite pure. Two other sections in the same country mark beds of lignite more or less impure, generally parted in thin layers by clay-beds, and therefore of little value. Up the Yellowstone Valley Dr. Hayden mentions, near the mouth of the Rosebud Creek, a lignite-bed 5 feet thick. "Three hundred yards above, it separates into two parts, 2 to 2½ feet each, with 6 to 8 feet of arenaceous clay between. Five hundred yards farther, the two beds begin again to unite, there being about 6 inches chocolate-clay between them. The lignite is quite pure." From the Big Horn to the union of the Yellowstone with the Missouri, the lignite-beds occupy the whole country with the exception of the portion already described and a distance immediately on the river of about seven miles called Shell Point. The lignite-beds are well developed, and at least twenty to thirty seams are shown, varying in purity and thickness from a few inches to 7 feet.*

In the records of a journey to Pumpkin Buttes and the sources of the Cheyenne River, Dr. Hayden remarks that the whole region from the Platte to Pumpkin Butte is covered with the true lignite formation, containing numerous beds of lignite more or less pure. The section of the buttes † is remarkably like that of the Gehrung coal in Colorado, with conglomerate beds at its top, underlaid by alternate layers of impure lignite, clay, and thin beds of sandstone, the whole measuring 428 feet. The section at Gehrung's is 426 feet. After this are seen, sloping down to Powder River, similar rocks with some thick beds of lignite, from 6 to 8 feet in thickness. Near the junction of Snake River we find in the same report the Tertiary beds prevailing to a great extent, and in a section of 80 feet six or eight seams of impure lignite which has ignited in several places.

March, 1858.—Proceedings Acad. Nat. Sci., Phil.: Description of new organic remains from Nebraska. (Meek and Hayden.)

June, 1858.—*Loc. cit.*: Explanations of a second edition of a geological map of Nebraska and Kansas, &c. (F. V. Hayden.)

November, 1858.—Report on collections obtained by the expedition under command of Lieutenant G. K. Warren. (F. V. Hayden.)

December, 1858.—Proceedings Acad. Nat. Sci., Phil.: Remarks on Cretaceous beds of Kansas and Nebraska, &c. (Meek and Hayden.)

January, 1859.—Trans. Saint Louis Acad.: On the so-called Triassic rocks of Kansas and Nebraska. (Meek and Hayden.)

December, 1858.—Proceedings Acad. Nat. Sci., Phil.: Remarks on the lower Cretaceous beds of Kansas and Nebraska. (Meek and Hayden.)

January, 1859.—*Loc. cit.*: Geological explorations in Kansas Territory. (Meek and Hayden.)

May, 1860.—*Loc. cit.*: Description of new organic remains from the Tertiary, Cretaceous, and Jurassic rocks of Nebraska. (Meek and Hayden.)

October, 1860.—*Loc. cit.*: Catalogue with synonyma, &c., of the fossils collected in Nebraska by the exploring expedition under Lieutenant G. K. Warren. (Meek and Hayden.)

January, 1860.—Am. Jour. Sci. and Arts.: On a new genus of Patelliform shells from the Cretaceous of Nebraska. (Meek and Hayden.)

March, 1861.—*Loc. cit.*: Sketch of the geology of the country of the head-waters of the Missouri and Yellowstone Rivers. (F. V. Hayden.) Followed in December, 1861, in Proc. Acad. Nat. Sci., Phil., by descriptions of new species of fossils collected in the same exploring expedition of Captain W. F. Raynolds. (Meek and Hayden.)

* Loc. cit., p. 59.

† Loc. cit., p. 73.

The geological notes of Dr. C. M. Hines, in the same report, mention beds of lignite in a number of sections in the same country; the thickness and quality of the material are not given. He says, however, of the beds on Tullock's Creek, that the lignite in this vicinity approaches more nearly to coal, and, the beds increase in depth; of those of Clear Fork of Powder River, that the outcrop of lignite is of better quality than any before seen, and that for some distance above the first camp on the Clear Fork to the junction with Powder River proper, there is a thick outcrop of lignite of the depth of 6 feet and upward, somewhat resembling Cumberland coal, but of looser texture and containing less bitumen. Eight miles below the camp, this coal was seen to be on fire. Considerable smoke issued therefrom, having a strong sulphurous smell. "The heat at this point was so intense that we could not stand with comfort within 20 feet from whence the smoke issued. A thick layer of sandstone lying immediately above it was completely calcined."

Passing from the northern part of the Lignitic to its southern division, extending along the base of the Rocky Mountains from the Black Hills to New Mexico, we have, especially on the lines of the different railroads, detailed records on the coal-strata, mostly made with care by competent geologists. I have already quoted the most interesting of these reports: Notes on the Geology from Smoky Hill River to Rio Grande, by Dr. John Leconte, February, 1862, soon followed by the preliminary report of Dr. F. V. Hayden, on the United States Geological Survey of Colorado and New Mexico, 1869. As my own explorations have been directed on about the same ground surveyed by these geologists, I shall now make use of my own notes on the distribution of the coal, using, however, former reports, either for comparison or for references for the sections of country which I have not visited.

§ 2. The New Mexico Lignitic Basin.

In the Raton and south of these mountains, Dr. F. V. Hayden* mentions, near the toll-gate south of Trinidad, a bed of coal 4 feet thick, of excellent quality.† Near the Vermejo Creek, six beds of coal are marked in a section of the same report, one of the beds from 6 to 10 feet thick, and another, the lowest, 4 feet. Dr. Hayden remarks that the coal of that vicinity is equal to any ever discovered west of the Missouri River, except that of the Placiere Mountains of New Mexico. Of this last bed, which has been partly transformed into anthracite by the immediate contact of a large dike of volcanic rocks, this geologist gives a detailed section, marking its thickness at 5 to 6 feet on the northwest side of the Placiere Mountains, at a distance from the dike and where the lignite has not as yet been disturbed and changed by heat. At another place in contact to the dike, the lignite (anthracite) is a little more than 3 feet thick. Of this same bed Dr. Leconte has a section (*loc. cit.*) indicating 4 feet of anthracite, with a lower bed of the same material, of which 14 inches only could be seen, the bottom being covered. In his report, too, for the survey of the Union Pacific Railway, the same geologist mentions: First. A bed of lignite 3 feet thick, 4 miles south of the toll-gate of the Raton Pass. Second. Another bed, 8 feet thick, five miles southwest of the same place. Third. The lignite-beds of the Vermejo Cañon, visited with General Palmer, where, in a section of 275 feet, we find marked two beds of partly poor coal, respectively 10 and 15 feet thick, and two beds of excellent lignite, each

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* Geological Report, 1869.

† This coal is also reported by Dr. Leconte; Notes on the Geology, &c., p, 21.

5 feet thick, separated only by 10 inches of slate. Coal-beds of the same kind are seen in the same vicinity: in Blackmore Cañon, where the lignite, not fully exposed, is reported 10 feet thick, and in the Bremer Cañon, immediately south of the Vermejo Valley, where a number of outcrops, mostly obscured by land-slides, were seen, indicating at least 4 feet of good coal. Fourth. Lignite-beds in the valley of the Rio Puerco, twenty-eight miles southwest of Albuquerque, with an exposure of 5 feet. Fifth. The lignite-beds from which the fuel for Fort Craig is obtained, nine miles east of Don Pedro, whose section indicates a thickness of 5½ feet of coal with two clay-partings of 3 inches. Besides this, Dr. Leconte was informed that a good bed of coal exists near the town of Limitar.

General W. M. S. Palmer's report of surveys across the continent in 1867 and 1868 completes the records on the distribution of the lignite-beds south and west of the Raton Mountains by the following informations: The coal of Tijeras Cañon, at a short distance northeast of the town, has been found 4½ feet thick and traced by Mr. Holbrook, division engineer, for a distance of 2,000 feet by sinking small shafts along the vein. A valuable seam has been discovered near San Felipe, (thickness not indicated,) within twelve miles of the Rio Grande. Coal also is reported in the Pecos Valley, five miles above Anton-Chico. On the Cimarron route of the railroad a large vein of coal, apparently 14 feet thick, has been reported by Dr. Steck, and at a number of places, similar coal or lignite beds are mentioned in the same report, without indication of thickness. On both sides of the Rio Grande, numerous beds of lignite (named bituminous coal) are found near Doña Aña and Mesilla, and others still are reported west of the Rio Grande, one three hundred miles from Albuquerque, by Dr. Newberry, who saw near the Moqui villages a bed 12 feet thick; another by Dr. Parry, who saw a bed 4 feet thick on the Zuñi Pass, near Pescado Springs; and still, by the same geologist, many beds of lignite about thirty miles west of the Rio Grande, in the Sarocino Cañon, varying in thickness from 3 to 4 feet. A number of localities where lignite-coal has been reported on the different lines proposed for the railroad are still mentioned in General Palmer's report. But this already gives us sufficient proof of the productiveness of the great Lignitic south of the Raton Mountains, and in countries still unexplored where the mineral deposits are as yet mostly unknown.

The lignite-beds in the vicinity of Trinidad have as yet been scarcely opened. Some coal is hauled to the town from the base of the Raton Mountains, on the road of the Raton Pass, where, as already reported in section, the lowest beds have a thickness of 4 feet or more. According to the information received from persons well acquainted with the country, there is a great deal of coal all around the town; so much, indeed, that everybody can take it and haul it for their own use whenever they like and without paying for it. As there is still an abundance of wood, pine and juniper, in the country, and a limited population without railroads, the demand for coal is very limited indeed. But there is for the future a reserve which already demands careful investigations and a sagacious investment of money, especially by the companies of railroads in process of construction to the south. This is especially the case in regard to the Lignitic deposit overlaying the Eocene sandstone from Trinidad to the foot of the Spanish Peak. A number of beds of lignite have been already reported from this basin; near Gray's ranch, a stage-station; near Chicosa, twenty miles north of Trinidad, &c., &c. The coal there, being considered as of no value whatever, has not been looked for, and the numerous outcrops remarked in the hills have not been tested. The lignite of this part of the country appears, however, of remarkably good quality, even richer in carbon than the Raton coal, and compact enough to give good hard coke by distillation, an important quality which has not as yet been recognized in any of the Tertiary lignite, except in the Placiere anthracite. The analysis of the lignite of Chicosa is given hereafter in a comparative table.

In resuming the remarks on the lignite of the country, it is allowed to conclude that from positive evidence there is along a nearly direct line from Pueblo to Santa Fé, and for a distance of more than three hundred miles, such a richness of combustible mineral in the Eocene lignite-beds as may be sufficient for the future demands of a large population. The supply of coal on that line can be considered from all appearances as inexhaustible.

§ 3. The Colorado Lignitic Basin, from Pueblo to Cheyenne.

A separated number of this great basin, or rather an isolated area spared by the work of denudation along the base of the Rocky Mountains, is the small Lignitic basin in the Arkansas Valley, east of Cañon City. Its exact productiveness is not as yet ascertained. The report of Mr. Nelson Clarke, already noticed, says that the coal-yielding rocks contain at least nine seams of lignite, varying in thickness from 6 inches to 8 feet: "two seams at the south, close to the range, are respectively 6 and 7 feet thick and but 50 feet apart; at the north, on the river, they are but 2 and 4 feet thick and at least 150 feet apart." The lowest of these seams of coal is known as the Cañon City coal, now the land property of the Colorado Improvement Company. The coal is 51 inches thick, black, compact, uniform in color and compound, separating in large cubic blocks by cleavage, and from appearance not liable to disintegration by atmospheric influence. This coal was already known and in demand for blacksmiths even at Denver, though before the building of the Denver and Rio Grande Railroad, the cost of transportation was very high. When I passed the place the branch of the railroad from Pueblo to Cañon City was not yet finished and the lignite was hauled to Pueblo for the use of the railroad at the cost of $5 per ton. Now it is already shipped from the newly opened mines at the rate of about one hundred and fifty tons per diem. Borings are in process at different places to ascertain the thickness and continuity of the veins. From what is known as yet, this small basin has a productive capacity which will afford combustible materials for a length of time.

The bed of lignite formerly mentioned as the Gehrung's coal, at the base of the Colorado pinery, does not promise well for future demand. It is too thin, only 2 feet thick, too friable, and, as worked now, the mine is subject to inundation in high water. It can, however, be found improving in thickness and quality to the south, where shafts could be sunk at a distance from the river. But abundance of combustible material is now easily and cheaply procured by railroad, and the cost of building a shaft and of working the coal would be above the value of lignite of inferior quality from a bed less than 4 feet thick.

The Eocene formation so largely developed along the Rocky Mountains, from the North Fork of Platte River to Cheyenne, will be for a long time to come the essential magazine of combustible, wherefrom an abundance of excellent materials will be supplied to the railroads, and the already large population of the country. If some of the opened veins do not yield now as largely as it was at first expected, the reason is especially in the want of good management in the mining, provoked by unprofitable working. Here, as everywhere, coal mines have been at first considered by the proprietors as true gold-mines, whose possession was to bring immediately splendid profits by exploitation. Lignite-beds have been opened everywhere, even far from a good market, and against great difficulty of transportation, &c. For many, the result has been disappointment, neglect of the working of the veins, and even their total abandonment. Now railroad branches have been built or are in process of construction from Denver, or from the Denver and Pacific Railroad to the most important coal-deposits. The supply, already fully equal to the demand, is increasing every day; and if nothing is done by the proprietors to moderate it, they may find a new cause of loss in the superabundance of coal mined for an overstocked market. This excitement might be dangerous for the future, if the lignite-beds already opened or worked were not thick and over extensive areas. But what is known of the productiveness of the Lignitic measures of this country indicates, indeed, an immense reserve of combustible materials.

Most of the lignite-beds exposed along the creeks of this section have been tested. Dr. Hayden* notices a coal-bed opened and worked to some extent near the cañon of the South Platte, and two beds now covered with loose materials, in all 5 feet of lignite separated by 2 feet of clay. The coal is not very good, and has not been used for years.

Going north, and before reaching Golden City, the first coal-vein seen opened is at Wheeler and Johnson's mines, near Green Mountains, one mile east of Mount-Vernon. The coal is 7 feet thick; not of very good quality. Then, three miles east, the Rowe coal-bank, 6 feet thick, of a better quality than the former. This vein, which is noticed in Dr. Hayden's report, 1869, dips east 67°; is very accessible, and not troubled with much water. It has furnished, up to 1868, about two hundred and fifty tons of coal, but is now idle for want of good communication.† The coal-veins of Golden City, three miles north of the Rowe mines, are now opened at five different points, the lignite-beds varying in thickness from 5 to 11, even to 14 feet. On the shaft near the railroad-line, the coal, 7 to 11 feet thick, is nearly vertical. Half a mile from this, another shaft 70 feet deep works the same bed, also nearly vertical, 9 to 11 feet of solid, very good coal. This vein of coal has been traced and opened from Rowe's coal-bank, five miles southwest of Golden, to a point seven miles north of Golden, and tapped in eleven different points without discovering as yet any appearance of failure in the vein. In what is called the Golden City coal-mines, the vein is opened at three different places, 9 to 14 feet thick, and has been worked continuously since 1865. It was discovered 1861–'62. The mines have furnished as yet about eight thousand tons only, and are worked at an average of thirty tons a day. The dip varies from 65° to 71° southwest.

At the Johnson's coal-mine, half a mile southwest of Golden, the vein is mined 9 feet thick, to a depth of 90 feet. And at Welsh & Company's coal-bank, one-third of a mile south of the former, the vein worked is 5 to 7 feet thick; dip, 71° southwest; and five veins of lignite are seen there parallel to one another and of various thicknesses.

Following northward the same lignite-strata, which, as said above,

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* Report, 1869, pages 37 and 38.

† These precise and valuable informations on the lignite-beds of Golden and of the country around are due to the kindness of Mr. E. Berthoud, civil engineer at Golden.

have been tested and recognized continuous, we find them opened on the Ralston Creek, at Murphy's, five miles north of Golden, where the vein, nearly vertical, averages in thickness 16 feet of solid coal without parting of any kind. Eighteen thousand tons of lignite have been taken from this mine since it was opened.

Half a mile south of Murphy's, the Mineral Land Company has opened the same vein, 9 feet thick, also without parting, but contorted in its uplift. The lignite is of the same quality, but the bed has not yet been worked to any extent.

North of Ralston Creek to Marshall, the lignite is not worked now. But, as it has been already remarked, in the banks of all the creeks which, descending from the mountains, have dug their beds through the Eocene formation, beds of lignite varying in thickness from 5 to 9 feet are exposed; some of them already tested have been worked formerly to some extent. The conclusion, therefore, on the continuity of the Lignitic basin from south of Golden, even from the North Platte to Boulder Creek, is fully warranted. It is, in a direct line, a distance of fifty miles, and even, as beds of lignite have been reported from Thomson Creek and Cacha la Poudre River, the continuity of the Lignitic beds may be admitted for fifteen to twenty miles further north. The extent of the basin from east to west, or its width, is not as yet ascertained. In the space limited between the primitive rocks and the basaltic dike, where the strata are thrown up nearly perpendicular, the amount of coal can be computed only from the depth attainable in the working of the mines. The length of this area from the Rowe mine to Coal Creek is about fifteen miles. Thence northward, as the strata take their normal horizontal position, the lignite-beds appear to be continuous from the base of the mountains to the Platte, or for about fifteen miles from west to east. I have no doubt that beds of lignite can be found further east by shaft, as they have been found east of Denver, on the Kansas Pacific Railroad. But as the quality of the lignite deteriorates in proportion to the distance from the mountains, the combustible mineral would be there of little value, especially while an immense amount of lignite of good quality is as yet untouched in the valley of Boulder Creek. The section at Marshall's indicates 63 feet of coal in a thickness of 500 to 600 feet, seven of the beds varying in thickness from 4 to 14 feet, the lowest one now worked, 10 feet. Even from Marshall's estate little coal has been taken out till now, on account of the difficulty of transportation. From information kindly given by the proprietor, the mining amounts to about twenty-five tons per day, while, with the facilities of railroad transportation, the same mine could be worked in a way to furnish at least three hundred tons per day. Most of the coal of this country is obtained from the Erie mine, fourteen miles southeast of Marshall's, where the bank is 8 to 10 feet thick. The land is the property of the Kansas Pacific Railroad, which has a branch railroad to Boulder City, and, of course, preserves the monopoly of transportation. They take out of the mine an average of two hundred tons daily. A railroad is now in progress of construction from Julesburgh to Golden, traced through the rich Lignitic deposits of the Boulder Valley, and passing three miles east and north of Marshall's. This railroad, of course, will change much the proportion of coal mining from different localities where lignitic coal is obtained, bringing to market the material in quantity relative to its quality.

The facility of transportation may not be at first an advantage to the proprietors on account of the greater competition in the market, the demand as yet not being considerable enough to justify explorations of large extent. The consumption from Denver and cities around is estimated at about four hundred tons per day. The lignite-bank of Erie can supply, for an indefinite time, the demand of the Kansas Pacific Railroad, while the Denver and Rio Grande Railroad has now a full supply from the Cañon City coal-bed, and a large overplus left for the Denver market or any other on its line.

It is evident, therefore, that there is for the present more danger of a glutted market than of a scarcity of combustible material, and that for the future the settlements in the valley of the Rocky Mountains, and especially along their eastern base, may rely on a permanent and cheap supply of coal. I should admit the same conclusion even in considering that the settlements along the Kansas Pacific Railroad from Denver to the limits of Kansas will have to get their fuel from the same source. The estimate in tons of the average productiveness of a bed of bituminous coal of the old measures, is generally marked at one million of tons per foot of thickness in one square mile. Counting a single bed of lignite of the Boulder Valley at 9 feet thick, extended over a surface of only twenty-five square miles, what should we find? Deducting one-fifth for difference in density between bituminous and lignite coal, or admitting only eight hundred thousand tons per foot of thickness in a square mile; deducting still from this amount one-half for drawbacks in mining, the result would be four hundred thousand tons per foot of lignite in a square mile, or for 9 feet three million six hundred thousand tons, and in an area of twenty-five square miles, ninety millions of tons obtainable from a comparatively limited extent of the Lignitic basin. Though I believe that this estimate is below the reality, calculations of this kind can never be positively reliable, and should be admitted with due caution. It is, however, of the greatest importance for the proprietors, and for the consumers too, to positively know the capacity of the lignite-beds, in order to regulate the mining, and to fix rates of price advantageous to both parties.

§ 4. The Lignite-Deposits along the Union Pacific Railroad from Cheyenne to Evanston.

The distribution and capacity of the lignite-beds of this section have been reported already in considering the geological distribution of the Eocene formation. The essential supply of coal, either for the railroad or for the demand along its line, has been, and is still, obtained from Carbon, Rock Springs, and Evanston. The beds of lignite at Carbon are distributed in three separate basins of limited extent. Two of these have furnished already abundant materials, being mined since the beginning of the construction of the railroad. No data have been obtained sufficiently precise to allow an estimate of the productive capacity of the Lignitic strata there still obtainable for exploitation. The superintendent of the mines remarks that the coal is difficult to work, being unreliable and cut by faults and irregularities. Moreover, the mine has been ignited by spontaneous combustion of the slack coal, and been on fire for a length of time. Now the amount of coal obtained from Carbon is about three hundred tons daily.

At Rock Spring the vein of lignite is still thicker than at Carbon, and the material of very fine quality. It has been, and is now, mined in the same proportion as at Carbon. The productive capacity of this basin is still very great, especially considering the amount of coal which could be obtained from lower beds by shafts. The area covered by the upper bed is, however, limited, and as this bed is now mined by three different companies, the supply of its excellent material cannot be relied upon for a great length of time.

At Evanston the enormous thickness of the coal seems to promise, for many years, an abundant supply of materials. But here the thickness of the clay-partings and the dip of the beds cause great difficulty of mining. A part of the bank has to remain for roof, another part is lost by slack in the separation of the parting, and this bed, which is also of limited extent, has to supply, on one side, the Union Pacific Company, by the Wyoming Company, and on the other, the Central Pacific Railroad to San Francisco, by the Rocky Mountain Coal and Iron Company. This last company's mining amounts to five hunded tons. per day in the average; that of the other, to three hundred tons. Besides this, beds of lignite have been opened by private enterprise at divers places, and are worked to a limited extent, especially at Black Buttes and Hallville. These and the already reported lignite-beds of Point of Rocks, Creston, and Washakie, promise some further supply for the future, and I have no doubt that a number of valuable deposits may be still discovered in the Lignitic basin at a short distance and on both sides of the railroad. It is, nevertheless, certain that if the coal is not carefully husbanded along the Union Pacific Railroad, there will be great difficulty of obtaining a large supply in a short time to come. The present production of the mine of the Wyoming Coal Company is about ten thousand tons per month, while the consumption of coal by the Union Pacific Railroad averages about ninety thousand tons per year.

§ 5. Concluding Remarks.

The loss of materials by mining the lignite-beds of the Rocky Mountains is especially caused—

1st. By the difficulty of sufficient roofing, on account of the scarcity and of the high price of the timber used for that purpose. At Rock Spring, a post six feet long by four inches in diameter costs one dollar.

2d. By the want of good reliable miners, who cannot be induced to go and live in such a rough and unsettled country but by a higher remuneration comparatively to the value of the work.

3d. By the great amount of slack, caused either by carelessness in mining a substance less hard and compact than true coal, or by disintegration from the walls and roofs in the mines under atmospheric influence. This slack or small coal is always difficult to dispose of, and dangerous too, being subject to spontaneous ignition, either in the mines or out of them. The superintendent of the Carbon mines, Mr. Williams, informed me that it was by neglect of the miners, who were on a strike, and during his absence, that the slack was ignited in some part of the mines, which have continued on fire ever since.

The uncertainty on account of a future sufficient supply of good lignite along the line of the Union Pacific Railroad, and the constantly increasing demand of this material for the Utah settlements, for towns and stations along this railroad from Omaha to San Francisco, even for the California markets on the Pacific, should induce researches by borings and detailed explorations for the discoveries of new deposits of lignite, and especially a more careful economy in mining. The improvement of the quality of the matter and the disposal of even its small parts, the slack, should be attempted by repeated experiments.

Experiments of this kind have been made long time ago in Europe, and the small coal, which by atmospheric influence soon becomes lost into dust, has been profitably used by mixing it with a certain proportion of moist clay. The same method has been tried in the Lehigh anthracite region of Pennsylvania, where the coal is comparatively of far less value than the lignite of the Rocky Mountains, and large, expensive machinery has been erected for that purpose. As yet these experiments have proved a failure, or, at least, have not given remunerative results. The mixing of clay, or of any other mineral incombustible cement, cannot improve the material, especially not when, as is the case with the lignite, the heating power of the matter in its purity, is not always as strong as required by enginery. It seems very probable, however, that the admixture of bitumen with small coal either pulverized or in pieces of moderate size, should, by compression of the paste, furnish an excellent combustible material. The bitumen, of course, should be obtained or reduced to the consistence of a kind of glue. I wonder that, with the immense amount of bitumen stored in the black shale of the Green River group, no trial has as yet been made by some company for the applicability of this material. Thick beds of these black shales are exposed all along the railroad from Rock Springs to Bryan and farther. And some of them are impregnated with so much bitumen that, as I have said already, the matter is percolating from them through the underlying sandstone. Though the shales do not consume, they are often used for fuel by the settlers. The coal of Elko Station was for a time burned in locomotives in the Utah Valley, and this coal is nothing but black shale of the same Green River formation. A few experiments, which would cost comparatively little, would settle this important question, and I truly believe that the result would be successful and would confer immense advantage on the people at large interested in the coal-supply of the Rocky Mountains, and still more on the railroad and the instigators of such an enterprise. Nature has done nothing in vain; this truth cannot be too often acknowledged. This bitumen of the black shale is a complement of the as yet unfinished work of the lignite matter. It depends on the ingenuity of man to render it what it should be, fully appropriate to the wants of that population which is crowding in that, as yet, undeveloped region.

I do not think, however, that without this improvement of its matter, the lignite, as it is, is inadequate to the present necessity. For the Rocky Mountains, however, the present is nothing in proportion to the promised future.

In comparing the value of the lignite for heating power, a great number of analyses have been made, and, of course, the results arrived at have not always proved reliable. All the lignite, and the coal, too, contain more or less water, in a degree relative to the progress of decomposition of the woody matter. In proportion as this decomposition advances the amount of water diminishes, and the compactness of the coal increases with its proportion of pure carbon. It is therefore admitted, as a general rule, that the value of a combustible of any kind, or its heating property, is proportionate to its density. The density for the combustible minerals is sometimes increased by an amount of earthy matter, easily recognizable in the proportion of ashes. In our lignite of the West this exceptionable case is not often remarked, and the lignite-beds of the Rocky Mountains generally give a material of good quality, weighing in the average one-fifth less than the best coal of our old Carboniferous measures. Local differences are remarked, of course, but, as I said above, mostly resulting from the degree of carbonization of the woody substance which appears to have been increased by the influence of the primitive rocks according to their proximity. It is for this reason that the quality of the lignite becomes impaired at a greater distance from the mountains, in beds of the same age.

The companies and proprietors of lignite-beds make constant inquiries of the possibility of reducing or smelting iron ore with their coal. I think that this could be done with lignite, producing good hard coke, which then could be used as charcoal. But scarcely any of the lignites of the West have been as yet so far deprived of water that their bulk may be left compact by combustion. I know only of the Placiere anthracite, (lignite,) and of the Chicosa coal, as having given such result; all the other lignite gives dust-coke. In confirmation of this assertion, and to end this subject, I append a few analyses made from specimens selected by myself as representing the average value of the beds where they were obtained. These analyses have the merit of being carefully made* all with the same process and by the same chemist, and therefore offer perfectly reliable points of comparison. They complete the table of analyses given by Mr. James T. Hodge in his excellent paper on the Tertiary coal of the Rocky Mountains. Put in opposition, as they are here, they present a reliable account of the essential compounds and of the comparative value of the more important deposits of our western lignitic coal. It is to be regretted that no more care is given to the preparation of documents of this kind. Comparative analyses should be made by the same chemist, and the result published under a well-known authority, to prevent frauds or impositions by the publication of misrepresented or often false statements.

Analyses of coals by Mr. C. Leo Mees.

Number of sample	1 a.	1 c.	2.	3.	4.	5.	6.
Specific gravity	1. 315	1. 304	1. 2303	1. 26	1. 288	1. 273	1. 315
Moisture	8. 10	6. 10	6. 25	1. 15	5. 40	12. 90	0. 90
Ash	5. 55	5. 80	9. 55	4. 20	3. 50	2. 00	20. 20
Volatile combustible matter	34. 70	38. 80	31. 75	37. 05	36. 40	39. 10	23. 50
Fixed carbon	51. 65	49. 30	52. 45	57. 60	54. 70	46. 00	55. 40
	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00	100. 00
Sulphur { in coal	0. 91	0. 917	0. 941	0. 851	0. 782	0. 576	0. 906
Sulphur { remaining in coke	0. 22	0. 343	0. 439	0. 617	0. 384	0. 302	0. 522
Sulphur { forming per cent. of coke	0. 385	0. 623	0. 708	0. 999	0. 66	0. 512	0. 688
Fixed gas, cubic feet, per pound of coal	3. 929	3. 926	3. 61	4. 21	4. 327	4. 088	3. 24
Character of coke	Pulv.	Pulv.	Pulv.	(*)	Pulv.	Pulv.	Pulv.
Color of ash	Gray.	Gray.	White.	Gray.	Yel'w.	Fawn.	Gray.

REGISTER OF SAMPLES.—1 a, Carbon, Union Pacific Railroad; 1 c, Carbon, Union Pacific Railroad. 2, Rock Springs, Union Pacific Railroad; 3, Fifteen miles north of Trinidad, New Mexico; 4, Canyon City, Colorado Territory; 5, Colorado Springs, Gehrung; 6, Raton Mountains, New Mexico.

COLUMBUS, OHIO, *January* 20–25, 1873.

* Hard metallic.

* By a young friend of mine, already an experienced chemist, Mr. Leo Mees, of Columbus. The analyses were made in the laboratory and under the supervision of Professor Wormly.

Analyses of coals from the Rocky Mountains by J. T. Hodge.

Localities.	Specific gravity.	Water.	Ash.	Volatile.	Fixed carbon.	Description.
Golden City, Colorado Territory, average of three analyses	1.35	13.22	3.91	35.95	46.57	Gray ash.
Murphy, Ralston Creek, Colorado Territ'y, average of three analyses	1.345	13.81	5.31	35.88	44.44	Orange-color ash.
Marshall's, Boulder County	1.33	12.00	5.20	33.08	49.72	Gray ash, light bulky.
Briggs, Boulder County	1.27	14.80	3.40	34.50	47.30	Orange-color ash.
Baker's, Boulder County	1.32	15.00	3.85	30.50	50.65	Olive-brown ash, hard & tough.
Carbon, Wyoming Territory	1.33	6.80	8.00	35.48	49.72	Light-gray ash, nearly white.
Hallville, Wyoming Territory, upper bed	1.32	12.12	3.76	29.75	54.37	Gray ash, smoke whitish.
Hallville, Wyoming Territory, lower bed	1.32	13.26	4.87	29.46	52.41	Yellowish-gray ash.
Van Dyke, Wyoming Territory	1.27	8.12	2.00	36.65	53.23	Light-gray ash.
Rock Springs, Wyoming Territory	1.29	7.00	1.73	36.81	54.46	Light-gray ash.
Evanston, Utah Territory	1.00	8.58	6.30	35.22	49.90	
Crisman's, Coalville, Utah Territory	1.32	10.66	3.11	38.23	48.00	
Mount Diablo, California	......	3.28	4.71	47.05	44.90	

ENUMERATION AND DESCRIPTION OF FOSSIL PLANTS FROM THE WESTERN TERTIARY FORMATIONS.

South Park, near Castello's Range.

A yellowish, laminated, soft shale, breaking easily and splitting in thin layers. Remains of plants well preserved and distinct, with remains of insects and feathers. Specimens collected and communicated by Mr. S. A. Allen.

OPHIOGLOSSUM ALLENI, *sp. nov.*

Leaf, elliptical, narrowed by a curve to the acute base; shorter and broader than in *O. vulgatum*, L., of our time, with the same areolation. The leaf is about 3 cent. long, (point broken,) a little more than 2 cent. broad, marked in the middle by the remnant of a fruiting pedicel. No fossil species of this genus has been as yet published, but a small one, *O. œocenum*, Mass., from the Tertiary of Verona, Italy.

THUITES CALLITRINA, *Ung.*, *chlor.*, p. 22, Pl. vi, Fig. 2.

Though the fragments are small, they are very distinct, and there is no appreciable difference from the description and figures of this species. The same specimen bears a fragment of *Salix* like *S. lingulata*, Göpp.

PLANERA LONGIFOLIA, *sp. nov.*

Leaves oblong, lanceolate, obtusely pointed, wedge-shaped at the base to a petiole; borders simply dentate; secondary veins thick, simple, craspedodrome.

It differs from *Planera Ungeri*, Ett., and its varieties, by longer, proportionally narrower leaves; by more oblique, straight, always simple, secondary veins, which are thicker and more distant; by more obtuse and larger teeth; some of the leaves are unequal at base and curved on one side. Average length, 4 cent., 1½ cent. wide. The distinct areolation is that of the species as marked in Heer, Fl. Fert. Helv., Pl.

lxxx, Fig. 3. The form is that of *Myrica Schlechtendali*, Heer, Bornstaedt, Fl., Pl. i, Fig. 7.

Elko Station, Nevada.

Specimens on the same kind of soft laminated clay shale as the former; collected and communicated by Mr. S. W. Garman.

SEQUOIA ANGUSTIFOLIA, *sp. nov.*

Leaves short, narrow, linear-pointed, erect, or slightly appressed all around the branches, decurring at base.

It is much like the small forms of *Taxodium dubium*, as figured by Ett., Bil. Fl., Pl. xii, Figs. 3, 14, 15, with leaves, however, shorter and decurrent.

THUYA GARMANI, *sp. nov.*

Branchlets short, alternate along a primary branch, of the same thickness; leaves nearly round, inflated, and marked by a gland at the point, narrowing downward; in four rows.

The specimen is small but very distinct; no remain of cone has been found. Its nearest affinity is with *Thuya sibirica*, Hort., a var. of *Thuya occidentalis*, L., differing by shorter, more obtuse, more inflated leaves. As it is to *T. sibirica* what this variety is to *T. occidentalis*, it may be considered as a parent form of our present species.

ABIES NEVADENSIS, *sp. nov.*

Leaves two ranked, horizontally spreading, 1 cent. long, 2 mill. wide, linear, abruptly pointed, obtusely narrowed at base to a short petiole, broadly nerved.

This species, represented only by a small branch, is like the large forms of *Taxodium dubium*, differing by exactly linear leaves, obtuse at both ends, larger size of branches and leaves, &c. From *Taxites olriki*, Heer, Arct. Fl., Pl. lv, Fig. 7, it differs, too, by linear, shorter, more horizontal leaves. Its nearest affinity is with our living *Abies Canadensis*, Mich., being only slightly more robust and the leaves more abruptly rounded and not enlarged at their base.

SALIX ELONGATA, O. Web. Pal., p. 63, Pl. ii, Fig. 10.

The base of the leaf is broken; the part left, 11 cent. long, exactly corresponds in size and nervation with the upper part of Weber's figure.

Raton Mountains.

The Thalassophytes described from this locality are all from the Eocene sandstone underlying the lignitic strata. Except the species of this class, none other has been added to those already known from specimens obtained formerly by Dr. Hayden and described in Supt., pp. 12 to 16. The very hard metamorphic sandstone and shale containing plants breaks under the hammer in irregular small fragments, of little value for the paleontologist.

SPHERIA LAPIDEA, *sp. nov.*

Perithecia round, highly convex, 1 to 2 millim. broad, growing in lineal series from under the bark and piercing it before opening; borders irregularly lacerated; color whitish.

This species is upon a petrified fragment of wood, part of which is still corticated, on another part the bark has been destroyed. The borders of the opened perithecia are somewhat inflated. A single one is still entire or unopened, comparable by its form and size to the living *Verrucaria nitida*, Ach.

CHONDRITES SUBSIMPLEX, *sp. nov.*

Frond cylindrical, flattened by compression, 5 mill. wide, with rare dichotomous, long, flexuous branches, mostly of the same size, some, however, reduced in size to one-half from the point of division from the main stem.

This species is found mostly flattened or expanded upon large slabs not passing across layers of sandstone. Upon some of these slabs the filaments appear simple, resembling *Halimenites lumbricoides*, Heer, (Urwelt der Schweitz.) The surface is irregularly roughened and generally marked in the middle by a depression indicating the fistulose character of the plant.

CHONDRITES BULBOSUS, *sp. nov.*

Frond plain, irregularly subpinnately divided in opposite or alternate branches, close to each other, or distant, short, inflated like irregular tubercles.

The branches vary in thickness from two to five mill., generally five to eight mill. long, often bilobed at the obtuse point; they are, like the main stem, inordinately inflated and narrowed.

HALYMENITES STRIATUS, *sp. nov.*

Frond cylindrical or compressed, erect, one foot long or more, dichotomous; branches short.

The ramification of this species is variable, the divisions being more or less open, sometimes at a right angle from an inflation of the main axis. The surface appears generally smooth; where the coating of stone is rubbed out, it appears coarsely ribbed as by a linear series of tuberculeiform sporanges. The branches perforate the sandstone in every direction. It is related to *Fucoides cylindricus*, Sternb. Common at the Raton; found also at Golden by Professor Meek.

HALYMENITES MAJOR, *sp. nov.*

Frond of the same thickness and mode of division as the former; surface marked by round contiguous or disjointed tubercles 2 to 5 mill. broad and as thick.

It has the same general appearance as the former. Its branches are sometimes longer and smaller. The stems are 2 cent. broad.

HALYMENITES MINOR, *F. O.*

Branches half as thick as in the former species, 8 mill. broad, marked with small tubercles.

These branches are of the same size and form as the one figured by Heer, in Urwelt der Schweitz, (Pl. xi, F. 1.) As they are, however, found in connection with the former species, at least in the same beds of sandstone, they may represent mere divisions of it.

DELESSERIA INCRASSATA, *sp. nov.*

Frond sessile, trifid from its base, divisions, thick, obovate, attenuated downward to a narrow pedicel; surface plicate-rugose.

The sandstone has deep prints of these leaves, which appear as united in groups from the base, or growing in tufts. One of these leaves or divisions seen isolated is oblanceolate, abruptly short-pointed, gradually tapering to the base, 2 cent. wide at its broadest part, near the point, 3 mill. at base, 5 cent. long. If by the form of its leaves this plant is a *Delesseria*, the thickness of its divisions, judged from their prints on the stone, is different from that of any living species of this genus. The prints, however, may have been made by the superposition of a group of segments of the same form.

DELESSERIA LINGULATA, *sp. nov.*

Leaf small, coriaceous, entire, obtuse, rounded at base, slightly contracted in the middle, with a broad inflated medial nerve.

The leaf or segment is 2 cent. long, 12 mill. broad, of a subcoriaceous or thickish consistence. The sandstone has many fragments of the same form and size.

ABIETITES DUBIUS, Lsqx., Am. Jour. Science and Arts, (1868,) p. 203.

Leaves erect or slightly open, imbricated around the branches, exactly lanceolate, sharp-pointed, broadest at the base, where they are abruptly contracted to the point of attachment.

I have found, probably at the same place where Dr. Leconte obtained his specimens, a quantity of branches of this species, varying from 2 cent. to 3 mill. in thickness, all indicating the same characters. The leaves are 8 mill. long, 1½ mill. broad, near the base. Stems and branchlets are marked by the deep and distinct scars of the base of the leaves, varying in form according to the size of the branches. No cones or seeds have been found as yet. It is common in the lower lignitic Eocene. Good specimens of the stems have been obtained in the chocolate-clay beds of the lignite, near Fort Steele, by Professor B. F. Meek. Its affinity to living species is as yet unascertained.

ARUNDO GÖPPERTI, *Al. Br.*

Large fragments of leaves with characters of this species.

PHRAGMITES OENINGENSIS, *Al. Br.*

In connection with *Abietites dubius* in the lignitic-bearing strata, and also in fragments within the Eocene sandstone.

SABAL CAMPBELLII, (?) *Newb.*

It is described in Supt., p. 13. The fragments are very abundant, but always obscure. It may be a different species.

POPULUS MONODON, Lsqx., Supt., pp. 13 and 14.

The leaf is smaller than those already described from this place and from the Mississippi Eocene, 6 cent. long, 4 cent. wide, ovate, lanceolate, pointed, rounded at base, or abruptly narrowed to the petiole, entire and coriaceous. The nervation is that marked in description of this species.

CINNAMOMUM MISSISSIPIENSE, Lsqx., Supt., p. 14.

Abundant. Already quoted from this locality.

RHAMNUS OBOVATUS, Lsqx., Am. Jour. Science and Arts, (1868,) p. 207.

Represented by some specimens exactly similar even in size to those obtained from Purgatory Cañon by Dr. Leconte.

Gehrung's coal-bed, near Colorado Springs.

The remains of fossil plants are here badly preserved, mixed in great number in a soft, easily disaggregating sandstone. They are mostly broken and undeterminable. The few which could be recognized are the following:

SABAL CAMPBELLII, (?) *Newb.*

The same form as that of Raton Mountains.

PLATANUS HAYDENII, *Newb.*

Two large well-preserved leaves.

DOMBEYOPSIS OBTUSA, *sp. nov.*

Leaf round, cordate, very obtuse, with two obtuse scarcely-marked lobes on each side, near the point at the extremity of the lateral veins, which ascend in curving from the base of the medial one.

The lower part of this leaf is broken, and therefore its description is incomplete. It is from its form and nervation a species of *Dombeyopsis* allied to *D. tridens*, Ludw., Pal., Pl. xlix, Fig. 3, twice as large, and differing by the very obtuse, round point, and scarcely-marked obtuse lobes.

FICUS TILIÆFOLIA, *Al. Br.*

In large identifiable fragments; no leaf entire.

Golden City, Colorado.

Most of the specimens are from a sandstone easily cut in the line of stratification, and where entire leaves, even of large size, were obtained.

SCLEROTIUM RUBELLUM, *sp. nov.*

Oval or linear, obtuse, 1 mill. broad, 2 to 4 mill. long, following or intermediate to the striæ of Flabellaria zinckeni, Heer, deeply impressed into the epidermis; reddish at its surface when young; center somewhat mamillate.

It has no apparent relation to any fossil species as yet published. In some specimens the center looks split, as in species of *Hysterium*.

DELESSERIA FULVA, *sp. nov.*

Frond membranaceous, dichotomous, (apparently long,) linear, with a thick medial nerve; divisions linear, distant, obtuse, or enlarged at the point.

The preserved part of the frond is 20 cent. long, its average width 6 mill. The divisions are irregular in distance and position, varying in length from 5 cent. near the base of the frond to mere obtuse lobes at its upper end. Its color upon the white sandstone is of a deep yellow. It is distantly related to *Delesseria Sphærococcoides*, Ett., from the Eocene of Promina.

SPHENOPTERIS EOCENICA, Ett., Foss. Fl. of Promina, p. 9, Pl. ii, Figs. 5–8.

Frond large, at least tripinnately divided; secondary pinnæ long, lanceolate, taper-pointed, oblique, from a half-round narrow rachis; pinnules numerous, very oblique, close to each other, contiguous, united from below the middle, acutely lobed; veins pinnate, the divisions either simple or forking once. This form somewhat differs from the one published by Ettinghausen, by the connection of the pinnules from below the middle, while they are separated from the base in the European species; also, by the sharp-pointed lobes of the pinnules, these being described as obtuse by the author. The nervation, too, shows a noticeable difference, the secondary veins in our specimens being strong, flat, generally simple, and ascending to the point of a lobe, or, when forking, one of the branches passing aside to one of the very acute sinuses. These differences may be specific or merely simple varieties resulting from the part of the frond represented by the specimens. The general appearance is the same. Splendid specimens of this species were obtained at Golden, especially by the kindness of Rev. L. Burns, the superintendent of the mining college of that place.

PTERIS ANCEPS, *sp. nov.*

Frond linear, lanceolate, thick nerved, with apparently entire borders; secondary veins at a right angle from the medial one, thin, though distinct, forking near the base, and one of the branches forking a second time from the middle.

A mere fragment, comparable to *Lomariopsis cilinica*, Ett., Fl. Bil., p. 13, Pl. iii, Fig. 13, somewhat different by the nervation.

PHRAGMITES ŒNINGENSIS, *Al. Br.*

Fine specimen of stems with articulation and scars, were found in the white sandstone under the lignite beds. Professor Meek has also well-preserved specimens of rootlets, with their capillary filaments from the same sandstone.

CAREX BERTHOUDI, *sp. nov.*

Leaves narrow, flat, narrowly and obscurely striate, except on the borders; seeds numerous, flattened, 2 mill. wide, with an oval, slightly pointed, and slightly broader perigynium.

The nervation of the leaves is marked only by two veins on each border, as in *Cyperus arcticus* Heer, Fl. of Spitzberg. The seeds, apparently attached on short pedicels, resemble those of *Carex antiqua*, Heer, of the Baltic flora, as represented Pl. iii, Fig. 18, being, however, larger, and the perigynia broader than the seeds, and distinct.

FLABELLARIA ZINCKENI, Heer, Fl. Bornstaedt, p. 11, Pl. ii, Fig. 3–4.

By the size of the segments, and by their nervation, the numerous and distinctly veined fragments found in the white metamorphic clay of Golden represent exactly the European species. The Bornstaedt lignitic formation is considered by Heer as lowest Miocene or upper Eocene.

FLABELLARIA LATANIA, Stern., (Foss., Fl., 1, Pl. xl.)

To this species of Sternberg, I refer a number of specimens, all of striated, tubulose, long, linear leaves, like those published under this name by Ettinghausen in Fl. Prom., p. 12, Pl. iii, Fig. 2–3. The striæ are coarse and deep, as figured by this author, but there is no remain of petiole.

SABAL GOLDIANA, *sp. nov.*

Distinct from Sabal Campbellii, Newb, by its large triquetrous or rather deeply keeled petiole, the keel being nearly acute. The sides at the base are 5 cent. wide. The rays appear larger than in *S. Campbellii;* the nervation is not more distinct. No specimen of the lower part of a leaf could be obtained.

PALMACITES, species.

Part of a trunk of palm; an impression 15 cent. broad, slightly concave, marked in the length by deep, nearly regular, and equal striæ, separated by sharp, acute, narrow ridges, 1 mill. distant. This is not referable to any fossil species published. Specific determination, however, is not possible.

POPULUS ATTENUATA, *Al. Br.*

Of the same character as the leaf in Fl. Fert. Helv., Pl. lvii, Fig. 12.

QUERCUS TRIANGULARIS, Göpp., (Schotznitz, Fl., p. 15, Pl. vi, Fig. 13–17.)

Leaves ovate, attenuated to a short petiole, more abruptly narrowed to an obtuse point, borders undulate above, entire from the middle downward, nervate or pinnate.

The stone where the leaves are preserved is coarse grained, the borders near the point are somewhat indistinct. The lowest pair of secondary veins ascends in an acute angle from the base of the leaf, the others, nearly opposite and parallel, pass in a more open angle to the borders, where they slightly and abruptly curve. The lowest pair, only branches outside. But for the indistinct borders near the point, this form is well identified with Göppert's species.

QUERCUS STRAMINEUS, *sp. nov.*

Leaves small, broadly ovate, obtusely pointed, rounded to the base, and abruptly recurved to the petiole, entire; nervation pinnate, secondary veins thick, parallel, camptodrome.

The leaf is 4 cent. long, 22 mill. broad, the secondary veins equidistant, diverging 40° from the medial nerve, curving slightly to near the borders, where they divide in two equally thick branches, anastomosing up and down with divisions of the other veins. The nervation is the same as in *Quercus Desloesii*, Heer, (Fl. Tert. Helv., p. 56, Pl. lxxviii, Fig. 7,) except, however, that the veins are less distant, not undulate, and without intermediate, shorter veinlets; the veins are distinct, shining, yellow.

QUERCUS ANGUSTILOBA, *Al. Br.*

We have two fine specimens of this rare Eocene species. Though not quite entire, they are positively identified. One is a large leaf as the one described and figured by Ludwig in Paleont., vol. viii, p. 103, Pl. xxxvi, Fig. 3. The lobes of the leaves are long, diverging, linear lanceolate, obtusely pointed. Heer has published it from the lignitic of Bornstaedt.

FAGUS FERONIÆ, Ung. Chlor., p. 106, Pl. xxviii, Fig. 3–4.

Leaves ovate, pointed, irregularly dentate above the middle, rounded or attenuated to a slender petiole, nervation simple craspedodrome.

One of the leaves is somewhat large, the lower part is destroyed. It appears rounded to the petiole. The other is a smaller leaf, lanceolate-pointed, with the veins on a more acute angle of divergence. Both forms are represented in the Bil. flora of Ettinghausen, Pl. xv, the first leaf like Fig. 20, the second like Fig. 16. The lower veins of the small leaf have strong fibrillæ downward, like thin secondary veins.

ULMUS (?) IRREGULARIS, *sp. nov.*

Leaf large, coriaceous, oval-oblong, narrowed or wedge-form to the petiole, nervation pinnate, secondary veins close and deeply marked.

The borders upward and the point are destroyed in all the specimens. The secondary veins are close, 16 pairs in part of a leaf 8 cent. long, (angle of divergence 40°) straight from the medial nerve, except near the base, where they curve slightly downward in joining it, generally simple, some anormally forking from near the base; fibrillose. Though the nervation and facies are those of *Ulmus*, the leaves are doubtfully referable to this genus on account of the unknown disposition of the veins along the borders.

FICUS ASARIFOLIA, Ett., Bil. Fl., p. 30, Pl. xxv, Fig. 2–3.

The leaf representing this species is larger than those described by the author; it is, however, positively referable to it by its form, its crenulate border, and its nervation.

FICUS SPECTABILIS, *sp. nov.*

Leaves large, coriaceous, entire, broadly ovate-lanceolate, contracted to a short point, round truncate to the petiole, pinnately nerved, the lowest pair of secondary veins opposite from the base, branching outside, the upper ones mostly simple, parallel, irregular in distance, oblique, camptodrome.

The leaf, an entire one, is 15 cent. long, 8 cent. broad in its widest diameter below the middle, equilateral. The first pair of secondary veins is basilar and branched; the others, though parallel, are at irregular distances, all curving along the borders and anastomosing with tertiary veins or fibrillæ. Allied to *Ficus Schimperi*, Lsqx., of the Mississippi Eocene, it differs by its coriaceous substance, by the basilar veins going out from the top of the petiole, by the somewhat abruptly-contracted (not tapering) point, &c. With an entire leaf, the collection has a number of fragments of this fine species.

FICUS AURICULATA, *sp. nov.*

Leaves membranaceous, entire, smooth, ovate-lanceolate, taper-pointed, rounded to the base into two auricles joined at the borders below the top of the petiole, pinnately nerved; the lower pairs of secondary veins opposite from the base of the leaf, the upper ones parallel, alternate, camptodrome.

The leaf described is perfect and its nervation distinct. Three pairs of veinlets curve downward from the top of the petiole, passing in curves to the borders of the auricles. All the secondary veins are more or less branching downwards, curving along and following the borders in anastomosing with divisions of the superior ones. Fibrillæ distinct, nearly continuous; the leaf, 10 cent. long, has, besides the basilar vein lets, ten pairs of secondary veins. It is somewhat unequilateral.

PLATANUS RAYNOLDSII, Newb.

Is represented by splendid specimens, but none as entire as the one described by the author, Extinct Fl. of N. Am., p. 69.

PLATANUS HAYDENII, Newb.

Most common at Golden. The leaves are still larger than marked by the author, some of them preserved entire.

BENZOIN ANTIQUUM (?), Heer, Fl. Ter. Helv., II, p. 81, Pl. xc, Figs. 1–8.

Leaf oval, obtuse, entire, narrowed to a broad petiole, pinnately nerved, lowest pair of secondary veins opposite, joining the medial nerve at a distance above the base; the others alternate, all thin and at an acute angle of divergence.

A single leaf, doubtfully referred to this species on account of obsolete details of nervation. The surface of the leaves is punctate as in *Benzoin attenuatum*, Heer, (*loc. cit.*, Fig. 10;) but the form of the leaf and the secondary veins are like Fig. 6, of *B. antiquum.*

CINNAMOMUM ROSSMÄSSLERI, Heer, Fl. Tert. Helv., II, p. 84, Pl., xcii, Figs. 15–16.

The leaves representing this species have the form and size of those *loc. cit.*, Fig. 2, with numerous straight, strong nervilles, perpendicular to the medial vein, and passing from it to the lateral ones, as in Fig. 16.

CINNAMOMUM MISSISSIPIENSE, Lsqx., Supt., p. 14.

Fine specimens of this species, of frequent occurrence in the American Eocene, were obtained at Golden.

CISSUS LÆVIGATUS, *sp. nov.*

Leaves subcoriaceous, polished, round-oval, abruptly narrowed or broadly wedged form to the petiole, three-nerved from the base, nervation actinodrome retiform; borders undulately crenate.

The collection has many specimens, but none complete, the upper part of the leaves being mostly destroyed. The leaves are petioled; the two lateral veins diverge at an acute angle and branch outside, the branches parallel, running to and entering the borders in dividing.

DOMBEYOPSIS TRIVIALIS, *sp. nov.*

The lower part of a leaf, round-cordate at base, entire subcoriaceous, three-nerved, lateral veins strong, curved upwards, branching outside.

This leaf resembles the one in Heer's Fl. Balt., p. 74, Pl. xvii, Fig. 11, named *Ficus Dombeyopsis*, which, however, has two pairs of lateral veins from the base, while ours has only one. As in Heer's leaf the lower part is destroyed, while the point is erased in ours, it is not possible to make an exact comparison.

DOMBEYOPSIS OCCIDENTALIS, *sp. nov.*

Leaves coriaceous, entire, cordate-acuminate, trinerved from the base, superior lateral veins at equal distance, alternate or opposite, camptodrome.

A number of specimens of these fine leaves present all the same form and characters; 12 cent. long, 10 cent. broad, below the middle or toward the enlarged cordate base, narowed or tapering to the point. The lower lateral veins are much branched outside, 8 to 10 branches, curving to and along the borders; the upper secondary veins are either simple or sparingly divided by under branches, all the divisions curving to and along the borders which they reach, becoming like marginal; nervilles strong, in a right angle to the thick medial nerve; the borders appear somewhat reflexed. The nervation is that of *Dombeyopsis grandifolia*, Ung.

SAPINDUS CAUDATUS, *sp. nov.*

Leaf unequilateral, entire, broadly lanceolate, tapering into a long acuminate point, narrowed to the petiole on one side, rounded to it on the other.

The secondary veins are alternate, unequally distant, the lowest ones more open, curving to and along the borders and anastomosing with shorter intermediate ones. The nervation is of the same type as in *Sapindus falcifolius*, Heer, Fl. Helv., Pl. cxix, Fig. 16. I found two leaves of this species; the largest 10 cent. long, 4 cent. wide in the middle.

CEANOTHUS FIBRILLOSUS, *sp. nov.*

Leaves subcoriaceous, ovoid, obtuse, rounded to the base, (petioled ?) five-nerved from the top of the petiole; nervilles in right angle to the medial vein, continuous.

Species related to *Ceanothus ovoideus*, Göpp., (Schossnitz) Fl., p. 36, Pl. xxii, Fig. 13, differing, however, by the thick substance of the leaves, their larger size, and all the lateral veins going out from the base. The lowest lateral veins are much branched, and not acrodrome, ascending only to above the middle of the leaf.

RHAMNUS CLEBURNI, *sp. nov.*

Leaves thickish, (not coriaceous,) narrowly oval-laceolate, equally tapering from the middle upward to a long sharp point and downward to a short petiole; pinnately nerved, secondary veins close, slightly arched in passing to the borders, where they abruptly curve along the margin.

The species is known by a number of finely-preserved specimens, with all the same characters. The leaves are variable in size, the largest 9 cent. long; the secondary veins always close to each other, parallel, simple, scarcely 5 mill. distant, abruptly curving quite near the borders, which they follow; fobrilles numerous, strong, subcontinuous in right angle to the medial nerve. The nervation and form of these leaves, like that of the following species, as also of *Rhamnus obovatus*, Lsqx., is much like that of some species of the genus *Bridelia* of the *Euphorbiaceæ*. When better known by their fructifications they shall probably form a separate group.

RHAMNUS GOLDIANUS, *sp. nov.*

Leaves thickish, subcoriaceous, smooth, entire, broadly oblong ovate, abruptly narrowed to a short blunt acumen, rounded at base to a short petiole.

These leaves, of which I obtained numerous fine specimens, vary in size from 7 to 15 cent. long, proportionally broad, have about the same nervation as the former species, the secondary veins being only slightly more distant, less oblique, (angle of divergence 40 to 45°,) and nearly straight to near the borders, where they more gradually curve. The lowest pair generally branch more or less downward, in anastomosing with their short marginal veins; even the superior veins have sometimes one or two divisions. The species still differs from the former by its more coriaceous substance, its rounded base, and the obtusely acuminate point.

RHAMNUS GOLDIANUS, *var.* LATIOR, Lsqx.

The leaves considered as variety may represent a different species. They are much larger, of a thicker substance, more rounded at the base, and passing to the petiole by a short decurrent curve. They much resemble the leaves referred to *Ulmus* (?) *irregularis*, being intermediate between this and the above species.

RHAMNUS OBOVATUS, Lsqx.

Already mentioned from the Raton Mountains, is a truly different species from *Rhamnus Cleburni*, to which it resembles by the nervation. Besides differing by the form of the leaf, the secondary veins are thicker and flat, and the nervilles scarcely distinct.

RHAMNUS ACUMINATIFOLIUS (?), Heer, Fl. Tert. Helv., III, p. 81, Pl. cxxvi, Fig. 3.

A fragment only, with the point and the base of the leaf destroyed. The form of the leaf and its nervation agree with the author's figure and description. It differs much from the other species described above.

RHAMNUS RECTINERVIS, Heer, Rept., (1871,) p. 295.

It is not frequent at Golden. We have only a few specimens from the white sandstone.

JUGLANS RHAMNOIDES, Lsqx., Rept. (1871,) p. 294.

Sparingly represented at Golden.

JUGLANS RUGOSA, Lsqx., Supt., p. 10.

Found in more numerous and better preserved specimens than the former.

JUGLANS (FICUS ?) SMITHSONIANA, Lsqx., Supt., p. 16.

The leaf referable to this species merely differs from the one published from the Raton, by the less tapering base, which is more abruptly attenuated to a broad petiole, a difference scarcely noticeable.

JUGLANS SCHIMPERI, Lsqx., Supt., p. 8.

The specimens of Golden have the same characters as described. The peculiar form of the leaves identifies them easily.

CARPOLITHES PALMARUM, Lsqx., Supt., p. 13.

A number of fruits of the same size and form as those from the Raton Mountains. They are not striated, however, and rather coarsely wrinkled. They may represent a different species.

Beside the leaves described from Golden's specimens, I found still there a stipule of Platanus, a leaflet, square in outline, 2½ cent. wide, acutely short-lobed at the two upper corners, truncate at base, without visible nervation. It is apparently referable to *Platanus Haydenii*.

A number of fragments of uncertain affinity, or whose character could not be recognized; among them, leaves doubtfully referable to *Alnus Kefersteinii*, Göpp, others to *Rhamnus Dechenii*, Web., and still others to *Cinnamomum Mississipiense*. Lx., have been obtained from the same locality by Prof. B. F. Meek.

Marshall's Estate, Boulder Valley.

Specimens of fossil plants are here found, either in clay-beds, where the fragments are heaped and mixed together in a mass of unrecognizable forms, or in a coarse sandstone, where the details of nervation are generally obliterated. I could, moreover, dispose of but a short time for researches in a locality which had been sufficiently explored by Dr. Hayden and other geologists. The few specimens got there represent the following species:

PHRAGMITES OENINGENSIS, Al. Br.

In numerous specimens.

FLABELLARIA ZINCKENI, Heer.

The same form and characters as the specimens of Golden referred to this species.

QUERCUS CHLOROPHYLLA, Ung.

A number of specimens of the same species which I considered as identical with this *Quercus*, in my examination of the fossil plants of Dr. Leconte, in Am. Jour. Sci. and Arts, (1862,) p. 206, and was described and figured under this name in Proc. Am. Phil. Soc., vol. xiii, p. 413, Pl. xvii, Fig. 5 to 7. These leaves are of a coriaceous substance and have scarcely any trace of secondary veins marked on the surface; their relation is undefined. The Marshall's leaves are slightly more rounded to the petiole than those of Mississippi.

CINNAMOMUM AFFINE (?), Lsqx., Am. Jour. Sci. and Arts, (1868,) p. 206.

The specimens are not distinct enough to ascertain if they represent this species or *Cinnamomum Mississipiense*, Lsqx.

The main coal of Marshall's is mixed near the bottom with large fossil-carbonized trunks, which, by cleavage, appear as cut by the ax. The same are found, too, in the same circumstances at the Cañon City coal-bed.

Erie Mines, Boulder Valley.

The soft, sandy shale overlying the lignite-bed is full of finely preserved vegetable remains. But this shale is left in the mines for roof, or when taken out it is soon crumbling into small fragments under atmospheric influence. By the kindness of the superintendent, Mr. Hill, I got from the mines a few pieces of shale, which, as seen from the following descriptions, indicate the richness of the flora of that locality. Further explorations should be pursued in the mines, or in the opening of a new tunnel, with sufficient authority to obtain fresh slabs from the roof shales.

Sabal Campbellii (?), Newb.

A number of fragments of rays of a Sabal, probably referable to this species. The shale being soft-grained and the specimens distinct, the striæ of the rays are distinguishable and may be counted. They are very thin and close, like mere woody fibres, 30 in a width of $3\frac{1}{4}$ mill. The rays between the plicatures are 16 mill. wide, and have, therefore, about 150 of these lines. They are all of the same thickness.

CAULINITES FECUNDA, *sp. nov.*

Branches of racemes, 2 mill. wide, smooth, with inflated borders, divided in opposite erect branchlets, half as thick, bearing on each side, and on short pedicels, simple round capsules, with a central nucleus.

The capsules are mostly opposite, rarely alternate, and close to each other along the branchlets. One of these, 2 cent. long, bears twelve of these capsules on each side. They are 1½ mill. wide; the black nucleus, slightly smaller, is represented by a vesicle of coaly matter easily separated from its envelope, slightly narrowed, however, toward the top of the small pedicel, which is slightly inclined from the main rachis. These racemes may represent the female infloresceme of some diœcious species. Their relation to species of our time is as yet unknown. The same specimen which bears this species has, too, some nutlets of larger size, oval, truncate at base, wrinkled in the length, apparently in racemes or agglomerations, resembling those which have been published by Ludwig in Pal., vol. viii, Pl. xliii, Fig. 13, under the name of *Hyppophaë striata.*

CAULINITES SPARGANIOIDES, *sp. nov.*

Described with better specimens from Black Butte.

FICUS PLANICOSTATA, *sp. nov.*

Var. LATIFOLIA.

Described, like the former, with specimens of Black Butte.

PALIURUS ZIZYPHOIDES, *sp. nov.*

Described from Black Butte's specimens. The leaf from Erie is only smaller.

JUGLANS SCHIMPERI, Lsqx., Supt., p. 8.

The leaf is of larger size than that from Green River Station, but has the same characters. The same specimen bears on the reverse a fine oval flattened nut, with an irregularly wrinkled surface like the nut of a *Juglans.* It is 26 mill. long, 18 mill. broad, slightly pointed on one side, and abruptly contracted at the other to an obtuse protuberance. The only fruit comparable to this is that of *Juglans venosa*, Göpp, as figured by O. Weber in Pal., vol. viii, Pl. vi, Fig. 11. The specimens from this locality are as yet too scanty to allow a conclusion of identity between this fruit and the leaves described as *Juglans Schimperi.*

CERCIS EOCENICA, *sp. nov.*

Leaf nearly round, entire, of a thin texture, smooth surface, deeply cordate at base, nervation of *Cercis Canadensis.*

The leaf has its point destroyed; it is apparently obtuse or round. Except that it is more deeply cordate than the average leaves of our *Cercis Canadensis*, there is no difference whatever between the fossil leaves and those of the living species.

Carbon Station, Wyoming Territory.

The specimens obtained at Carbon are from the same limited area, but from two different levels. In order to mark difference of vegetation according to horizontal station, these specimens are described separately.

1st. From below the main coal,* in a soft-grained, very hard shale, irregularly breaking by cleavage, but where the vegetable remains are distinctly preserved, some of them are of large size.

EQUISETUM HAYDENII, Lsqx., Rept. 1871, p. 284.

The specimens represent some rootlets and tubercles of this species. One of the tubercles split lengthwise in the middle exposes a central solid axis 1½ mill. thick, while the parietes or intervals from the axis to the borders, 4 mill. each side, appear formed of a spongy though compact cellular tissue, becoming more compact and darker-colored near the borders. A cross-section of another tubercle shows it to be oval or somewhat flattened by compression, 12 mill. in one direction and only 9 mill. in the other. Another specimen has a linear rootlet or stem whose main axis is 4 mill. wide, apparently central, and surrounded by cellular tissue of equal thickness. It is marked by distant nodi with round scars of the same form as those of *Equisetum Haydenii*, and is referable to this species.

SMILAX GRANDIFOLIA, Ung., Chl. Pl. XL, Fig. 3.

The leaf which I refer to this species is of the same size as the one figured by Unger in the Sillog., Pl. II, Fig. 8; but it has only 7 basilar veins, while Unger's leaf has 9. The same form as ours is published by Heer in Fl. Tert. Helv., Pl. XXX, Fig. 8 and 8*b*. A variable species.

ACORUS BRACHYSTACHYS, Heer.

Exactly the same form as described in Rept. 1871, p. 288, from Creston. It is represented by three specimens which merely differ from the Spitzberg ones by shorter and broader spadices, 5 mill. broad, 7 mill. long, with only four rows of flowers or ovaries; the stem, too, is narrower, scarcely 5 mill. broad.

CAULINITES SPARGANIOIDES, *sp. nov.*

Described with better specimens from Black Butte.

POPULUS ARCTICA, Heer, Arct. Fl., p. 100, &c.

This species is represented at Carbon in most of its numerous varieties, with nearly round and entire leaves, or with undulate or more or less crenate borders, &c. They positively prove that the leaves named *Populus subrotunda*, Lsqx., in Am. Jour. Sci. and Arts, 1868, p. 205, as also those described as *P. Nebrascensis*, Newb., in Notes on extinct floras, p. 62, belong to this species.

POPULUS DECIPIENS, *sp. nov.*

Leaves broadly rhomboidal or round, enlarged in the middle, abruptly narrowed into a very obtuse point, rounded or broadly wedge form to

* See section of Carbon in first part of this report.

a long slender petiole, with very entire borders; three to five nerved from the top of the petiole.

A very fine species, with leaves scarcely variable in size, 3 cent. long and at least as broad. The three primary veins ascend from the top of the petiole to three-fourths of the leaves, branching outside and anastomosing with branches of a second or marginal pair of veins which ascend only to half the leaf. The texture of these leaves is somewhat thick, subcoriaceous. They are generally found on the same specimens with *Paliurus Columbi*, Heer, which they resemble. The slender petiole is nearly as long as the leaves. This species is distantly related to some small varieties of *Populus arctica*, Heer.

POPULUS ATTENUATA, *Al. Br.*

The same form as already published, Am. Jour. Sci. and Arts, (1868,) p. 205. It is found at Carbon both above and below the main coal.

POPULUS MUTABILIS, var. CRENATA, Heer.

Our specimen represents an entire leaf agreeing in form and nervation with Göppert's, Fig. 2 of Pl. XVI, in Schossnitz Flora. In the Carbon leaf, however, the teeth of the borders are large, sharply pointed outward, or less turned upward. This difference is not specific.

ALNUS KEFERSTEINII, Göpp.

The same form as described in Rept. 1871, p. 292, from Evanston. The borders of the leaf, however, appear merely undulate as in Ludwig's Pal., Vol. VIII, Pl. XXXII, Fi

BETULA STEVENSONI, Lsqx. Rept., (1871,) p. 293.

Already published like the former from Evanston, where the species is abundant. It is not as common at Carbon, but represented in very good specimens.

QUERCUS PLATANIA, Heer, Arct. Fl., p. 109.

Leaf membranaceous, broadly ovate, rounded to the base in broad auricles, with distantly dentate borders; pinnately nerved; secondary veins numerous, craspedodrome.

There is in the collection a beautiful leaf of this species which somewhat differs from the description of the author, as it is made in the 1st vol. of the Arct. Fl., but exactly agree with the fine leaf of this species figured in Vol. II, Pl. XLVI, Fig. 5, of the same work. This one is nearly an exact representation of ours, and, too, has the point destroyed. It is 13 cent. wide above its base, the borders marked by short somewhat distant teeth; the lower lateral veins opposite, diverging 30° from the medial one, the other pairs at a short distance from each other, alternate, parallel, with a thin lateral basilar veinlet going out at right angle from the medial nerve, just under the lowest pair of secondary veins. These are much branched outside; the upper ones branch once or twice near the borders. This leaf has the characters of a *Platanus*, and I was inclined to consider it as different from Heer's species on account of the difference in the denticulation. But in his description of a specimen from Spitzberg, the author remarks, p. 57, that the difference in the form of the teeth cannot be considered as specific. The authority is not refutable, being the result of the examination of a number of specimens of different localities.

FICUS OBLANCEOLATA, *sp. nov.*

Leaves subcoriaceous, obovate or oblanceolate, entire, taper pointed, gradually narrowed to a short petiole, pinnately, closely nerved.

The form of the leaves is about like that of *Ficus lanceolata*, in Heer, (Fl. Tert. Helv., Vol. II, p. 62,) broader, however, toward the point, with more numerous secondary veins. There are 14 pairs of these veins in leaves 7½ cent. long, the lowest pair at an acute angle from the medial one and following the borders; the superior ones, at a broader angle of 50°, straight to near the borders, which they follow in anastomosing in successive bows. The relative position of the secondary veins is more regular than in Heer's species.

COCCOLOBA LAEVIGATA, *sp. nov.*

Leaves round, (obtuse?) subcoriaceous; borders entire, undulate; surface, smooth; nervation, brochidodrome.

Only two fragments, both representing the lower part of the leaves. The form of the point is merely indicated; the undulate borders, rounded downward, join the petiole by a short, slightly decurrent curve. The lowest secondary veins are thinner than the upper ones, the medial nerve broad and flat; the details of nervation are like that of *Coccoloba Floridana*, Mich. These leaves are related in form and nervation to *Ficus penninervia*, Ung., as figured by Ett., Fl. Badoboj., Pl. II, Fig. 2.

PLATANUS GUILLELMÆ, Göpp., in Rept. 1871, p. 290.

The most common species at Carbon, where its numerous varieties may be studied. One of the more marked ones is represented by small broadly ovate leaves, truncate at base, scarcely lobed; borders marked with large acute teeth; basilar lateral veins from quite near the top of the petiole.

CINNAMOMUM AFFINE, Lsqx.

Mentioned above from Marshall's. The upper part of a large leaf with the base destroyed, 8 cent. long, 5 cent. broad, ovate, tapering into an obtuse point, the two lateral veins of the same thickness as the medial one, ascending, in curving, to near the point of the leaves, where they connect with the medial nerve without distinct anastomosing. The form is that of *C. Buchi*, Heer, except that the broadest part is below the middle, not above as in the European species.

CINNAMOMUM MISSISSIPPIENSE, Lsqx.

Mentioned already from Golden. A number of well-preserved specimens.

ASIMINA EOCENICA, *sp. nov.*

Leaves lanceolate, entire, thickish, equally tapering upward to a point and downward to a short petiole, penninerve, camptodrome.

A large number of these leaves, varying in length from 10 to 15 cent., 2½ to 4 cent. wide, with a petiole about 2½ cent. long; medial nerve thick, secondary veins numerous, distinct, parallel, diverging about 60° to a distance from the borders, where they curve irregularly, anastomosing many times with the superior veins and undulating along the borders; fibrillæ thin, but distinct; some of them intermediate to secondary veins, being thicker and ascending as Tertiary veinlets to half the leaf, anastomosing, with branches of the true secondary veins. This species closely resembles *Asimina triloba*, Dun, by the form and size of the leaves, and *A. parviflora*, Dun, by the nervation. A fruit of this genus, *A. leiocarpa*, Lsqx., has been published from the Mississippi Eocene.

ACER TRILOBATUM, VAR. PRODUCTUM, Al. Br. in Heer, Fl. Tert. Helv., Vol. III, p. 47, Pl. cxv, Figs. 6 to 12.

Among other fragments representing this species, there is a large leaf preserved entire 15 cent. long, narrowed at base to a long petiole, enlarging in the middle into two long, sharply taper-pointed, nearly entire lobes, with obtuse sinusses and a middle, elongated lobe, marked by large distant teeth, a form resembling that in Heers' *loc. cit.*, Figs. 8, 11, 12. The narrow base and taper-pointed lobes are as in Fig. 8, and the medial lobe with its base enlarged to the obtuse sinusses as in Figs. 11 and 12. Our leaf is at least twice as large as the European ones. Some pieces of shale of the same locality have fossil fruits of *Acer* with small oval nutlet and narrow erect wings, not larger than those represented in Heer, *loc. cit.*, Pl. cxii, Fig. 21, which the author refers to *Acer grosse-dentatum*. Fig. 166, however, has too, in its upper part, a fruit like the one of Fig. 21, still smaller, referred to *Acer trilobatum*. In ours, the support of the wing on the border is scarcely arched.

PALIURUS COLOMBI, Heer, in Rept. 1871, p. 288.

A large number of leaves all of the same character as those described from the Washakie group.

ZIZYPHUS MEEKII, *sp. nov.*

Leaves ovoid, obtusely acuminate or obtusely pointed, rounded to the petiole, obtusely crenate, three-nerved from the base.

Many leaves of this species were found at Carbon by Professor B. F. Meek and myself. They differ little in their characters, being only slightly more or less wide. They average 5 cent. in length, from 2½ to 3½ cent. broad; the borders are crenate from near the base to the obtuse point, the three primary veins are simple, the lateral ones ascending to or quite near the point of the leaves. In the broader leaves there is from the base a second pair of lateral veins, which follow the borders to the middle of the leaf; the substance is somewhat thick, sub-coriaceous, the surface being generally covered by a thin coating of carbonaceous matter which obliterates the fibrillæ. These are in a right angle with the medial nerve. The species is allied to *Zizyphus ovatus*, Web., in Pal., Vol. VIII, p. 89, Pl. vi, Fig. 1, at least for its nervation. It has also some analogy with *Zizyphus hyperboreus*, Heer, from which it differs by shorter, broader leaves, &c.

RHAMNUS GOLDIANUS, var. LATIOR, Lsqx.

Described with specimens from Golden.

JUGLANS DENTICULATA, Heer, in Rept. 1871, p. 298.

A large form, only found in fragments. It may be a new species.

Carbon, above coal.

TAXODIUM DUBIUM, Sternb.

The same small form as the one published by Heer in Arct. Flor. I, p. 89, Pl. ii, Fig. 24 to 27. It is represented by a number of small but distinct specimens.

POPULUS ATTENUATA, Al. Br.

Found also below the coal of the same locality.

QUERCUS ACRODON, Lsqx., Am. Jour. Sci. and Arts, 1868, p. 205.

A good specimen of this fine species. The ovate pointed leaf, wedge-form to the petiole, has the borders deeply cut into large, sharp teeth, with straight, mostly simple, secondary veins, passing in an acute angle to the point of the teeth. In this new specimen, the upper secondary veins are slightly curved in ascending to the borders.

CORYLUS MCQUARRYI, Heer, in Rept. 1871, p. 292.

Represented by fragments and in various forms. I have not seen, as yet, an entire leaf of this species.

FAGUS DEUCALIONIS, Ung.

The same form represented in Arct. Fl. I, Pl. xlvi, Fig. 4. Specimen found by Professor B. F. Meek.

PLATANUS ACEROIDES, Gopp.

A number of specimens, all imperfect, referable to this species by the larger size, the thickness of the leaves and the coarseness of nervation.

ZIZYPHUS MEEKII, Lsqx.

Described above from specimens of the lower shale.

ZIZYPHUS HYPERBOREUS (?) Heer, Fl. Arct. I, p. 123.

Leaf large, broadly lanceolate, largest below the middle, rounded-attenuated to the short petiole, tapering into a long linear point, irregularly crenate; five-nerved from the base.

This leaf is 10 cent. long with its short or broken petiole, 5 cent. wide; the first lateral veins are as deep and thick as the medial one, nearly acrodrome; the marginal ones, thinner, ascending to above the middle; the Tertiary veins, or fibrillæ, are obliterated. This leaf resembles the figure of this species as given in the Groenl. Flora, Pl. 1, Fig. 20. It is, however, longer, and the lateral veins are stronger. The borders, mostly erased, appear obtusely crenate.

JUGLANS RUGOSA, Lsqx.

Broken specimens of a large form of this species.

There are still a number of small fruits or seeds, which should be named from Carbon specimens. As their relation to living species is as yet unknown, it is impossible to describe them clearly enough to give a good idea of their forms, without figures. Among them is that *Carpolithes cocculoides*, Heer, in Rept. 1871, p. 290, which I have found also at Golden, Black Butte and Evanston. They are reserved for publication in a final report.

The upper shales, where the leaves and most of the fruits were found, near the Carbon mines, are, though hard, easily disaggregated under atmospheric influence. They are formed of sandy grayish clay and contain small Tertiary species of mollusks mixed with the vegetable remains. These are very distinct, their surface being coated by a pellicle of coaly matter. Could there be some fresh shale obtainable, one might have at Carbon rich and valuable specimens for the study of the botanical paleontology of the Upper Lignitic.

Black Butte Station.

The largest part of the specimens from this locality are from a bed of sandy yellow, somewhat hard shale overlying the main coal, in following the bed behind the hills, back of the opening into the vein. The shale splits horizontally, and the leaves may be, with some care, obtained in a good state of preservation. A number of specimens described separately were found at a higher level; at one place in connection with Saurian bones, at another with small Tertiary shells.

SPHERIA MYRICÆ, *sp. nov.*

A small species upon leaves of *Myrica Torreyi*, Lsqx., forming rings 1 mill. in diameter, with round black borders and very small, scarcely perceptible, scattered perithecia. Resembles *Xylomites varius*, Heer, Fl. Tert. Helv., Pl. i, Fig. 9.

OPEGRAPHA ANTIQUA, *sp. nov.*

Nucleous linear, from 1 to 4 mill. long, larger in the middle, pointed at both ends, either single or united in two or three in opposite directions, sometimes flexuous; perithecium thick, split in the middle, hard.

The specimen shows the print or counterpart of this species molded into clay, where the nuclei have been either left imbedded or have marked their forms very distinctly. They grew upon a large stem of *Caulinites sparganioides*, Lsqx.

HALIMENITES MAJOR, Lsqx.

Described above from the Raton Mountains. The finest specimens of this species are seen in the sandstone below the coal of this locality.

SEQUOIA LANGSDORFII, Heer, Fl. Tert. Helv., p. 54, Pl. xxi, Figs. 3 and 4.

By the obtusely-pointed leaves, their decurrent base, their size, &c., our specimens are evidently referable to this species. Fragments of conifers, though very abundant in the bottom clay of the lignite beds, are rarely found in the shale overlying them.

PHRAGMITES OENINGENSIS, Al. Br.

Numerous fragments of leaves.

FLABELLARIA EOCENICA, *sp. nov.*

Petiole long, flat, smooth, truncate at the point of union of the rays. The petiole is broken two inches below its top, which is exactly flat or truncate; the rays, about 30, are much diverging and expanding, from 1 mill. wide at the point of union with the petiole, to 3 cent. at a short distance above where they separate; primary veins eight, large, obtuse; space between them irregular, marked by 12 very thin obsolete secondary striæ. By the truncate point of the rachis the species is like Fig. 4, Pl. i, of Flora Haringa., Ett., which the author considers as an intermediate form between *F. Martii*, Ung., and *F. raphifolia*, Sternb. Our species, however, has the top more straightly truncate, with a flat smooth petiole.

SABAL CAMPBELLII, (?) Newb.

Represented by fragments of leaves or rays with obsolete nervation, and fruits referable to *Carpolithes palmarum*, Lsqx.

SMILAX OBTUSANGULA (?) Heer, Fl. Tert. Helv. II., p. 166, Pl. cxlvii., Fig. 25.

Leaf large, coriaceous, entire, hastate-cordate, seven-nerved from the base.

The leaf is too imperfect for precise determination; the lower part only is preserved. The lobes are still longer and less obtuse, or slightly more acute than in the quoted figures of this species. It is probably a new one. The division of the veins and their direction in the auricles cannot be seen.

CAULINITES SPARGANIOIDES, *sp. nov.*

Stem 12 mill. broad, flattened, horizontally wrinkled or warty, with distantly articulations, and comparatively large rootlets; branches alternate, distant, bearing sessile small ears, or groups of flowers.

Fragments of these stems are numerous. The branch-scars are deep, round, marked in the center by a mamilla, either smooth, or with rays diverging, star-like. Smaller scars of the same form mark the point of attachment of ovate-cylindrical bodies, 3 mill. in diameter, club-shaped or ovate-pointed, marked by protuberances like a receptacle with seeds. One of the branches bears three oval-pointed buds at a distance of 1 inch; one of them is open and appears to contain small seeds compressed between ovate, striate, thin involucels. A specimen with fragments of stems and branches of this species is covered with small seeds, placed star-like upon a slightly inflated short pedicel; the seeds are obovate, apparently surrounded by a perigynium like seeds of *Carex*, or, rather similar by form and position to those published by Heer, Fl. Tert. Helv. III., p. 171, Pl. cxlvii., Fig. 28, as *Laharpia umbellata.* The buds along the stems are sessile and may represent unopened receptacles. The relation of these remains is as yet unknown. The stems, distantly articulate, bearing sometimes one large branch-scar, with smaller scars in rows, might be comparable to *Phragmites.* But they are entirely smooth, not striate in the length, and moreover differ by the mode of branching, and by the form of the scars. The relation to *Sparganium* seems at first admittable on account of the small sessile groups of flowers, or of fructification; but this analogy, too, is rendered doubtful by the mode of branching and the articulations of the stems.

POPULUS ATTENUATA, Al. Br.

A small leaf, with strongly crenate borders. The leaf is still smaller than the one in Fl. Tert. Helv., Pl. lvii., Fig. 8, and could be referred to a variety of *Populus mutabilis, repando crenata*, but for the deeply crenate border and the thinner substance of the leaf.

POPULUS LEUCOPHYLLA, Ung., in Rept. 1871, p. 296.

A small leaf, with the borders less deeply undulate-lobed than in the form represented from European, and especially from Alaska specimens. They are merely deeply undulate. The nervation is distinctly that of the species.

MYRICA TORREYI, *sp. nov.*

Leaves membranaceous, narrowly lanceolate, tapering to a long, linear, narrow point, gradually narrowed to a short, broad petiole, distantly toothed, penninerve.

The medial nerve is broad, secondary veins numerous, variable in distance, emerging on a broad angle of divergence, 60°, ascending to a marginal vein which follows the borders, separated by intermediate veinlets, anastomosing with them in broad, irregular meshes. The leaves vary from 1½ cent. to 3 cent. wide, the largest is 16 cent. long from the base of the petiole, which is 2 cent.; most of the leaves are of the larger size; the borders are distantly but distinctly obtusely toothed, as in *Myrica (Banksia) longifolia*, Ett., to which this species is closely related. It is, however, by its nervation, a true *Lomatia*, and by this character is referable to *Lomatia borealis*, Heer, Fl. Balt., p. 79, Pl. xxiv., Figs. 9 to 13, differing essentially from it as from *Myrica longifolia*, by the large size of the leaves, &c. The positive relation of these leaves to the genus *Lomatia* seems, however, controverted by the presence of small oval seeds, apparently seeds of *Myrica*, on the same shale as the leaves. These nutlets are 3 mill. long and nearly as wide, obtuse on one end, slightly pointed at the other, convex and narrowly obscurely striate, resembling the fruits of *Myrica acuminata*, Ung., as published in Heer's Arct. Fl., p. 102, Pl. iv., Figs. 15 and 16. One of my specimens has even a fragment of a small catkin, like that represented in Fig. 15*a*. It is therefore advisable to consider this fine species as belonging to *Myrica*.

FICUS PLANICOSTATA, *sp. nov.*

Leaves large, thickish, entire, elliptical or broadly ovate, slightly pointed or obtuse, rounded—subcordate to a short petiole, three-nerved from the top of the petiole, penninerve above, nervation comptodrome.

Species represented by a large number of fine specimens. The basilar secondary veins are branched outside, 5 to 6 times, the upper lateral veins at a distance from the basilar ones, are closer to each other, all on the same acute angle, 30°, to the broad, flat, medial nerve, ascending to the immediate borders where they curve, following them as marginal and anastomosing in bows from one to the other. These secondary veins, too, are broad and flat; nervilles very distinct in right angle to the veins. The size of these leaves vary from 7½ to 12 cent. long, and from 5 to 10 cent. wide. This fine species is distantly related to *Ficus Schimperi*, Lsqx., of the Mississippi flora.

FICUS PLANICOSTATA, var. LATIFOLIA, Lsqx.

This form differs so much from the primitive type that it should, perhaps, be considered as a distinct species, though the nervation is the same. The leaves are broadly round, broader than long, with a short, scarcely-marked, obtuse point, cordate at base, with the borders curving downward and slightly decurring on the short broad petiole. These leaves are 10 cent. broad and 7 to 8 cent. long, resembling *Ficus tiliæfolia*, A. Br., but of a thinner texture, of equilateral base, and of less coarse nervation. Though there is no transitional form between this form and that described in the former species, I consider them as yet as varieties.

The shales bearing these leaves have also some small fruits of Ficus, probably referable to the same species. They are nearly round, abruptly narrowed to a short, broad pedicel, irregularly wrinkled, of the same size and form as the fruits of *Ficus dimidiata*, Gray, of Cuba.

On the same specimens, too, there is a slender branch with opposite, small leaflets, which, though still unopened, are referable to this species by their nervation. The branch is smooth, inflated at the point of attachment. It bears two pairs of these leaves at a distance of 2½ cent., with naked opposite branchlets between them. These leaves are scarcely 2 cent. long.

FICUS TILIÆFOLIA, (?) Al. Br.

A mere fragment of a large leaf, referable to this species on account of its coarse nervation and rugose surface.

FICUS CLINTONI, *sp. nov.*

Leaves of a thinner substance, comparatively small, entire, broadly ovate, oblong, obtuse, rounded at the base, three-nerved from the top of the petiole, with two upper pairs of secondary veins at a distance from the base, camptodrome.

This species, represented by numerous specimens, has, too, some likeness with the varieties of *Ficus planicostata*, Lsqx. It has, however, leaves of much thinner texture, with only two pairs of secondary veins at a great distance from the basilar ones, all much smaller in size, varying from 3 to 6 cent. long, broadly oval, entire, and more or less undulate on the borders. The two basilar lateral veins ascend by an acute angle of divergence to the borders, near the middle of the leaves, where, without curve, they enter the margin and follow it. The two upper pairs of lateral veins are nearly opposite, diverge from the medial nerve in a less acute angle, and enter and follow the borders like the other divisions, the fibrilles are thick, their divisions and the areolation distinct. A beautiful small species, very distinct, though the differences are scarcely appreciable from description.

FICUS (?) CORYLIFOLIUS, *sp. nov.*

Leaves thick, coriaceous, oblong or ovate—lanceolate, entire, tapering downward to a petiole, penninerve; medial nerve thick; secondary veins alternate, mostly craspedodrome.

These leaves, represented in many specimens, are deeply, coarsely veined, the lowest secondary veins much divided, their branches anastomosing in bows along the borders, the upper ones passing to the borders and entering them like their division or craspedodrome, therefore with a complex narration like the leaves of some species of *Quercus*. The leaves vary from ovate-pointed to broadly lanceolate. I do not know of any relation to this species.

FICUS HAYDENII, *sp. nov.*

Leaves subcoriaceous, entire, ovate, tapering into a long twisted acuminate point, round truncate, or attenuated wedge form, to a long petiole; pinnately nerved.

These leaves, with the form of leaves of *Populus*, are related to those of *Ficus appendiculato* or *Ficus populina*, Heer. They are, however, pinnately nerved, with numerous open parallel secondary veins, curving in passing to the borders, and uniting in bows to the upper ones at a short distance from the borders. These secondary veins scarcely branch, but they are joined at intervals by strong fibrillæ; their angle of divergence is about 40°. The nearest relation to this species, in fossil plants at least, is *Ficus maravigna*, Mass., Fl. Senig., Pl. XXXI, Fig. 7.

PLATANUS GUILLELMÆ, Gopp.

Very rare in the shale of Black Butte; represented by one good specimen only.

BENZOIN ANTIQUUM (?) Heer.

One leaf referable to this species is, by its form and nervation, like Fig. 1, Pl. XC, of Fl. Tert. Helv. It is, however, indistinct, and its specification somewhat uncertain like that of the leaf from Golden.

DIOSPIROS BRACHYSEPALA, Heer, Fl. Tert. Helv. III, p. 11, Pl. CII, Figs. 10 to 14.

Leaves entire, lanceolate, obtusely pointed, narrowed to a petiole, pennately nerved, lateral veins oblique, brachiodrodrome.

A number of specimens, all agreeing with the figures and description of this species. The petiole is 12 mill. long, the secondary veins, emerging at an acute angle of divergence, are somewhat distant, curve in bows, and anastomose along the borders.

DIOSPIROS ANCEPS, Heer, Fl. Tert. Helv. III, p. 12, Pl. cii, Figs. 15 to 18.

The leaves of this species, of which we have also many specimens from the same locality, are proportionally broader and shorter, with a shorter, thick petiole; the nervation is more simple, the secondary veins, and their divisions more irregularly branching and anastomosing, and the base of the leaves more rounded to the petiole. The secondary veins branch outside, and their bows along the borders are formed by anastomose with the upper branches; the Tertiary divisions are, however, simple. The lower pair of secondary veins is generally opposite the other alternate, all more curved in ascending than in the former species.

VIBURNUM MARGINATUM, *sp. nov.*

Leaves broadly ovate, or obovate, cuneiform to the petiole, round truncate upward, abruptly short-pointed, regularly toothed, strongly pinnately veined, craspedodrome.

This species is represented by a large number of specimens, indicating its numerous distant forms. So different, indeed, are some of these leaves that but for the permanent character of their nervation it would be impossible to consider them as representing the same species. The small leaves are about 5 cent. long, half as broad in the upper part, or above the middle, tapering downward to the petiole. The largest are 12 to 14 cent. long, fully as broad below the middle, abruptly contracted to the petiole, rounded upwards, or often nearly truncate to a short point entered by the end of the medial nerve. The secondary veins are like the medial nerve—broad, straight, distinctly marked, 5 to 6 pairs, at an acute angle of divergence, 15 to 20°, all more or less branching outside, according to their position, the branches straight, the largest ones subdividing, and all the divisions entering the point of sharp teeth turned outward, regular in form and distance. The petiole is half an inch long, inflated at its base. The fruit is oblong, round, truncate at one end, round, short-pointed at the other, contracted in the middle. By its nervation this species is closely allied to our *Viburnum pubescens*, Pursh; the dentation of the leaves is like that of *Viburnum dentatum*, L., while the veins and their divisions are of the same type as in *Viburnum lantanoides*, Mich., and covered, as these, by a thick coating of villosity. It extends, too, around the borders, marking them in black, like the veins and their divisions, and forming a narrow, distinct border all around the leaves. The fossil leaves especially differ from those of the living species by their attenuated or wedge-form base. Some of the species of *Viburnum* and *Tilia*, described by Professor Newberry in his notes on the extinct floras, appear to be referable to this species; but from the descriptions it is not possible to make an exact comparison. The ultimate nervation is distinct in many of our leaves. The thick fibrillæ in right angle to the secondary and tertiary divisions branch irregularly, forming an irregular loose netting of mostly pentagonal meshes. The leaves are dentate only from below the middle, or from the point where the secondary veins or divisions reach the borders.

VIBURNUM WYMPERI, Heer, Arct. Fl., II, p. 475, Pl. xlvi, Fig. 16.

Leaf ovate, narrowed to an obtuse point, wedge-shaped, rounded to the base, penninerve, craspedodrome.

Our leaf is slightly smaller, but exactly of the same form and nervation as that published by Heer from North Greenland. It evidently differs from *V. marginatum* by its more rounded and elongated form, by the nervation less deeply marked, the veins not blackened, and less divided, the upper secondary veins simple, the tertiary areolation more deeply and equally marked, and the borders less deeply, acutely, and equally dentate. In the Spitzberg flora Professor Heer has described and figured Pl. XIII, Figs. 3 to 23, some fruits which he refers to this species. Their form is different from that of the fruit of *Viburnum marginatum*, which resembles that of Fig. 24, of the same plate, referred to *Viburnum macrospermum*, Heer, known only from seeds, ours being merely slightly smaller, with a small point in the middle of the round truncate top.

VIBURNUM CONTORTUM, *sp. nov.*

Leaves small, obovate or nearly round, unequal at base, rounded on one side, attenuated at the other, curved; borders entire or obscurely serrate; nervation, pinnate, craspedodrome.

Two leaflets of this species, which might be considered as varieties of *Viburnum marginatum*, but for the irregular and different form of the leaves, and their entire borders; one of the leaves, however, is slightly toothed. The nervation is of a same type, but the secondary veins more distant and less numerous.

CISSUS LOBATO-CRENATUS, *sp. nov.*

Leaves thickish, coriaceous, smooth, nearly square in outline; abruptly, short obtusely pointed, round truncate to a broad petiole, crenate short-lobed all around; nervation, tri-nerved from the base, alternately pinnate upwards, craspedodrome.

A number of leaves variable in size from 2½ to 9 cent., nearly square, with generally two obtuse, short lobes on each side, crenate like the borders between them. The basilar veins branch outside, and pass into the obtuse point of a lobe. The smallest of these leaves are somewhat like some varieties of *Populus mutabilis* var. *repando-crenate*, Heer; far different, however, by the nervation.

VITIS TRICUSPIDATA, Heer, Fl. Balt., p. 91, Pl. xxviii, Figs. 18 and 19.

Leaves small, enlarged on the sides, three-lobate, lobes pointed, sparingly dentate.

Our specimens present a true counterpart of the figures given of this species. It is related to the former. In the small leaves, the teeth are slightly obtuse, but in the large ones they become, with the lobes, more distinctly pointed. Per contra, the large leaves of *Cissus lobato-crenatus* are more and more obtusely and obscurely crenate and dentate. Both forms, hovever, may represent varieties of one species of *Cissus*. No transition is remarked from one form to the other in our specimens.

MAGNOLIA INGLEFIELDI (?), Heer, Fl. Arct., p. 120, Pl. xviii, Fig. 1.

Leaf elliptical, subcoriaceous, entire, medial nerve thick; secondary veins distant, camptodrome.

The leaf resembles by its form the figure quoted above; the nervation appears about the same, differing only by the lowest secondary veins being in our leaves on a broader angle of divergence than that of the upper veins. In Heer's Fig. 1, *loc. cit.*, the lowest veins are more inclined. But in another, Fig. 3*a*, of the same plate, the secondary veins are still more open than in our leaves, though all parallel. All our specimens have the lower part of the leaf destroyed; the comparison, therefore, is not conclusive, though these leaves belong evidently to a *Magnolia* of a same type.

SAPINDUS CAUDATUS, Lsqx.

Described above with specimens from Golden. The leaves here are slightly shorter, narrowly taper-pointed or with a shorter point than those of Golden, indicating thus still more the relation of this species with *Sapindus dubius*, Heer.

ALEURITES EOCENICA, *sp. nov.*

Leaves membranaceous, thickish, oval, pointed, wedge-shaped to a long petiole, minutely and distantly glandulosely denticulate, penninerve; secondary veins alternate parallel; nervation complex.

Many fragments with one leaf preserved in its whole. It is 6½ cent. long, 2½ cent. broad in the middle, its widest part, with a petiole of the same length, 2½ cent. long. The nervation is complex and mixed. The secondary veins, emerging under an angle of 40°, either curve at a distance or near the borders in angular bows, their branches passing straight from the angles to the borders, where they enter a very small round glandular point; or these secondary veins themselves pass up after anastomosing on both sides, and enter, too, a small gland of the borders. The same nervation and same form, consistance, &c., of leaves are marked in *Aleurites triloba*, Gr., of Cuba. I consider these leaves referable to this genus.

PALIURUS ZIZYPHOIDES, *sp. nov.*

Leaves subcoriaceous, entire, oval, or obovate obtuse, curving downward to a thick, short petiole, five-nerved, the two lowest lateral veins from the borders of the petiole, the other from the medial vein a little higher; camptodrome.

The leaves vary in size, the largest one, nearly round, being 5 cent. wide. They are properly three-nerved from the base, the lowest veins being rather marginal ones, much shorter than those of the first pair. These ascend in acute angle to the borders, which they follow, branching outside; the medial nerve is pinnately divided from the middle upward. The same species, represented by a smaller leaf, has been found at Erie.

RHAMNUS RECTINERVIS, Heer.

Represented by two good specimens.

RHAMNUS DECHENII, Web., Pal., VIII, p. 90, Pl. vi, Fig. 2.

A broken specimen only, representing, however, this species. It merely differs by the more deeply-marked nervilles. The secondary veins are not as strong and deeply marked as in the former species. A broken specimen from Golden by Professor B. F. Meek is also referable to this.

RHAMNUS DISCOLOR, *sp. nov.*

Leaves membranaceous, entire, round or ovate, narrowed into an obtuse point, rounded to the short, thick petiole; secondary veins simple, 8 to 10 pairs.

A fine species, with leaves varying in size from 2½ to 6 cent., oval, or sometimes round, emarginate, or obtuse at the point; secondary veins diverging 40 to 50°, curving in ascending to and along the borders where they are united by strong nervilles; always discolor, an indication that they were covered with a villosity, and either black on the yellow surface of the leaves, or yellow upon the black ones, often split in the length by maceration; nervilles distinct and distant. It has some affinity of nervation with *Rhamnus brevifolius*, Heer, Fl. Tert. Helv., p. 78, Pl. cxxiii, Fig. 27, for the curving of the veins along the borders. The lowest pair of veins join the medial nerve by a downward (decurring) curve. Closely allied by the form of the leaves and the nervation to *Rhamnus Purshianus*, D. C., now living in Oregon.

JUGLANS BALTICA (?), Heer, Fl. Balt., p. 98, Pl. xxix, Figs. 9 and 10.

A fragment only, with the point and base broken. The form of the leaf and its peculiar nervation refer it to this species. The leaf is of a thin texture.

JUGLANS RUGOSA, Lsqx.

Represented by uncomplete but identifiable specimens.

CARPOLITHES PALMARUM, Lsqx.

A few specimens of the same characters, form, and size as those obtained at Golden.

CARPOLITHES FALCATUS, *sp. nov.*

A small scythe-shaped fruit, attenuated at both ends, narrowly and distinctly striate in the length, 2 cent. long, 4 mill. wide in the middle, pointed at one end, blunt at the other. The relation of this species is as yet unknown.

Black Butte, saurian bed.

The station of this bed is about 150 feet higher in the measures than the shale, with fossil-plants of the former section. The matter, embedding leaves, fragments of wood, of charcoal, ash, clay, fossil Cones and shells all kneaded and mixed together, has been hardened by fire and breaks with difficulty and in irregular fragments. It contains an abundance of vegetable remains, mostly broken, however, and in a bad state of preservation.

SABAL CAMPBELLII, Newb.

In large specimens bearing, as elsewhere, the character of very narrow, close, indistinct striæ of the rays.

FICUS CORYLIFOLIUS, Lsqx.

Described from the lower station, the shale above main coal. Professor B. F. Meek found in this saurian-bed a fine leaf preserved entire.

LAURUS OBOVATA, Web. Pal., VIII, p. 66, Pl. iii, Fig. 4.

Leaf coriaceous, entire, oblong-ovate, acuminate, narrowed to a petiole, pinnately nerved, secondary veins very thin, the lowest ascending parallel to the borders.

The lowest veins of this leaf only are discernible in the two leaves found. These are slightly broader and shorter than the one figured as marked above, and could be referred to *Laurus benzoidea*, Web., Fig. 5 of the same plate, but for the secondary veins on a more acute angle of divergence and the narrower medial nerve. I believe, however, that both these leaves of Weber represent the same species.

PLATANUS RAYNOLDSII, Newb.

A large fragment of this fine species. The borders are scarcely dentate or less acutely toothed than in the normal form. The substance of the leaves is evidently coriaceous.

VIBURNUM DICHOTOMUM, *sp. nov.*

Leaf subcoriaceous, thickish ovate-oblong, obtusely pointed, round, slightly cordate to the petiole, sharply serrate from above the middle, pinnately nerved.

The lowest secondary veins are opposite, at some distance from the upper ones, emerging on an angle of 30° to 35°, branching thrice; the upper secondary veins are alternate and dichotomous-like, in separating from the medial nerve, two on each side; the teeth of the borders are entered either by the point of secondary vein or of their branches, as in *Viburnum marginatum*, Lsqx., to which this species is allied. It however differs by the greater thickness of the leaves, the smooth surface, the form of the teeth, whose points are turned upwards, and especially by the peculiar nervation. I have found a single well-preserved entire specimen of this form. Professor B. F. Meek has another fragment of the same from the same locality. This species is, by its leaves at least, intimately related to *Viburnum ellipticum*, Hook, of Oregon.

Black Butte, red baked shale.

These shales form the top of small hills about at the same level as the saurian-beds, and at a short distance to the east. They are as hard as bricks, and of the same color. By disintegration they are parted in thin lamellæ in the plane of stratification, but no good specimens can be obtained by the hammer.

PHRAGMITES OENINGENSIS, Al. Br.

Fragments of roots and rootlets.

MYRICA TORREYI, Lsqx.

Described already from the shale above the main coal of this locality.

QUERCUS WYOMINGIANA, *sp. nov.*

Quercus Olafseni var., Heer, Arct. Fl., p. 471, Pl. xlix, Fig. 1.

A large ovate lanceolate pointed leaf, with borders undulate, or marked by distant short teeth; nervation penninerve, craspedodrome.

Heer, *loc. cit.*, has considered this species as probably a variety of *Quercus Olafseni*, which is described in the first vol. of the Arct. Flor., with numerous figures. All these show the borders doubly and obtusely dentate, with mostly simple secondary veins, on a broader angle of divergence and somewhat curving in ascending to the borders. In this leaf of Black Butte, as in that considered as a variety by Heer, the borders are merely undulate, or distantly marked with short, pointed, simple teeth, while the secondary veins are on a more acute angle, straight and comparatively much branched. The permanence of these characters, remarked in our specimens from Black Butte, force us to consider them as specific.

EUCALYPTUS HAERINGIANA (?), Ett., Här. Foss. Fl., p. 84, Pl. xxviii, Figs. 2 to 25.

Leaves small, linear-lanceolate, pointed, tapering to the base, thickish, entire, medial nerve thick, nervation obsolete.

The similarity of these two leaves of ours with those *loc. cit.* Fig. 4, 7, and 11 is perfect; but in the European species, as in ours, the nervation is obsolete, and the mere outlines of leaves of this kind, without comparison of specimens, are not sufficient for identification.

MACCLINTOCKIA LYALLII, Heer, Arct. Fl., i, p. 115, Pl. xv, Fig. 2.

A mere fragment, good enough, however, to show the characters of this remarkable species. It is the lower half of a coriaceous, entire, lanceolate, or oblong leaf, marked by five primary veins, with alternate thinner secondary ones, all nearly parallel. The details of areolation are not discernible.

RHAMNUS CLEBURNI, Lsqx.

Species described from Golden specimens. Professor B. F. Meek found two fine leaves of the same species also in burnt red shale of another locality. The specimens are labeled: *In the hills west of Black Butte.*

RHAMNUS SALICIFOLIUS, Lsqx., Am. Jour. Sci. & Arts, 1868, p. 206.

Found, like the former, by Professor Meek, at the same locality.

JUGLANS RHAMNOIDES, Lsqx., Rept. 1871, p. 294.

Represented by a large number of good specimens. However, the relation of these leaves is still uncertain; some of them, by strong fibrillæ and secondary veins less curved, appear referable to *Rhamnus Eridani*, Heer, though different by the form of the leaves, while others have a nervation more analogous to species of *Juglans*, especially to *Juglans rugosa*, Lsqx.

Evanston.

The materials taken out of a tunnel and heaped near its mouth, when former explorers visited this place, have furnished, especially, the specimens from which the descriptions of species were made in the former Report and its Supplement. When I passed Evanston, these shales, rich in remains of fossil plants, had been covered with slack, and the whole heap was burning. I could therefore obtain little materials in addition to those from which is derived our acquaintance with the flora of that locality.

POPULUS ARCTICA, Heer.

A species common in the Upper Lignitic formation, already remarked upon with specimens from Carbon.

POPULUS MUTABILIS REPANDO-CRENATA, Heer.

A splendid leaf of this species, 15 cent. long, without the 8 cent. long petiole, and 8 cent. broad toward its round truncate base; of exactly the same form as Fig. 4, Pl. lxii, of Flor. Tert. Helv. This leaf is distinctly preserved upon a block of sandstone used for construction at the mines of the Wyoming Company.

ALNUS KEFERSTEINII, Heer, in Rept. 1871, p. 292.

A species represented with numerous and well-preserved remains.

BETULA STEVENSONI, Lsqx., Rept. 1871, p. 293.

Like the former, very common at Evanston. I found mixed with the leaves some bracts of *Betula*, referable to two different species. One of the forms is comparable to the bract figured by Heer in Flor. Arct., Pl. xxv, Fig. 25, which he refers to *Betula prisca*, Ett. The other, with the three divisions short and pointed, is of the same type as that of Fig. 30 of the same plate named *Betula Forshammeri*, Heer. Perhaps both forms belong to the same species. I consider, however, the first and more common one as referable to *Betula Stevensoni*, Lsqx., most commonly represented by its leaves; and the second to *Betula caudata*, Gopp., a few leaves of which have been found at Evanston. With these bracts are mixed some ovate-pointed seeds, truncate at the lower part, without wings, and twice as large as the seeds of *Betula*. They may be referable to *Alnus Kefersteinii*, being, for the upper part at least, of the same form and size as those figured by Heer, same plate as above, Fig. 8. The lower part of the Arctic specimen is, however, destroyed. The shale at Evanston has, as at Carbon, many species of fruits which can be described only with figures.

DIOSPIROS LANCIFOLIA, Lsqx., in Rept. 1871, p. 293.

The leaves referable to this species are very numerous and variable in size. I found, in connection with them, a round or slightly oval-tumid nutlet, 9 mill. in diameter, smooth, like that of some species of *Prunus*. These leaves might then be referable to a thick-leaved *Prunus*, like *P. sphærocarpa*, Lois., of Cuba.

RHAMNUS RECTINERVIS, Heer.

The same form as described in Rept. 1871, p. 295.

RHAMNUS OBOVATUS, Lsqx.

Represented in two badly preserved specimens. They are, however, easily ideniifiable.

RHUS EVANSII, Lsqx., Rept. 1871, p. 293.

The specimens are of the same size and form as those described in the report.

JUGLANS RHAMNOIDES, Lsqx., Rept. 1871, p. 293.

Already described from the same place.

CARYA ANTIQUORUM, Newb., Rept. 1871, p. 294.

I found a large number of well-preserved leaves referable to this species, some larger still than the one formerly described. The general form is of the same type as that of *Juglans rugosa*; the borders of the leaves, however, are crenulate and the secondary veins craspedodrome, their points and their divisions entering the crenules, the lowest ones after curving along the borders. There is a great variety in the nervation of these leaves. Their substance is thickish, subcoriaceous.

CASSIA CONCINNA, Heer, Flor. Tert. Helv., III, p. 122, Pl. xxxviii, Fig. 41.

The figure given by Heer represents a branch of apparently unfolding leaves. We have one specimen with a single leaf so remarkable in form and so exactly similar to that figure enlarged, 41^6, *loc. cit.*, that it is impossible to doubt that it represents the same species. It is, however, uncertain if these leaves represent a species of Cassia. The young branches of *Peltophorum adnatum*, Gr., of Cuba, bear leaves of exactly the same form. The half opened buds of our Gleditschia triacanthos have also their leaves of the same kind.

CALYCITES HEXAPHYLLA, *sp. nov.*

An open calyx or involucre of a detached fruit, at the top of a slender pedicel. The point of attachment is round, 4 mill. wide, with a central small mamilla 1 mill. broad; the follicule divides at a short distance from the central point in six linear, entire, undulate, obtuse segments, 2 cent. long from the central point, diverging star-like, coriaceous and narrowly striate in the length. The central point evidently marks this vegetable as representing a calyx, rather than a coriaceous corolla. It may be compared to what Dr. Newberry has named *Calycites polysepala*, though the form of the divisions is far different. It is apparently referable to an involucre or persistent calyx of some *Lauraceæ*, or perhaps of some *Diospiros*, though few species of this genus have hexamerous divisions.

CARPOLITHES ARACHIOIDES, *sp. nov.*

Fructification racemose; branches long, 3 mill. thick, bearing alternate, oblong-ovate pointed capsules, striated in the length, inflated at one side near the point like a one-celled pod.

These capsules or pods are turned upward in the upper part of the branches, downward or pending in the lower part, 2½ cent. long, 1 cent. wide in the middle, rounded to a short pointed acumen, narrowed to the point of attachment, where they are generally somewhat more inflated on one side than on the other, distinctly striate in the length except on the inflated part near the point, where they are obscurely and transversely wrinkled. These racemes of fructifications, of which I obtained good and distinct specimens, are indeed remarkable; but their relation is as yet unknown. Nothing of this kind has been published, and, except the pods of our pea-nut plant, *Arachis hypogœa*, *L.*, which they distantly resemble, I do not know any living species to which they may be compared.

CARPOLITHES PALMARUM, Lsqx., Supt., p. 13.

As yet no remains of leaves of Sabal have been found at Evanston; the relation of fruits from this locality to species of palms is still doubtful.

Professor Meek has, too, among his specimens, a few fragments of *Platanus Guillelmœ*, Göpp., already described from this locality, and one obscure fragment of *Platanus*, which appears to belong to *P. nobilis*, Newb.; this last is, however, uncertain.

Elk Creek, near Yellowstone River.

Specimens in fragments of hard metamorphic calcareous shale, mostly representing pieces of leaves of *Platanus nobilis*, Newb., labeled A. C. Peale, Jos. Savage, and O. C. Sloane.

CYPERITES ANGUSTIOR, Al. Br.

The specimen is distinct, and agree exactly with the figure of this species in Heer, Fl. Tert. Helv., p. 79, Pl. xxix, Fig. 7. The leaf is 2½ mill. broad, with a thick medial nerve ½ mill. or more, smooth surface, and secondary veins totally obsolete. This fragment of leaf is enlarged at its base (?) into what appears to be a vagina, embracing a cylindrical culm (?) preserved in its cylindrical form like a small branch of petrified wood. The preservation of this grass stem is accountable by the nature of the embedding substance, which is evidently a kind of calcareous tufa.

FAGUS ANTIPOFI, Heer, Fl. Foss. Alask., p. 30, Pl. VII, Figs. 4–8.

Leaf elliptical, narrowed by a curve to its base, lanceolate-pointed, entire, membranaceous; secondary veins straight, oblique 30° to 35°, simple, numerous.

This form is referable to Heer's species by its general outline and characters, especially to var. *a:* leaves ovate, lanceolate, very entire. One leaf is, however, shorter and broader and apparently more abruptly pointed, (the point is broken.) The nervilles, too, are at right angle to the medial nerve and more oblique to the secondary veins. The nervation is that of our living *Fagus ferruginea*, Ait.

PLATANUS NOBILIS, Newb.

Represented by a large number of fragments.

JUGLANS RUGOSA, Lsqx.

Only an obscure specimen.

CARPOLITHES OSSEUS, *sp. nov.*

Fruit hard, covered with a thin, bony shell, compressed, oval, round, obtuse at one end, obtusely pointed (?) at the other.

The point is half destroyed. This fruit is 6 cent. long, 3 cent. wide in the middle, irregularly narrowly striate in the length and rugose on the surface. It has the form of a large nut, like those of some species of *Astrocaryum* of the Palms. It is slightly flattened, apparently by compression.

Six miles above Spring Cañon, near Fort Ellis.

I have to place in a single division a number of specimens marked with three kinds of labels, for the reason that they represent some identical species from the different localities, and appear, therefore, as from the same horizon. These labels are: "Near Fort Ellis, above coal; A. C. Peale, Jos. Savage." "Above Spring Cañon, near Fort Ellis; Jos. Savage, W. H. Holmes." "Six miles above Spring Cañon; A. C. Peale, Jos. Savage." All the specimens are of a very hard, metamorphic shale, breaking across the plane of stratification, therefore, mere fragments, rarely representing an entire leaf. The localities are indicated for the new or interesting species of this section.

GYMNOGRAMMA HAYDENII, Lsqx., Rept., (1871,) p. 295.

Two specimens of this species, from above Spring Cañon.

ABIETITES DUBIUS, Lsqx.

Described formerly with specimens from the Raton Mountains. The specimens are from near Fort Ellis, above coal, and above Spring Cañon.

ABIES SETIGERA, *sp. nov.*

Leaves distant, simple, very narrow, needle form, in right angle around and from the branches.

These very narrow filiform leaves are 18 mill. long, less than one mill. wide, linear sharp pointed, abruptly enlarged at the base in the point of attachment to the branches, from which they diverge all around in right angle. The leaves are nerved, channeled on one side, keeled at the other. It has no relation to any fossil or living species known as yet.

SALISBURIA POLYMORPHA, Lsqx., Ment. Jour. Science and Arts, (1859,) p. 362.

Leaf fan-like in outline, tapering or wedge form to the base, divided upward in lobes of various forms, either linear oblong obtuse or lanceolate, short or deeply parted.

The medial vein is marked to above the middle, the veins very thin, close, straight, or nearly so, dichotomous in ascending. "From six miles above Spring Cañon."

A very fine and well-characterized species, mentioned from specimens in the collection of Dr. John Evans from Vancouver's Island. The plants from this locality were described and figured for a final report, which was delivered to Dr. Evans, but has never been published. A short mention only is made of this species in the Journal. The presence of this leaf, easily identified, in strata evidently Eocene, with species which, like *Platanus aceroides*, *Quercus Pealei*, *Cinnamomum Rossmaessleri*, &c., cannot be considered as Cretaceous, confirm my opinion on the Tertiary age of coal of Vancouver, *loc. cit.*

CAULINITES SPARGANIOIDES, Lsqx.

Described above with specimens from Black Butte.

POPULUS LEUCOPHYLLA, Ung.

A small leaf, representing the variety figured by Gaudin, 1st Mem., Pl. iv, Fig. 3.

"Near Fort Ellis, above coal."

POPULUS MUTABILIS, VAR. REPANDO CRENATA, Heer.

A fine leaf, the upper half of which is, however, destroyed. The preserved part is 6 cent. long, 6 cent. wide in the middle, the petiole 5 cent. long. The second pair of lateral veins is nearer to the basilar ones than in any of the leaves in Heer Flor. Tert. Helv., p. 62; but this difference is scarcely noticeable for leaves of so variable a species as this. Though very common in the European Miocene, it has few representatives in our Eocene flora.

SALIX ANGUSTA, (?) Al. Br.

The specimen represents only the middle part of a linear leaf, 4 cent. long, 12 miil. wide, with numerous secondary, deeply-marked veins, curving along the borders, and forming undulate margins by their depressions. This fragment is of the same type as that published by Ludwig in Pal. Wetter. Braunkohle, Pl. xxxi, Fig. 2*d*, which, too, has the borders undulate by the depression of the veins. On account of the imperfect fragment, the identification is, however, uncertain.

ALNUS KEFERSTEINII, Göpp.

In broken specimens. "From six miles above Spring Cañon."

QUERCUS WYOMINGIANA, Lsqx.

Like the former, in fragments. "From near Fort Ellis, above coal."

QUERCUS PLATANIA, Heer, *var.* ROTUNDIFOLIA.

Leaf round in outline, obtuse or obtusely short-pointed, deeply cordate at base, borders undulate.

These leaves are three-nerved from the base, with two or three pairs of upper secondary veins, parallel, mostly opposite, craspedodrome, branching outside, and connected by strong nervilles. This form appears at first specifically different from Heer's species and also from the leaf referred to it from Carbon. The leaves, 9 cent. broad and just as long, have entire undulate borders, and the base merely cordate. One of them, the best preserved, has only three pairs of secondary veins; the lowest nearly as strong as the medial nerve, much divided outside, ascending to the borders in an angle of divergence 50°; the other, at a more acute angle, 40°, branching, too, and connected with strong nervilles, the leaf, except for its form, appearing a leaf of *Platanus*. A number of specimens, however, present marked differences intermediate between this leaf and those from Greenland, not only in the nervation, but in the basilar, auriculate borders, which, too, in one specimen, are dentate. From this, as from the leaf described at Carbon, this species appears very variable and well represented in our northern Lignitic formation. I have not seen it as yet south of Carbon. The leaf of ours has evidently a long petiole.

LAURUS PRIMIGENIA, Ung., Fl. v. Sotzka, p. 38, Pl. XIX, Figs. 1–4.

Leaves thick, coriaceous, lanceolate, tapering to a long petiole; lower secondary veins at an acute angle of divergence.

One of the specimens represents the lower half of a leaf with a still longer petiole, than marked by Unger, *loc. cit.*; another has only the upper part with the point broken. In both the character of nervation and the form of the leaves agree with those of this species. The lowest pair of secondary veins is at a more acute angle than the upper ones, and ascends higher along the borders. In one of the specimens some nervilles go out from the medial nerve as intermediate veinlets to the secondary veins. The ultimate divisions, however, pass into round, very small, areolæ, the whole of the same type as in *Laurus princeps*, Heer.

QUERCUS PEALEI, Lsqx., Rept. 1871, p. 297.

Many specimens of this fine species indicate the form of the leaves as variable from broadly ovate pointed to oval lanceolate-pointed. The nervation and the form of the obtuse teeth is always as described in Rept., loc. cit. One of these leaves is 7½ cent. long, only 2½ cent. broad, while another is 4½ cent. broad and only 5 cent. long.

Represented, like the former, by specimens from all the localities of this section.

PLATANUS ACEROIDES, Göpp.

A good specimen, from six miles above Spring Cañon.

FICUS AURICULATA, Lsqx.

Described with specimens of Golden. The collection has an identifiable fragment, representing the lower half of a leaf from the same locality as the former.

CINNAMOMUM ROSSMÄSSLERI, Heer.

Represented by three specimens from six miles above Spring Cañon.

FRAXINUS DENTICULATA, Heer, Arct. Flor. I, p. 118, pl. xlvii, Fig. 2.

This leaf is intermediate between the one figured loc. cit., and another much smaller, with more acute teeth, (Pl. XVI, Fig. 4.) It is nearly as large as the first, with large, obtuse, distant teeth, but with a distinct nervation like that of the second, the lowest secondary veins curving and anastomosing along the borders, with divisions or nervilles entering the teeth; while the upper ones directly end into them. There is no doubt about the identity of these leaves with those figured by Heer, but I am uncertain if they represent a species of *Fraxinus*.

QUERCUS CHLOROPHYLLA, (?) Ung.

Same species of leaves as those described under this name from Marshall.

NYSSA LANCEOLATA, *Sp. nov.*

Leaves subcoriaceous, entire, broadly lanceolate-pointed, rounded to the petiole, secondary veins alternate, parallel camptodrome.

The leaves are 7½ cent. long, 4 cent. broad in the broadest part, with 9 pairs of secondary alternate veins, diverging 40° from the medial nerve, curving in ascending to the borders, where they disappear; areolation punctate. The nervation and areolation are as in our living *Nyssa multiflora*, Wang. The form of the leaves, however, is different, the fossil ones being broader below the middle, more rounded in descending to the petiole. Except *Nyssa punctata*, Heer, in Balt. Flor., the European tertiary species are known only by the fruits. The Baltic species, like *Nyssa (?) vetusta*, Newb., are far different from this one. Three species of *Nyssa* are known, by fructifications only, from the Brandon lignites of Vermont.

Six miles above Spring Cañon.

RHAMNUS ACUMINATIFOLIUS, O. Web.

Leaves large, broadly oval, accuminate pointed, rounded to the base; secondary veins parallel, curving to and along the borders; nervilles indistinct.

These leaves, represented by two fragments only, differ from *Juglans rugosa*, Lsqx., by round base and a less distinct and more regular nervation. They may, however, be mere varieties of this omnipresent and polymorphous species. The same form has been found at Golden.

RHUS BELLA, (?) Heer, Flor. Arct. II, p. 483, Pl. lvi, Figs. 4 and 5.

The lower half of a subcoriaceous entire leaflet, gradually tapering from the middle to a petiole, appearing part of a compound leaf. The specimen is not sufficient for a reliable identification. The nervation, like the form of the leaf, are, however, the same as in Heer's species.

Above Spring Cañon, near Fort Ellis.

JUGLANS RUGOSA, Lsqx.

The specimens from all the localities of this station represent distant varieties of this species. The leaves are especially variable in size, some still larger than the largest forms of *Juglans acuminata*, published by Heer, some so small that though the characters taken from nervation and outline are identical, they can scarcely be recognized as belonging to this species. Among them are two specimens from above the coal of Spring Cañon, near Fort Ellis, representing the same leaf. It is 6 cent. long, 3 cent. wide, elliptical, lanceolate-pointed, tapering to the petiole in a round curve, with secondary veins numerous, variable in distance, some separated by shorter veinlets, the lower ones at a broader angle of divergence than the superior ones, and the lowest shorter pair nearly at a right angle to the medial nerve; nervilles perpendicular to the lateral veins. If these characters of nervation are those of *Juglans rugosa*, Lsqx., as also of *Juglans acuminata*, Heer, they are those also of *Juglans vetusta*, Heer, Flor. Tert. Helv., p. 90, Pl. cxxvii, Figs. 40–44; a species with smaller leaves, of a form similar to that of ours. We have, however, intermediate specimens which, coming from the same stations, seem to disparage the separation of these forms into two species.

JUGLANS DENTICULATA, Heer.

The same small form as the one remarked upon in Rept., 1871, p. 298. The specimens are from the same place.

CASSIA PHASEOLITES, Ung. Fl. v. Sotzka, p. 58, Pl. xlv.

Leaves, membranaceous; petiole elliptical, tapering downward by a curve to the petiole; lowest pair of secondary veins at a distance from the base, opposite.

This species is figured by Unger, with numerous leaves and one of its pods. Heer, too, has it in the same way in his Flor. Tert. Helv., Pl. cxxxvii, Figs. 66 to 74. The numerous specimens obtained from the different localities of this station merely represent leaves. These in their different forms and variety of nervation agree so well with the European leaves that they may be referred to this species with little doubt. The angle of divergence of the secondary veins is variable, as also the more or less rounded base of the leaves. It is often unequilateral.

GENERAL REMARKS.

The following table of comparison, indicating the distribution of species at different localities, completes, to this time, the one published in the former report. For researches like those which have been detailed in this paper, and for a science which, like vegetable paleontology, is still, with us at least, in an incipient state, a document of this kind cannot be dispensed with. Besides pointing out the march of the researches and the discoveries made in the flora of our Tertiary, the table is a most convenient record to show at a glance the points of relations or of differences which may be more reliably considered in the discussion on the geological age of certain groups. It has been essentially prepared to that purpose, and, therefore, slightly modified or rather simplified, to render it more explicit. The characters of the Tertiary groups of Europe are not satisfactorily fixed by vegetable paleontology; therefore, the relation of some our species with separate Miocene divisions is unimportant. On another side, the few fossil species known as yet in Europe as truly Eocene, claim a more scrupulous comparison with ours on account of the conclusion admitted in the first part of this report—that the whole North American Lignitic formation is Eocene. The table, therefore, has a single division for the European Miocene, and another for the Eocene, both for indication of geological age; and it has, too, one for the Arctic and another for the Alaska Tertiary, for indication of original derivation of species rather than for comparison of geological divisions. The American divisions are defined by stratigraphy as by paleontology. The Upper Tertiary or the Miocene (?) is represented in the Rocky Mountains by the Green River Group, and some identical strata of Elk Station and of South Park. The second group in descending order, named as yet Upper Eocene, has for its essential members Carbon, Evanston, and Washakie deposits, which may be hereafter subdivided into two stages. The lower Eocene is considered in separate geographical divisions, of identical age, as far, at least, as it is known as yet, the Raton Mountains, Golden, Black Butte, and Six miles above Spring Cañon. Detached areas of the same group, which have as yet furnished to examination a too small number of fossil plants, are united with the essential divisions. The Placer Mountains and the Cañon City go with the Raton; the Gehrung's, Marshall's, and Erie coal deposits with Golden; the Point of Rock and Hallville, with the upper and lower divisions of Black Butte,; and the different localities at and around Fort Ellis, with Six miles above Spring Cañon. More precise details of the distribution of each species are given, with their descriptions. The Elk Creek division is as yet scarcely fixed by its remains of fossil plants. It could have been omitted or united, perhaps, with Spring Cáñon but for a few peculiar species which seem to indicate a distinct flora, and which may afford matter for consideration. The distribution of the table is, besides, clear and explains itself.

Table of distribution of the species of fossil plants from the Tertiary formations of North America.

Name of species.	Miocene.			Upper Eocene.				Lower Eocene.									Europe.	
	Green River, &c.	Elko Station.	South Park.	Washakie group.	Carbon Station.	Evanston.	Sage Creek, &c.	Raton Mountains.	Golden, &c.	Black Butte.	Spring Cañon, six miles above.	Elk Creek, Yellowstone Lake.	Fort Union.	Mississippi.	Alaska.	Arctic.	Eocene.	Miocene.
Spheria lapidea, s. n								+										
Myricæ, s. n										+								
Sclerotium pustuliferum, H					+													
rubellum, s. n									+									
Opegrapha antiqua, s. n										+								
Choudrites subsimplex, s. n								+										
bulbosus, s. n								+										
Delesseria fulva, s. n									+									
incrassata, s. n								+										
lingulata, s. n								+										
Halymenites striatus, s. n								+	+									
major, s. n					+	+		+	+	+	+						+	
minor, F. O											+						+	
Onoclea sensibilis, L													+					
Hemitelites Torelli, H	+																	
Pteris pennæformis, H	+																	+
anceps, s. n									+									+
erosa, s. n								+										+
Aspidium Fischeri, H	+																	
Sphenopteris Eocenica, E									+								+	
Gymnogramma Haydenii, Lx								+			+	+						
Lygodium compactum, Lx									+									
neuropteroides, Lx	+																	+
Fern, species							+									+		
Ophioglossum Alleni, s. n			+															
Equisetum Haydenii, Lx	+															+		
limosum, (?) L													+					
Taxodium occidentale, Ny													+					
dubium, St					+													+
Tijanorum, H	+														+			
Glyptostrobus Europeus, Br													+		+			+
Sequoia Heerii, Lx					+													
angustifolia, s. n		+																
Langsdorfii, Br										+			+		+	+		+

Thuja gracilis, Ny													+					
Garmani, s. n		+																
Thuites callitrina, n			+															+
Abietites dubius, Lx								+			+							
Abies Nevadensis, s. n		+																
setigera, s. n											+							
Salisburia binervata, Lx														+				
polymorpha, Lx											+							
Arundo Gœpperti, A. Br	+							+										+
Phragmites Oeningensis, A. Br					+	+		+	+	+						+		+
Alaskana, H												+			+			
Juncus, species					+													
Poacites lævis, H	+															+		+
Cyperites, species	+																	
angustior, A. B												+	+					+
Deucalionis, H	+															+		+
Cyperus Braunianus, H	+																	+
Chavanensis, H						+												+
Carex tertiaria, (?) H	+															+		+
Berthoudi, s. n								+	+	+								
Smilax grandifolia, U					+													+
obtusangula, H										+								+
Sabal Grayana, Lx														+				
Campbellii, Ny								+	+	+			+					+
Goldiana, s. n									+									
major, (?) U	+																	+
Flabellaria Zinkeni, H									+						+			
latania, H									+								+	
Eocenica, A. B										+							+	
Calamopsis Danai, Lx														+				
Palmacites, species									+								+	
Sparganium, species	+																	
Acorus brachystachys, H				+	+													
Caulinites sparganioides, s. n					+				+	+	+							
fœcunda, s. n									+									
Psilotum inerme, Ny													+					
Zingiberites, species	+																	
Liquidambar gracilis, Lx				+														+
Populus arctica, H				+	+					+					+	+		
decipiens, s. n					+													
smilacifolia, Ny													+					
attenuata, A. B					+			+	+	+								+
cuneata, Ny													+					
cordata, Ny													+					
acerifolia, Ny													+					
Nebrascensis, Ny													+					
genetrix, Ny													+					
nervosa, Ny													+					
monodon, Lx								+						+				
æqualis, Lx				+														
mutabilis repando-crenata, H					+	+		+			+			+				+
lancifolia, H											+					+		+

Table of distribution of the species of fossil plants from the Tertiary formations of North America—Continued.

Name of species.	Miocene.			Upper Eocene.				Lower Eocene.									Europe.	
	Green River, &c.	Elko Station.	South Park.	Washakie group.	Carbon Station.	Evanston.	Sage Creek, &c.	Raton Mountains.	Golden, &c.	Black Butte.	Spring Cañon, six miles above.	Elk Creek, Yellowstone Lake.	Fort Union.	Mississippi.	Alaska.	Arctic.	Eocene.	Miocene.
Populus balsamoides, G								+			+				+			+
ovalis, G						+												+
latior var. transversa, A. B				+											+			+
var. cordifolia, A. B				+														+
leucophylla, U										+	+				+			+
Zaddachi, H						+									+	+		
Salix elongata, W		+																+
angusta, A. B	+										+							+
media, A. B	+																	
species	+																	
Grœnlandica, H											+					+		
Evanstoniana, Lx						+												
Worthenii, Lx	+																	
densinervis, Lx														+				
tabellaris, Lx														+				
Myrica ambigua, Lx											+							
nigricans, Lx	+																	
salicina, U	+																	+
Torreyi, s. n										+							+	
Alnus Kefersteinii, G					+	+					+				+	+		+
serrata, Ny													+					
Ulmus irregularis, s. n								+	+									
Betula caudata, G						+												+
Stevensoni, Lx					+	+												+
Planera longifolia, s. n		+																+
microphylla, Ny													+					+
Celtis brevifolia, Lx														+				
Quercus angustiloba, A. B									+								+	
Moorii, Lx														+				
Lyellii, H														+		+		+
retracta, Lx														+				+
chlorophylla, U								+	+		+			+				+
triangularis, G									+									+
stramineus, s. n									+									

platania, H					+						+					+		
semi-elliptica, G		+																
aemulans, Lx				+														
negundoides, Lx				+														
drymeja, U				+												+		+
acrodon, Lx					+													
Wyomingiana, s. n										+	+					+		
Olafseni, H										+						+		
Haydenii, Lx					+													
Gaudini, Lx											+							+
Ellisianus, Lx											+							
Pealæi, Lx											+							
Godeti, H											+							+
Laharpi, G											+					+		
Saffordi, Lx														+				
lonchitis, Ung	+																	
dubia, Ny													+					
crassinervis, U														+				+
myrtifolia, (?) W	+																	+
Corylus grandifolia, Ny										+			+					
orbiculata, Ny													+					
Americana, W													+					
McQuarryi, H					+	+				+	+				+	+		
Fagus Antipofi, H					+							+			+			
Deucalionis, U				+	+											+		+
Feroniæ, U									+									+
ferruginea, (?) M., (fruit)														+				
Ficus Schimperi, Lx														+				
cinnamomoides, Lx														+				
tiliæfolia, A. B						+		+		+	+					+		+
planicostata, s. n									+	+								
var. latifolia and fruit										+								
Clintoni, s. n										+								
asarifolia, E									+									+
lanceolata, H					+	+												+
oblanceolata, s. n					+													
multinervis, H					+													+
arenacea, Lx					+													+
Ungeri, Lx	+																	+
Gaudini, Lx					+	+												
spectabilis, s. n									+									
corylifolia, s. n										+								
ulmifolia, Lx								+										
Haydenii, s.n										+								
auriculata, s. n									+		+							
populina, H	+																	+
Morus affinis, Lx	—					+												
Platanus nobilis, Ny						(?)						+	+					
Raynoldsii, Ny									+	+			+					
Haydenii, Ny								+	+	+			+					
heterophylla, Ny													(?)					
Guillelmæ, G	+			+	+			+		+						+		+

Table of distribution of the species of fossil plants from the Tertiary formations of North America—Continued.

Name of species.	Miocene.			Upper Eocene.				Lower Eocene.									Europe.	
	Green River, &c.	Elko Station.	South Park.	Washakie group.	Carbon Station.	Evanston.	Sage Creek, &c.	Raton Mountains.	Golden, &c.	Black Butte.	Spring Cañon, six miles above.	Elk Creek, Yellowstone Lake.	Fort Union.	Mississippi.	Alaska.	Arctic.	Eocene.	Miocene.
Platanus aceroides, G				+	+	+					+					+		+
Coccoloba lævigata, s. n					+													
Laurus, primigenia, U											+							+
obovata, W										+								+
pedata, Lx								+						+				
carolinianus, (?) Mx	+																	
Persea lancifolia, Lx														+				
Benzoin antiquum, H									+	+								+
Cinnamomum affine, Lx					+				+					+				+
Mississippiense, Lx					+	+		+	+					+				+
Scheuzeri, H						+	+		+		+				+	+		+
Rossmaessleri, H									+		+							+
polymorphum, H					+													+
Eleagnus inæqualis, Lx														+				+
Banksia Helvetica, H														+				+
Aristolochia cordifolia, Ny													+					
Andromeda Grayana, H						+	+	+							+			
dubia, H														+				+
reticulata, H											+					+		
vacciniæfolia, U														+		+		
species										+								
Diospiros lancifolia, Lx						+									+			
stenosepala, H												+			+			
brachysepala, H										+								+
anceps, H										+								+
Sapotacites Americanus, Lx														+				
Echitonium Sophiæ, (?) Web								+	+							+		+
Viburnum marginatum, s. n										+								
Wymperi, H										+						+		
contortum, s. n										+								
dichotomum, s. n										+								
asperum, Ny													+					
lanceolatum, Ny													+					
Fraxinus denticulata, H											+							

Prunus Carolinianus, Mx														+				
Aralia triloba, Ny													+					
Cornus incompleta, Lx									+									
acuminata, Ny												+	+					
Studeri, H						+												+
rhamnifolia, Web										+								+
Nyssa lanceolata, s. n											+							
Cissus laevigatus, s. n									+									
lobato-crenatus, s. n										+								
Vitis tricuspidata, H										+								+
olriki, H						+										+		
Islandica, H										+						+		
Ampelopsis tertiaria, Lx	+																	
Magnolia, species				+														
Hilgardiana, Lx						+		+						+				
laurifolia, Lx														+				
tenuinervis, Lx								+										
Losleyana, Lx								+						+				
ovalis, Lx														+				
cordifolia, Lx														+				
Inglefieldi, H										+						+		
Asimina Eocenica, s. n					+													
leiocarpa, Lx														+				
Terminalia radobojensis, U								+										+
Eucalyptus Haeringiana, (?) E										+								
Americana, Lx	+																	
MacClintockia Lyallii, H										+						+		
Dombeyopsis trivialis, s. n									+									
occidentalis, s. n									+									
obtusa, s. n								+										
aequifolia, G										+								+
Acer, species		+						+										
trilobatum, H						+												+
var productum, H					+													+
secretum, Lx						+												
Negundo triloba, Ny													+					
Sapundus affinis, Ny													+					
membranaceus, Ny													+					
undulatus, A. B														+				+
caudatus, s. n									+	+								
Aleurites Eocenica, s. n										+								
Ilex affinis, Lx	+																	
stenophylla, U	+																	+
Ceanothus cinnamomoides, Lx	+																	
fibrillosus, s. n									+									
Paliurus Colombi, H				+	+											+		
Zizyphoides, s. n									+	+								
Zizyphus Meekii, s. n					+													
hyperboreus, H					+											+		
Berchemia parvifolia, Lx								+										
Rhamnus elegans, Ny													+					
marginatus, Lx														+				

Table of distribution of the species of fossil plants from the Tertiary formations of North America—Continued.

Name of species	Miocene.			Upper Eocene.				Lower Eocene.							Alaska.	Arctic.	Europe.	
	Green River, &c.	Elko Station.	South Park.	Washakie group.	Carbon Station.	Evanston.	Sage Creek, &c.	Raton Mountains.	Golden, &c.	Black Butte.	Spring Cañon, six miles above.	Elk Creek, Yellowstone Lake.	Fort Union.	Mississippi.			Eocene.	Miocene.
Rhamnus obovatus, Lx						+		+	+									
salicifolius, Lx									+	+								
intermedius, Lx											+							
rectinervis, H						+			+	+	+							+
Dechenii, W										+								+
Cleburni, s. n									+	+								
Goldianus, s. n									+									
var. latior					+				+									
discolor, s. n										+								
acuminatifolius, W									+		+							
deletus, (?) H								+										+
Fischeri, Lx								+										
Tilia antiqua, Ny													+					
Rhus deleta, H						+												+
Evansii, Lx						+												
nervosa, Ny													+					
bella, H											+							
Xanthoxylum dubium, Lx								+								+		
Juglans appressa, Lx						+								+				
Saffordiana, Lx														+				
acuminata, (?) H				+				+							+	+		+
rugosa, Lx				+	+	+		+	+	+	+	+			+			
obtusifolia, (?) H						+												+
thermalis, Lx								+										
rhamnoides, Lx						+			+	+					+			
Schimperi, Lx., and fruit	+								+									
Smithsoniana, Lx								+	+									
Baltica, (?) H										+								+
denticulata, H	+				+						+							
Carya Heerii, E	+																	
antiquorum, Ny						+							+					
Cercis Eocenica, s. n									+									
Cassia concinna, H						+												+
phaseolites, U											+						+	+

Calycites polysepala, Ny													+					
hexaphylla, s. n						+												
Phyllites venosa, Ny													+					
carnosa, Ny													+					
cupanioides, Ny													+					
truncata, Lx														+				
sulcata, Lx				+														
Carpolithes lineatus, Ny													+					
palmarum, Lx						+		+	+	+								
cocculloides, H					+	+			+									
falcatus, s. n										+						+		
arachioides, s. n						+												
osseus, s. n											+							
spiralis, Lx								+										
compositus, Lx								+										
Mexicanus, Lx								+										

This table enumerates three hundred and ten species; that of the former report, established from the species published formerly by myself from the Eocene of Mississippi and Tennessee, later, from the specimens which Dr. Leconte had obtained in exploring the Lignitic of Colorado and New Mexico, and also with the species described by Dr. Newberry from Fort Union, &c., had only one hundred and eighty species. The addition to the flora of the North American Tertiary formations amounts, therefore, to more than one hundred species. Of these, sixty-one are new forms, and forty-two had not as yet been recognized in our Tertiary flora, though published from other countries. The large number of new species is explained in considering the age of the formation where most of them have been obtained; that is, in strata which pertain to the Lower Eocene at Golden and at Black Butte. The flora of this formation is as yet little known to European paleontologists.

Considered merely in a botanical point of view, a number of these new species of ours are of marked interest. In the class of the Lichens one species, *Opegrapha antiqua*, is the first of this family which has been found as yet in the old Tertiary formation. Eight species of Lichens have been mentioned by Göppert as recognized in the amber, and three upon the bark of Lignitic wood of the Upper Tertiary of Germany, but none of them have been described, apparently on account of the insufficiency of specific characters. These are, however, recognizable in the Black Butte species. This discovery, together with that of two species of *Spheria* and one of *Sclerotium* in the same Eocene formation, proves that the scarcity of fossil cryptogamous plants of a lower order does not indicate the absence of these vegetables at the former epochs, but is due to the maceration which soon destroys the soft cellular tissue of these plants. In the ferns, the list reports from South Park one species of *Ophioglossum*, a fine genus which was as yet known, in a fossil state, by a single species from the Upper Tertiary of Italy. In the Conifers we have a new *Sequoia*, whose relation to *Sequoia gigantea*, the California big tree, is, by its leaves at least, more intimate than that of any fossil species of this genus; a *Thuya* which claims our *T. occidentalis*, not as a relative, but rather as a mere variety; then an *Abies*, which comes to our *Abies Canadensis* in about the same degree of affinity. These three species belong to the Green River or Upper Tertiary formation. From the Lower Eocene we have two species of the same genus *Abies*, whose characters are at variance with those of any species of Conifers known as yet, either living or fossil. One species of *Salisburia*, *S. polymorpha*, already known from specimens of Vancouver Island, merits also to be remarked among the Tertiary Coniferous species as positively fixing the Eocene age of the Lignitic of that island. In the *Glumaceæ* the Lower Eocene has a fine species of *Carex*, *C. Berthoudi*, found with its seeds; in the Palms, new species of *Sabal* and *Flabellaria*; in the *Spadicifloræ* two stems, *Caulinites*, with their fruits, all from Golden and Black Butte. Higher still in the vegetable series we note a splendid *Myrica*, *M. Torreyi*, with its seeds; the bracts of *Betula Stevensoni*; a peculiar form of oak, *Quercus platania*, Heer, with a variety distinct enough to be considered as a species; a number of new species of *Ficus*, one represented with leaves, branches, and fruits; a *Coccoloba*, three new forms of *Viburnum*, one of them exposing by its numerous leaves and its fructifications the characters of three species of our present flora; leaves of *Cissus* and *Vitis*, of *Asimina*, *Dombeyopsis*, *Sapindus*, *Rhamnus*, *Cassia*, &c., all represented by numerous and well-preserved specimens. With the leaves some still more remarkable fruits, *Carpolites*, whose affinity is unkown as yet; especially that from Evanston—*C. arachioides*—represented by bunches of fructification resembling the common pea-nut.

The exposition of the general characters of our Tertiary flora, as indicated by the nomenclature of a number of its species, is, however, far less interesting and important than the documents furnished by the table for definitively solving the question of the age of the formations which the vegetable remains represent. I shall now use these documents especially as a final summary of the arguments in favor of the assertion that the Lignitic of the Rocky Mountains is, in its whole, an Eocene formation.

1st. No section is marked in the table for the comparative distribution of the Cretaceous flora, for the good reason that it represents the same group of the Cretaceous, and that as yet not a single one of its species is recognized as identical or even positively allied to any of our Eocene.

2d. The table has in the Eocene division a number of fucoids or marine plants, eight species; and, too, a proportionally large number of palms, all vegetables, which are not only homologous or identical in forms to fossil species of the European Eocene, but which, taken altogether, constitute two groups characteristic of the Lower Tertiary, and of which not a single representative, as yet, has been found in connection with a true Cretaceous formation.

3d. The same may be said of some species marked in the same division; one *Fern*, one *Myrica*, one *Quercus*, one *Cassia*, &c., identical with species admitted in Europe as positively Eocene.

4th. Of the species enumerated from the Raton, Golden, Black Butte, and Spring Cañon, a large number are allied to Eocene species, as, for example, *Cinnamomum affine*, *C. mississipiense*, species of *Ficus*, of *Ceanothus*, *Dombeyopsis*, &c., and, considered in its essential groups, *Ficus*, *Laurus*, *Cinnamomum*, *Viburnum*, *Cissus*, *Magnolia*, *Dombeyopsis*, *Sapindus*, *Rhamnus*, *Juglans*, *Cassia*, &c., the whole flora bears a facies which, if not positively comparable to that of the European Eocene, on account of the scantiness of this flora, has, however, a marked analogy to that of the Lower Miocene. As the characters, either separately, for a number of species, or generally, in considering the facies of the groups, are identical in all the strata which we have considered as Eocene, it is evident that neither Black Butte nor any other locality can be separated as from a different epoch, and that, therefore, no member of the American Lignitic, as far as this formation is known by its vegetable remains, can be referred to the Cretaceous. An exception to this conclusion is claimed for two localities, Bear River and Coalville, wherefrom no fossil remains of land-plants have as yet been obtained. But I do not see how the separation could be made for strata which contain an abundance of Eocene fucoidal remains, and whose thick deposits of lignite indicate evidently, for the time, a land formation of exactly the same nature as that of the other localities. The lignite matter, indeed, by its degree of decomposition, its chemical compounds, all its characters, bears evidence of its origin by the same kind of land vegetation, and, therefore, of its contemporaneity. On another side, the North American Eocene is considered by European paleontologists, from the character of its flora, as related to the Miocene formation. It is, therefore, convenient to look further into the documents offered by the table in regard to this last opinion.

The proportion of species, of what is considered our Miocene flora, as marked in the first three sections, is, with that of the Arctic, 11½ per cent.; of the European Miocene, 39 per cent. Our Upper Eocene has

13⅕ per cent. of its species in common with Alaska, 20¾ per cent. with the Arctic flora, 40 per cent. with the Miocene; and our Lower Eocene has only 8¼ per cent. of its species in common with the Alaska, 10⅝ per cent. with the Arctic, and 25 per cent. with the European Miocene. Or counting the species of Alaska, Arctic, and Miocene of Europe as Miocene, the relation of the American Tertiary flora with this formation of Europe is, for the Miocene, 47¾; the Upper Eocene, 57⅓, and for the Lower Eocene, 37 per cent.

This comparison, somewhat unreliable on account of the greater or less degree of affinity of a few species, may be, however, admitted in full confidence for our purpose, and proves that the flora which we consider as representing our Miocene, that of Green River, Elko, and South Park, does not bear to that of Europe a marked analogy by its forms. These, indeed, appear of younger type, more intimately related even by identity to species of our time. The flora of the group marked as Upper Eocene has, *per contra*, the greatest analogy to that of the European Miocene by the identity of its most common species of *Populus*, *Quercus*, *Ulmus*, *Betula*, *Platanus*, *Fagus*, &c. It may be that farther researches may force a separation of this group from the Eocene, though as yet there is no apparent line of division, either in the measures or in the distribution of the flora. I believe that the discrepancy is merely apparent, resulting from and indicating a precedence in time of our botanical types over those of Europe. This fact has already been remarked upon in considering the flora of the Carboniferous formations, and it becomes the more evident as the history of the old vegetable world is better known. The relation of the Lower American Eocene to the Miocene of Europe, 37 per cent., does not indicate a difference more marked than could be expected between the flora of two members of the same formation; and the difference, too, is becoming more and more definite, and will continue in the same way as far as the acquaintance with our fossil flora is more intimate. The most common species of fossil-plants are not only found over wide areas, and therefore collected from all the explorers, and in numerous specimens; but they pass through the different stages of the formations. The first researches bring them to view from everywhere; the selection, however, becomes more discerning and exclusive in proportion to the amount of materials supplied for comparison.

On the question of the distribution of Tertiary fossil species in regard to climatic circumstances, the table does not show anything more than what has been observed from that of the former report. The relation of our Upper Eocene flora with that of Alaska and Greenland is well defined, while the vegetable types of the Lower Eocene are rather tropical than Arctic. It is then possible that the characters which I have considered as resulting from climatic influences have a relation to difference of age of the formations. If it is the case, we may expect to find the flora of the Lower Eocene with the same southern types from Vancouver Island to the Mississippi, while the Arctic facies may predominate in the Upper Eocene from Greenland to the same southern latitude.

This important question of the regulation of Tertiary groups of vegetables according to their geological stations, or to climatic influences, cannot be settled without long researches. Some species of the Lower Eocene appear to have, with types of the present flora of Cuba, a relation which has not been recognized before. Such are forms of *Flabellaria* and *Calamopsis; Myrica Torreyi*, compared to a *Lomatia;* a group of *Ficus*, represented by *Ficus planicostata*, *F. Clintoni*, *F. spectabilis*, *F. corylifolia;—Cissus lævigatus*, *Aleurites Eocenica*, and the group of *Rhamni; R. obovatus, R. Cleburni, R. Goldianus*, &c., with multinerve leaves comparable to those of some *Bridelia*. The points of analogy are not precise; they are merely recorded for directing further researches.

Description of species of fossil-plants from the Cretaceous of Kansas.

The specimens from which the following species are described were obtained by myself from two localities: 1st. From nine miles above Salina, in the Salina Valley, where I was kindly directed by Professor B. F. Mudge, of Manhattan College. 2d. From six miles south of Fort Harker, where specimens of fossil-plants are found in abundance, but over a limited area. This locality was discovered and first explored by Mr. Charles Sternberg, who resides in the vicinity, and who a few years ago presented fine specimens from it to the Smithsonian Institution. Some of these specimens have been previously used for description, especially of *Sassafras*, there represented in a multitude of forms. The vegetable remains are found at both these places, as also east of Fort Harker, in a hard, more or less soft-grained, shaly, red, ferruginous sandstone, a member of the Dakota group of Messrs. Meek and Hayden. The number of specimens, generally fine, is large, proportionally to the number of species which they represent.

ZONARITES DIGITATUS, Brgt.

Frond flat, dichotomous, branches of the same size or broader than the main axis, diverging in acute angles, linear, entire, obtuse, slightly enlarging upward.

The divisions or branches of this species are somewhat broader than in the specimen figured and described by Brongniart, Veg. Foss., p. 61, Pl. ix, Fig. 1. The whole frond, as preserved, is 9 cent. long, its base slightly narrowed, the divisions 1 cent. broad, the angle of divergence about 30°.

I have already remarked that the relation of this form to other kinds of vegetables is not as yet ascertained, Schenk considering it as a fern. This supposition is inadmissible on account of the connection of these remains with animal, deep marine fossils. I am even uncertain if it represents a vegetable form, and would rather consider it as a sponge. It has, indeed, a punctate or perforated-like surface, an appearance which, however, may be caused by the porous compound of the stone. I found it about 100 feet above the red shale of the Dakota group in a shaly limestone especially formed of large shells of the Fort Benton group.

HYMENOPHYLLUM CRETACEUM, *sp. nov.*

Frond linear-lanceolate, bipinnately divided; pinnæ slender, from a narrow, smooth, convex rachis; wedge-form, erect, alternately lobed.

The lobes are small, truncate at the top, cuneate to the base, the nervation dichotomous, one branch ascending to the point of each lobe. It resembles *Sphenopteris furcata*, Brgt., of the Carboniferous measures. *Sphenopteris corrugate*, Newb., is apparently described from a small fragment of this species.—Fort Harker.

GLEICHENIA KURRIANA (?) Heer, Mol. Fl., p. 6, Pl. ii, Fig. 3.

Frond pinnate; pinnæ linear, long, pinnately lobed; pinnules connate at base, alternate, oblong, obtuse; nervation pinnate; secondary veins alternate, the lower ones forking above the middle, the upper ones simple.

Though this form is very much like that published by Heer, (*loc. cit.*,) from the Cretaceous of Moletin, it differs in some points. 1. The pinnules are connate to one-fourth of their length; they are larger, more obtuse, and the secondary veins are forked. In the specimens from Moletin, the pinnules are separated to the base and have no trace of secondary veins. A small specimen published by the same author from Quedlinburg, Pl. i, Fig. 3, shows, however, the pinnules connate, as in the American form, with secondary veins figured simple. The fragment indicates a smaller form; not separable, however, from mere difference of size. I consider it, therefore, as representing the same species. As Heer has figured a specimen with fructifications, a fructified specimen of our plant may decide the question of identity.—Fort Harker.

SEQUOIA REICHENBACHI, Heer, Mol. Fl., p. 8, Pl. i, Fig. 2–3.

The specimen represents a cone cut vertically, and thus exposing a narrow axis on which are attached horizontally, linear or narrowly ovate receptacles, attenuated at both ends, containing a small oblong seed separated by foliaceous scales. The form of the cone is the same as that of both those which are represented by Heer's figures, (*loc. cit.*) It is only slightly longer and narrower, and the receptacles of the seeds more closely approached to each other. The specimen does not bear any remains of leaves of Conifer, but small round, smooth branches, apparently referable to the same species.—Fort Harker.

CAULINITES SPINOSA, *sp. nov.*

Stem or branch cylindrical, 1½ cent. in diameter; its surface marked by small irregular points or depressions, resembling scars of scales; it bears apparently strong spines; one of them is marked, going out of the stem at right angles. Its scars are left in round holes through the stone. The spines and the stem, too, enlarge to the point of attachment.—Fort Harker.

LIQUIDAMBAR INTEGRIFOLIUS, Lsqx., Amer. Jour. Sci. and Arts, July, 1868, p. 93.

I found at Salina three leaves of this species. They vary in size, and also in the more or less pointed form of the lobes, and in their direction, one specimen showing the lower divisions turned downward rather than horizontal.

POPULITES FAGIFOLIA, *sp. nov.*

Leaf elliptical, entire, subcoriaceous, tapering from the middle to a slightly obtuse point, narrowed to a thick petiole; pinnately veined; secondary veins numerous, parallel, craspedodrome.

The thick petiole is broken near the base of the leaf, which tapers to it. The general form is that of *Populus mutabilis*, the leaf being enlarged in the middle, and tapering upward and downward about in the same degree. It is 10 cent. long, 8 cent. broad, with eight pairs of secondary veins, the lower ones dividing outside, all the veins and divisions entering the borders. The leaf is thickish but not quite coriaceous.—Fort Harker.

POPULITES SALINÆ, *sp. nov.*

Leaf large, thickish, membranaceous, smooth, broadest near the base, truncate or subcordate, narrowed into an obtuse point, five-nerved from its base; borders regularly undulately lobed.

A splendid leaf, preserved entire except the petiole. It is 12 cent. wide, only 10 cent. long, triangular in outline, with the base subcordate and the borders regularly obtusely undulate-lobed. The nervation is in five primary veins from the base, all much divided, passing with the principal divisions to the point of an obtuse lobe, anastomosing with thick perpendicular nervilles. The medial nerve is pinnately divided from above the middle in three pairs of secondary veins. This form is remarkable, and unlike any leaf known to me; it has, however, a distant relation to the leaf published as *Acer obtusilobum*, (?) Ung., in Amer. Jour. Sci. and Arts, July, 1868, p. 100. Another specimen referable to this species, but broken, indicates the leaf as coriaceous, and has the nervation more distinct, much like that of a *Platanus.*—Salina Valley.

POPULITES AFFINIS, *sp. n.*

Leaf round-quadrangular, thickish, membranaceous, rounded to the petiole, abruptly narrowed to a short point, with undulate-dentate borders; nervation pinnate, craspedodrome.

This leaf is much like the one which I have described as *Populites cyclophylla*, (?) Heer, in Amer. Jour. Sci. and Arts, July, 1868, p. 93, differing, however, by its square form, its undulately distantly dentate borders, its secondary veins less numerous and more divided. The fibrillæ are distinct and the areolation alike.—Salina Valley.

FICUS STERNBERGII, *sp. n.*

Leaf large, thick, coriaceous, entire, broadly oval, obtusely pointed, (?) (point broken,) tapering to the petiole; nervation pinnate, thick, coarse, camptodrome.

The leaf, destroyed in part, measures about 16 cent. in length, 9 to 10 cent. in width, has entire undulate borders and the nervation of a *Ficus.* The lowest secondary veins, from a distance above the base, are opposite, ascend in a more acute angle than the upper ones, (six pairs) which are alternate and more distant from the basilar pair, all much divided by tertiary veinlets, or thick fibrillæ, anastomosing in bows along the borders.—Fort Harker.

SASSAFRAS CRETACEOUS, Newb.

I have studied this form upon a large number of specimens, especially at Fort Harker, where it is predominant. It varies, in the size of the leaves, from 4 to 14 cent. long, without counting the petiole, which is, according to the size of the leaves, from 3 to 5 cent. long. Two forms are especially recognizable as varieties, with intermediate characters: one with narrower, more pointed, less diverging lobes; the other with broader, more obtuse, more diverging divisions. The nervation is the same, generally deep and coarse; the borders are more or less marked with a few short teeth, especially on the lower sides of the lateral lobes. The following-described forms may be considered as species, not only on account of their characters, but also from their local distribution:

SASSAFRAS MUDGII, Lsqx., Amer. Jour. Science and Arts, July, 1868, p. 99.

The description is right. This species is found at Salina only. I have not seen it represented by specimens from Fort Harker.

SASSAFRAS MIRABILIS, *sp. nov.*

Leaves large, coriaceous, three-lobed, lobes diverging nearly in right angles to the medial nerve, proportionally short, obtuse; nervation very thick.

Beside the large size and broader lobes of the leaves, the species differs by the lobes of the leaves being more or less deeply cut or undulate-dentate, with obtuse teeth. I have an entire leaf of this species, measuring 23 cent. broad, 16 cent. long, without the petiole, which is 6 to 7 cent. in length. Though the nervation is of the same type as in *S. cretaceus*, the primary veins are twice as large, the lateral curving outside and diverging from the medial one. It has somewhat the appearance of leaves of *Platanus*. It is apparently an incomplete specimen of this kind which has been named and described as *Platanus latiloba* by Dr. Newberry.—Fort Harker.

SASSAFRAS OBTUSUS, Lx.

Leaves small, obtusely and equally three-lobed to below the middle; cuneate-narrowed to the long petiole; lobes oblong, very obtuse; nervation trifid from above the base.

The leaves of this species are proportionally small, of a thinner substance, with secondary veins, narrow, straight, ascending to the border of the lobes, and secondary veins thin, mostly camptodrome, parallel. In one specimen the lateral lobes are cut in one short, obtusely-pointed lobe, entered by one of the secondary veins; but in all the other specimens the secondary veins are mostly camptodrome, simple, and the lobes entire. In report 1871, p. 303, I considered this species as the same as the leaf which I had named *Populites Salisburiæfolia* in Amer. Journ. Science and Arts, July, 1868, p. 94. It, however, differs by the more marked and diverging entire obtuse lobes, and by the secondary camptodrome nervation. In this new species of Sassafras the lateral secondary veins are pinnately marked on both sides of the veins. In *Populites Salisburiæfolia* the lateral veins divide on the outside only.—Salina Valley.

SASSAFRAS RECURVATUS, *sp. nov.*

Leaves of medium size, thick, coriaceous, enlarged upward, divided to below the middle in three lanceolate-pointed, long lobes, the external ones scythe-shaped outside, three-nerved from the point of the petiole.

Somewhat like the small forms of *S. mirabilis*, differing evidently, however, by narrower, longer, obtusely-pointed lobes, by the primary nervation from the top of the petiole, and by the lateral veins dividing near the base in two nearly equal strong branches, one ascending to the point of the lobes, the other following the border and anastomosing in a curve with the upper secondary veins. Sometimes this outer division of the lateral veins seems to curve backwards and enter another inferior lobe. But this appeareme is remarked only upon one specimen broken at the sides, and whose form can merely be surmised from the direction of the veins.—Fort Harker.

SASSAFRAS HARKERIANA, *sp. nov.*

Leaves proportionally small, thick, coriaceous, cuneiform, or narrowed to the petiole, round-truncate from above the middle, three-lobed, with obtusely-pointed, very short lobes, and undulate-dentate borders between them.

The leaves are thicker and larger than in *S. obtusus*, 9 cent. broad and as long, three-nerved from above the base, deeply veined; the secondary veins camptodrome, except a few, which pass into short teeth between the lobes.

LAUROPHYLLUM RETICULATUM, *sp. nov.*

Leaves long, linear-lanceolate, thick, coriaceous, entire, tapering to a thick, short petiole; medial vein broad, secondary veins open, numerous, anastomosing in an irregular reticulation from above the base; camptodrome.

These leaves resemble those of some species of *Laurus* by their form, their texture, and the thick medial nerve; the nervation, however, is of a different type. The secondary veins numerous, close to each other at unequal distance, often intermixed with shorter veins, curve and anastomose from near the base in irregularly polygonal small meshes, ascending with their ramifications to the borders, and curving along them. Professor Heer has in his Flora of Moletin a species *Myrtophyllum Geinitzi*, which has the same form of leaves, but a different nervation, the upper end of the veins following the borders and uniting as a kind of marginal veinlet. This character is not remarked in our leaves, of which I have many specimens with distinct nervation.

It is remarkable, that this Cretaceous Flora of Moletin, which is known as yet by eighteen species, has one *Aralia*, one *Credneria*, one *Gleichenia*, and one *Sequoia*, or four species, which are, if not identical, at least intimately related to species of our Cretaceous.

All the specimens of this species are from Fort Harker.

PLATANUS HERII, Lsqx., Rept. 1871, p. 303.

Beside the form, whose characters have been described, there is from Salina a leaf preserved entire, which differs by more acute lobes and its apparently membranaceous consistence.

PTEROSPERMITES QUADRATUS, Lsqx., Rept. 1871, p. 301.

A number of specimens from Fort Harker, varying in size, confirm the description of this fine species. The undulations of the leaves appear more generally as short, distant teeth, entered by the point of the secondary veins and their divisions.

PTEROSPERMITES STERNBERGII, *sp. nov.*

Leaves large, thick, coriaceous, ovate, tapering into an obtuse point, round cordate at base; borders entire, or slightly undulate.

A splendid leaf, 23 cent. long, 20 cent. broad, deeply pinnately nerved; secondary veins more open than in the former species, with two or three pairs of simple, smaller basilar veinlets, inclined downward, or at right angle from the medial nerve; the other 10 to 11 pairs above are parallel, the lowest branching twice, the upper ones simple, all craspedodrome.

This species, like the former, are referable to the genus *Credneria*, one species of which, *Credneria Leeonteana*, Lsqx., is related to this. The description of *Credneria Leeonteana*, as given in Amer. Jour. Sci. and Arts, July, 1868, p. 98, answers exactly the description and figure of *Credneria maerophylla*, Heer, in Mol. Fl., p. 16, Pl. 4. Only one of the basilar veinlets is marked on my figure of this species, representing our best, though incomplete, specimen; but the description remarks the position of two lower secondary *pairs of nerves*, as observed from other specimens, and which indicate *the essential character of the leaves of the genus Credneria.*—Fort Harker.

PTEROSPERMITES HAYDENII, Lsqx., Rept. 1871, p. 302.

A good specimen of this species has been found at Fort Harker. It answers in every point the description of this species, *loc. eit.*

PTEROSPERMITES RUGOSUS, *sp. nov.*

Leaves rather small, coriaceous, rough and wrinkled on the surface, triangular oblong in outline, truncate obtuse to the base, obtusely pointed, medial nerve very thick, overlapped at its base by the undulate borders.

The leaves vary, at least in our specimens, from 9 to 12 cent. long and 6 to 9 cent. broad. The nervation is that of the genus, three pairs of thinner basilar veins passing horizontally, or in a downward direction, to the borders. The secondary veins above are thick, emerging at an open angle of divergence from the medial nerve, branching outside and curving upward in ascending to the point of an obtuse lobe, or the enlarged middle of the leaves. The strong nervilles, deeply impressed into the stone, give to the leaves of this species a peculiar appearance.—Salina Valley.

CONCLUSION.

From this enumeration of Cretaceous fossil-plants, it appears that in the twenty-three mentioned species, fourteen are considered as new; three as identical with some ones already described from Europe, but not as yet discovered in our Cretaceous strata; and six have been formerly described from the same Dakota group. It is thus an addition of seventeen species to the American Cretaceous flora, which now has about one hundred and twenty so-called species.

The remarks made in the first part of this paper, in regard to the analogy of some vegetable forms of our Cretaceous with those of plants of our time, and also of the Miocene flora of Europe, are rather confirmed than eliminated by the descriptions of these species. They represent especially forms of *Sassafras*, *Pterospermites*, *Populites*, with *Sequoia Reiehenbaehi*, two ferns, &c. Considering the relation of the Cretaceous groups, enough has been said already in this and in the former report. I wish only to record once more the geological evidence afforded by the remarkable disconnection of the American Cretaceous flora from that of the Eocene. Both these formations are now represented by a number of species large enough for a reliable comparison, which, made by any palaeontologist, proves that there is not a single species, either identical or in intimate relation, in both the Cretaceous and the Eocene flora of our continent. Even that fucoidal plant described as *Fueoides digitatus*, is not related whatever to any of the marine species described from the

Eocene sandstone, though the characters of marine vegetables appear to have been preserved somewhat longer in the series of geological divisions. Such a total discordance of types cannot be supposed for a flora of a same period, not even for members separated by a great thickness of strata. Most of the genera of animal fossils, and a large number of species, too, are represented in all the Cretaceous divisions, from the lowest member to the base of the Eocene. In the Tertiary formations the vegetable types represented by most of the genera, and by a large number of species, too, are recognized identical in the whole extent of the measures. The same remark can be applied to the vegetable and animal remains of all the formations. It is, then, judicious to admit as a conclusion, that such a marked disconnection of the typical character of a whole flora is a positive evidence of a new geological period, and that, therefore, the whole Lignitic of the Rocky Mountains is, from the base of the fucoidal sandstone, a Tertiary-Eocene formation.

PALEONTOLOGICAL REPORT.

BY

F. B. MEEK.

NOTE.—The author was prevented by sickness from superintending the printing of this report, and is under obligations to others for the reading of the proof.

PRELIMINARY PALEONTOLOGICAL REPORT,

CONSISTING OF

LISTS AND DESCRIPTIONS OF FOSSILS,

WITH REMARKS ON THE

AGES OF THE ROCKS IN WHICH THEY WERE FOUND, ETC., ETC.

By F. B. MEEK, Paleontologist.

GENERAL REMARKS.

SILURIAN AGE.

East side Gallatin River, &c.—All of the Silurian fossils collected by the survey, during the explorations of 1872, evidently came from comparatively near the base of the system. The specimens from the east side of Gallatin River, above Gallatin City, Montana, were collected from four subdivisions. Those from the lowest or fourth subdivision, (numbering from above,) are few, and in a fragmentary condition. Among them we have one of those curious bodies formerly sometimes called bilobites, apparently under the erroneous supposition that they have some relations to the crustacea known as trilobites, though they are now generally regarded as marine plants, and designated by the generic name *Cruziana*, d'Orbigny, (Rusophycus, Hall.) Along with this fossil were found imperfect specimens of *Lingula*, or *Lingulepis*, *Conocoryphe*, *Bathyurus*, &c., which, when taken together, point to a rather low position in the series, especially in view of the forms that occur in the succeeding subdivisions above.

From the third and second subdivisions, occurring successively above, we have the genera *Acrotreta*, *Hyolithes*, *Agnostus*, *Conocoryphe*, *Bathyurus*, &c., a group of types which, in the present state of paleontological science, could hardly be expected to occur *together*, higher in the series than the Quebec group of the Canadian survey. And, when we take into consideration the entire absence among these collections of any type elsewhere *peculiar* to any higher horizon, and the fact that several of the species are closely allied to forms found in rocks of that age, we feel quite safe in referring these beds to the Potsdam, or Primordial zone.

Big Horn Mountain.—The same may probably be said of the rocks from which a few fragments of *Conocoryphe* and *Dikelocephalus* were collected on the west face of Big Horn Mountain.

The few specimens from the first or upper of the subdivisions at the locality referred to above Gallatin City, are in a fragmentary condition, but from the position of this subdivision above the others, as well as from the character of the fossils, and the similiarity of the rock in texture and composition to beds to be mentioned below at another locality of the age of the Quebec group, it probably belongs to that horizon.

Malade City.—The collections from Malade City, Northern Utah, include the genera *Camerella*, *Orthis*, *Euomphalus*, *Agnostus*, *Conocoryphe*, *Bathyurellus*, *Bathyurus*, *Asaphus*, and perhaps *Dikelocephalus*, most of which are common to the Potsdam and Quebec groups; but from the affinities of most of the species and the actual identity of others with Quebec forms, it appears quite clear that these beds belong to that horizon, as stated by Professor Bradley in the Am. Jour. of Science. Two of the species of *Euomphalus*, for instance, seem to be identical with forms described by me some time back among Mr. King's collections from Muddy Creek, Utah, and referred to the horizon of the New York Calciferous group; generally regarded as representing in part, at least, the Quebec; while a species of *Camerella* and one of *Orthis* seem to be identical with Canadian species of that age. *Bathyurus Saffordi*, a Canadian Quebec species, is also represented among these collections by specimens agreeing exactly with authentic examples of the same, sent from that horizon in Canada. Several of the other genera are represented by species most nearly allied to Quebec forms.

Flat-Head Pass.—A few specimens from Flat-Head Pass, Montana, consisting of fragments of *Bathyurellus*, and perhaps *Dikelocephalus*, seem also to be of the same age as the above, judging from the occurrence among them of *Dikelocephalus? truncatus*, one of the. Malade species.

CARBONIFEROUS AGE.

Mystic Lake, &c.—The fossils from the outlet of Mystic Lake; Cañon, east side of Madison River; Bridger Peak, near Fort Ellis; Black-Tail Deer Creek; north side Gros Ventres Butte; Flat-Head Pass; north side Henry's Lake; and Cañon west of Gallatin River, (all in Montana,) and Camp 19, Idaho, all evidently came from the same geological formation, a considerable portion of the species being common to several of these localities. They belong, without exception, to genera that are common both to the Carboniferous and Devonian, while a smaller proportion of the genera are also represented even in the Silurian. That these fossils are not of Silurian age, however, is obvious at a glance; but as most of the species are either new, or, owing to the state of preservation of the specimens,* not in a condition to be certainly identified with known forms, almost the only guides we have in determining whether we should refer them to the Carboniferous or Devonian are the absence of certain genera and the general specific affinities of the entire group of forms. Some of the *Producti*, *Chonetes*, and *Spirifer* have rather a Devonian look, while a very finely striated *Hemipronites* is very similar to some of the Devonian types of that genus. Even the form I have referred to, *H. crenistria*, is quite as nearly like some varieties of *H. Chemungensis* (*Streptorhynchus Chemungensis*, of the 4th vol. Paleont., N. Y.,) from the Chemung and Hamilton groups of the New York Devonian, as it is like the Carboniferous forms of *H. crenistria*. According to Mr. Davidson and others, however, *H. crenistria* occurs in both the Carboniferous and Devonian of Europe, while the New York form, *H. Chemungensis*, differs *very* little from some varieties of *H. crenistria* from the Carboniferous.

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* These collections consist mainly of separate valves of brachiopoids, imbedded in hard limestone.

Notwithstanding the resemblance of some of these fossils to Devonian forms, and the fact that scarcely any of the species can be identified beyond doubt with forms peculiar to the Carboniferous, I must regard the whole as belonging to the lower part of the lower Carboniferous. It is extremely improbable that in a collection containing so many brachiopods there would be no *Atrypa*, *Strophodonta*, Pentameroid, and other Devonian and older types, if the rock belonged to the Devonian. The entire absence of any strictly Devonian and older types of corals, crinoids, Lamellebranchs, &c., also favors the conclusion that this formation belongs to the Carboniferous, which conclusion is also supported by the specific affinities, if not even by the specific identity, of some of the species of *Spirifer*, *Productus*, *Chonetes*, *Retzia*, &c.

In looking over the collections from these localities, I have been impressed with the similarity of their general facies (without being quite sure that any of the species are identical) to the fauna of the Waverly group of Ohio, now known to belong to the Carboniferous. At the same time that I would refer the beds from which these fossils were obtained to the Carboniferous, it should be remarked that we have every reason to believe that they belong to a lower horizon in the series than those from which nearly all of the collections from "Old Baldy," Montana, were obtained; also, than the fossiliferous beds on the divide between Ross Fork and Lincoln Valley, Montana.

Lyon Hill.—The fossils from Lyon Hill, Ophir, East Cañon, Utah, are of Carboniferous age, but it is not possible to determine, owing to the small number and imperfect condition of the specimens, the particular horizon in that system to which they belong.

Swan Valley.—A few specimens from Swan Valley, Idaho, have been placed provisionally in the Carboniferous list, but they are very fragmentary and difficult to make out, and may belong to rocks of some other age.

Between Ross Fork and Lincoln Valley.—The species from the divide between Ross Fork and Lincoln Valley, marked with an asterisk in the list, are nearly all very small fossils, and occur crowded together in such great numbers that all the specimens in the collection (including many individuals of some species) were broken from a few fragments of the matrix, perhaps altogether not more than one-tenth of a cubic foot in volume. Some seven or eight of the thirty-two or thirty-three species thus found, seem to be in all respects, so far as the specimens afford the means of comparison, identical with forms occurring at the celebrated Spergen Hill locality, near Bloomington, Indiana, while five or six others, if not more, may be only varieties of Spergen Hill species; and nearly all of the remainder belong to genera found at that locality, and so closely resemble in their small size and other characters, that they may be regarded as representative forms.

The occurrence of so many apparently identical and representative species of such a peculiar group of pigmy forms, all crowded together in the same way, at these two widely separated localities, is certainly a very remarkable and interesting fact; and one, too, so far as yet known, without a parallel in all of our American rocks. It is all the more curious because not a single species of these little fossils has hitherto been identified from any intermediate locality west of Iowa and Missouri, and even there the few species that have been found generally occur isolated among larger species. In comparing two collections of such peculiar fossils from localities so remotely separated, many interesting questions bearing on the geographical distribution of species naturally suggest themselves. Adopting the view that each species, in all cases, originated at some single locality, and thence distributed itself over the world wherever we now find its remains, and admitting that a part of these little shells, at the two localities, are really exactly identical, specifically, it may be asked, were these species created somewhere in the bottom of the old Carboniferous sea, at or near the Indiana locality, from which they migrated 1,200 to 1,500 miles to the northwestward; or, was the reverse the direction of their distribution? Such questions are, of course, far more easily asked than answered; but if we do not admit that there were distinct centers of distribution for species, it would seem more probable that these forms originated at some intermediate point, (where the strata, containing their remains, are now beneath thousands of feet of more modern rocks,) and migrated thence southeastward and northwestward to the two remotely separated localities.

Professor Edward Forbes maintained that, to find the same group of fossils at two distantly separated localities, as in this case, so far from proving that the rocks are exactly contemporaneous, as often supposed, demonstrates exactly the reverse; or, in other words, that time enough must have intervened between the deposition of the strata at the two localities, for the migration of the species of fossils through all the intermediate distance. However this may be, there is little reason to doubt that in such cases the rocks occupy very nearly the same relative horizons in the series of their respective districts, whatever may be the differences between their actual ages. Hence, I regard the bed from which these little fossils were obtained in Montana as representing the Saint Louis limestone of the Lower Carboniferous series of the Mississippi Valley, to which horizon the Spergen Hill beds are known to belong. It is also evident that the physical conditions affecting animal life must have been very similar at these localities during the deposition of the strata in which these fossils occur, although, lithologically, the rocks are quite different, that in Montana being a bluish-gray, somewhat crumbling semi-crystalline limestone; while that at Spergen Hill is a light-colored oolite mass.

"*Old Baldy.*"—The collections from "Old Baldy," near Virginia City, Montana, present a group of forms that could only, in our present state of knowledge, be referred to the Lower Carboniferous series. The presence among them, however, of such coal-measure types as *Athyris subtilita*, *Pleurotomaria sphærulata*, *Astartella Newberryi*, &c., with the affinities of other species, point to a high position in this lower series; while the occurrence in the same association of *Pentremites Godoni* and *P. symmetricus*, or very closely allied representative forms, together with the affinities of other types, show that their position is that of the Chester beds (or possibly of the Saint Louis limestone) of the Mississippi Valley.

A single species, however, *Strophomena analoga*, Phillips, from the same locality, would indicate that lower members of the series probably also exist there, as this species, if I remember correctly, is not known to occur above the horizon of the Burlington beds, in the Carboniferous series of the Mississippi Valley. There is thickness enough, however, of Carboniferous strata, at these distant northwestern localities, for this whole system of rocks to be developed there.

The collections from this and some of the other localities in Montana contain the first specimens of the genus *Pentremites* I have ever seen from any localities west of Missouri and Iowa.

JURASSIC AGE.

Lower Cañon of Yellowstone.—The collections from the Lower Cañon of the Yellowstone, the lower beds at Spring Cañon, and those from the

Devil's Slide, Montana, are evidently all of Jurassic age. They are nearly all bivalves, and belong to *genera* that also occur in the Cretaceous, and in part in older formations than the Jurassic, as well as in more modern rocks than the Cretaceous. None of them are, beyond doubt, identical with foreign Jurassic species; but from their specific affinities to European Jurassic forms, and their positive identity, in a few instances, with species found at other localities in the West, in well-determined Jurassic beds, as well as from the entire absence among them of any strictly Cretaceous types, we can safely refer the rocks in which they occur to the Jurassic.

Spring Cañon.—The few specimens from the upper beds at Spring Cañon are probably also Jurassic types, but the number and condition of the specimens scarcely warrant the expression of a positive opinion on this point.

Those from the lower beds near Fort Hall, Idaho, although all belonging to one species, evidently came from a Jurassic rock; while a few casts from the upper beds at the same locality, also, seem to belong to the same epoch; but the specimens being all casts, cannot be satisfactorily studied.

CRETACEOUS AGE.

Coalville.—The coal-bearing rocks at Coalville, Utah, are undoubtedly of Cretaceous age, as stated by Mr. King and Mr. Emmons, and as was from the first maintained by myself. During the past summer I had an opportunity to examine, personally, this interesting locality, and to note the thickness, order of succession, and composition of the great group of beds exposed there, as well as to collect and study a large series of the organic remains found in the same. From these observations it is now proposed to give, below, some remarks on this extensive series, in more detail than has hitherto been done. Before proceeding to do so, however, it seems desirable that a few words should be said in regard to what has been already published respecting the geological age of this formation, as there would at least appear to be some misapprehensions on this point. Perhaps the shortest way to place this preliminary information before the reader will be to quote from Dr. Hayden's Report of 1870, page 299, the following paragraphs, written by myself, on this coal series, in a paper contributed to that report:

> Some of the specimens from near Bear River, and at Coalville, Utah, from a light colored sandstone, containing beds of a good quality of brown coal, appear to belong to a member of the Cretaceous series not corresponding to any of those named in the Upper Missouri country, though it is, as I believe, represented by a similar sandstone under the oldest Estuary Tertiary beds at the mouth of Judith River, on the Upper Missouri. In 1860, Colonel Simpson brought from this rock, on Sulphur Creek, a small tributary of Bear River, in Utah,* several casts of *Inoceramus* and other fossils; and in some remarks on Colonel Simpson's collection, published by the writer, in connection with Mr. Henry Engelmann, the geologist of Colonel Simpson's survey, we referred this formation to the Cretaceous.† The collections that have been brought in from Utah, by Mr. King's and Dr. Hayden's surveys, confirm the conclusion that it belongs to the Cretaceous, as they contain, among other things, species of *Inoceramus*, *Anchura*, and *Gyrodes*—genera that seem not to have survived the close of the Cretaceous period. In addition to this, there is among Dr. Hayden's collections from this rock, at Coalville, a *Turritella* that I cannot distinguish by the figure and description, even specifically from *T. Martinezensis*, described by Mr. Gabb, from one of the upper beds in Cali-

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* This locality on Bear River is really within the western border of Wyoming, though it was supposed by me at the time of writing this paragraph to be, like Coalville, in Utah.

† See Proceed. Acad. Nat. Sci., Philad., 1860.

fornia, referred to the Cretaceous. A *Modiola* from the same horizon, also, appears to be specifically identical with *M. Pedernalis*, of Roemer, from the Cretaceous of Texas. Dr. Hayden also has, from a little above the coal-beds at Coalville, specimens of *Ostrea*, that seem much like *O. Idriaensis* and *O. Breweri*, of Gabb, from the upper beds of the California Cretaceous. As no other fossils were found directly associated with these oysters, however, nor any marine forms above them, it is possible that they may belong to the Lower Tertiary.

From the affinities of some of these fossils to forms found in the latest of the beds referred in California to the Cretaceous, and the intimate relations of these marine coal-bearing strata of Utah to the oldest Tertiary of the same region, and the apparent occurrence of equivalent beds bearing the same relations to the oldest brackish-water Tertiary beds at the mouth of Judith River on the Upper Missouri, I am inclined to believe that these Coalville beds occupy a higher horizon in the Cretaceous than even the Fox Hills beds of the Upper Missouri Cretaceous series; or, in other words, that they *belong to the closing or latest member of the Cretaceous.*

These remarks certainly *ought* to make it clear enough, one would think, that I regarded the coal-bearing strata at Coalville, Utah, and near the mouth of Sulphur Creek, on Bear River, Wyoming, as being of Cretaceous age.* A few pages further on in the same report, I gave a list of all the fossils collected during the preceding summer by Dr. Hayden's party, that I referred to the Cretaceous epoch. In this list, it will be seen, I placed all of the few fossils in the collections then under consideration, from the coal series at Coalville, Utah, and Bear River.

In making out the Cretaceous list mentioned above, I endeavored to express, by a number opposite the name of each species, the particular horizon in the Cretaceous series of the Upper Missouri, to which the bed that contained it belongs. This I fully explained on page 289 of the same report cited, as follows: "The numbers 1, 2, 3, 4, and 5, along the right-hand margin of the list,† opposite the localities, show to which member of the Upper Missouri Cretaceous each species belongs, the subdivisions of the Upper Missouri Cretaceous having been severally named and numbered from below upward, as follows: No. 1, Dakota group; No. 2, Fort Benton group; No. 3, Niobrara division; No. 4, Fort Pierre group; and No. 5, Fox Hills beds; the names being derived from localities where the several formations are well developed."

In accordance with this plan, I assigned each species in the list to its proper horizon in the Cretaceous series, by adding after the locality, "Cret. No. 1," "Cret. No. 2," &c., according to its position, excepting those from Coalville. These I could not refer to their precise horizon in the Cretaceous, because, although not doubting that they belong to the Cretaceous system, I was, as already explained, in doubt whether the beds in which they were found correspond exactly to any of the recognized subdivisions of the Upper Missouri series, being, as stated, rather inclined to think they form the closing member or division of the Cretaceous, holding a position above the horizon of No. 5 of the Upper Missouri section. Consequently, in order to give expression to this doubt, as well as to follow out the system of notation, I placed opposite each of the species from Coalville, and the coal-bearing sandstones at Bear River, the words "Cret. No. ?" meaning thereby, of course, that I was in doubt whether these beds corresponded exactly with any particular one of the recognized subdivisions of the Upper Missouri series; which, it should be remembered, only represents a part of the whole Cretaceous system.

* Another quite distinct formation at the Bear River locality, containing a peculiar group of fresh and brackish water types of fossils, all entirely different from forms found in the marine beds containing the valuable beds of coal there, was referred by me provisionally to the lower Eocene.

† These numbers were placed on the right-hand margin of the list in the MS., but are not exactly so in the list as printed.

In reading over the last proof of this list, it occurred to me that possibly the query after the words "Cret. No.?" might be misunderstood as intended to express a doubt in regard to the Cretaceous age of these species. Consequently, I struck out, with a pencil, the abbreviation "Cret.," leaving it simply "No.?" after each of these species. But afterward I thought there could certainly be no misunderstanding on this point, with the accompanying explanations, and made an effort to rub out the pencil-markings I had made in the proof. The printer, however, being misled by the soiling of the paper, did not understand what I wanted, and instead of leaving it "Cret. No.?" in all these cases, only left it so after one species; while, after another, he struck out "Cret.," leaving it merely "No.?"; after two others he struck out the abbreviation "No.?" leaving it "Cret., ?" and after two others he struck it all out.

In regard to the two Coalville species, by mistake of the printer, left with only "Cret. ?" after them, I admit that it might appear, to one glancing hastily over the list without reading the remarks and explanations on the preceding pages of the same report, that I had intended to express doubts respecting their Cretaceous age. It certainly seems to me, however, that any person reading, with even a moderate degree of attention, my remarks and explanations respecting this list, and the age of the Coalville and Bear River coal-bearing strata, in the same report, ought to understand that I did not question the fact of these beds belonging to the Cretaceous system.

Again, in giving a list of the Cretaceous fossils collected by Dr. Hayden's party, at various localities during the summer of 1870,* in his report of 1871, pages 375 and 376, I placed in it a few additional forms from Coalville, nearly all of which are entirely distinct from any I had before seen from there, or, indeed, from any other locality. These are mainly casts in hard arenaceous rock; and as I had little or no time then to work out and study them, I merely placed them in the Cretaceous list, without specific names, and with a mark of doubt in regard to the genera to which five of them belong. I explained, however, in the accompanying remarks, that I regarded them as Cretaceous species, giving my reasons for so doing.

I have been somewhat particular in giving the foregoing statement of formerly published opinions respecting the age of the rocks under consideration, because the question-marks used in the lists mentioned have been alluded to as if they had been used to express doubts in regard to the Cretaceous age of the coal-bearing rocks at Coalville and other localities in this region; and my opinion on this subject has been consequently treated as if so vague and undecided that it was not even necessary for any one, subsequently arriving at the same conclusion in regard to the Cretaceous age of any of the coals of this region, even so much as to allude to it.†

Having thus briefly cleared away some misapprehensions in regard to what has been well known for some years past respecting the Cretaceous age of the coal-deposits of Coalville, Utah, and at Bear River, Wyoming,

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*It should be remembered that each of these lists only includes the collections brought in from the explorations of the preceding summer, and that they were not intended to include all of the known species that had previously been found in the same beds, at the same localities.

† See a paper on the existence of *Dinosauria* in the transition beds of Wyoming, by Prof. Edward D. Cope, read before the Am. Philosophical Society, 1872; also, Remarks on the Geology of Wyoming, by Prof. Edward D. Cope, Proceed. Acad. Nat. Sci. Philad., December, 1872, page 279.

I will proceed to describe in detail the various beds composing the great thickness of strata exposed at and near Coalville; also to explain their order of succession, the nature of the organic remains found in each, &c.

In order that these remarks may be the more readily understood, the accompanying section has been prepared, from observations made at the locality during the past summer. It runs from the principal coal-bed near Coalville, in a northwesterly direction to Echo Cañon, a distance, by a right line a little obliquely across the strike of the rocks, of perhaps three to three and a half miles.

It may be proper to explain here that the beds were not always found well enough exposed to afford absolutely exact measurements of their thickness, while the elevations of the ridges crossed, as well as the breadth of intervening valleys, were merely estimated. Another section across the same outcrops on a different line, even at no great distance from that of the section here given, would probably not agree in minor details, because the beds are liable to vary in thickness and composition at different localities in this series of rocks. The heavy beds of harder sandstone are more persistent, and, as might be expected, generally more exposed than those of softer material. Those of soft, decomposing sandstones, shales, clays, &c., more frequently form slopes, and consequently are more apt to be covered and obscured by loose earth. In some cases we, therefore, had no other means of determining the nature of the strata occupying such spaces, than by examining the disintegrated surface materials, and a few small projecting ledges. Hence some of these spaces that appeared to be occupied by clays or shales, with only a few intercalations of sandstone, may be mainly or entirely made up of soft sandstones, or alternations of the same with clays and shales. Again, it is an important point to be remembered, that there may be other beds and seams of coal, in addition to those represented in the section, because these coals generally occur in, or are connected with, clays and shales, or other soft beds such as are most frequently hidden from view.

A mile or so in a southeasterly direction from Sprigg's mine, situated directly in Coalville, coal has been found in one or two openings not more than about forty feet above the valley of Weber River; and the bed or beds have been by some supposed to hold a lower position in the series than the main coal (division 5) of our section. The locality of these openings, with relation to the known position and dip of the main bed, would certainly indicate for them a lower horizon in the series, and they may possibly belong lower; but from all the appearance at these excavations, (which had partly fallen in at the time of our visit,) I have the impression that this coal is merely a portion of the same bed thrown out of its natural horizon with relation to the rocks represented in the section, by the same powerful forces that upheaved and tilted all of the strata of this region. We did not see more than five or six feet of this coal exposed, but it is overlaid by a sandstone similar to that forming the roof of the main bed at Sprigg's mine in Coalville, and seemed to correspond in other respects, excepting in showing a (probably local) reversed dip.

Between this locality and the lowest beds represented in the section, as they are seen nearly at Coalville, there is a space not well exposed at any points examined, and consequently we did not determine the thickness and nature of the beds occupying the same.

Commencing, then, with the lowest strata represented in the section on the right, and describing the beds in *ascending order*, we have the following series:

SECTION FROM ABOUT $1\frac{1}{4}$ MILES NORTHEAST OF COALVILLE, IN A NORTHWESTERLY DIRECTION, TO ECHO CAÑON.

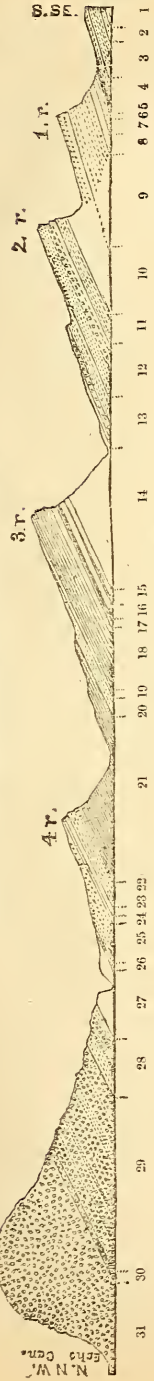

Fig. 52.
Coalville Section.—Elevation of base line above sea 5,540 feet.

	Ft.	In.
No. 1. Thin beds and seams of sandstone and clays, reddish and gray below, with some pebbly beds near the middle, and whitish and light-gray soft sandstones and clays above	120	0
No. 2. Yellowish and reddish sandy clays	43	0
No. 3. Alternations of light-gray and yellowish sandy, more or less laminated, clays, and beds and thin layers of sandstone, with *Inoceramus problematicus*, *Cardium subcurtum*, *Lucina*, *Macrodon*, *Modiola multilinigera*, *Arcopagia Utahensis*, *Corbula*, *Martesia*; and many other bivalves; with *Neritina pisum*, *Turritella Coalvillensis*, *Eulima funiculus*, *Fusus* (*Neptunea?*) *Gabbi*, *Melampus*, &c., &c	150	0
No. 4. Light-grayish and ash-colored clays, with occasional beds and seams of sandstones, altogether from 60 to 80 feet	80	0
No. 5. Heavy bed of good coal, said to vary from 11 to 13 feet in thickness	13	0
No. 6. Yellowish-gray sandstone forming roof of coal, and containing *Ostrea soleniscus (?) and Inoceramus*	25	0
No. 7. Dark-colored (nearly black) clay with *Inoceramus problematicus;* varying from 60 to 100 feet in thickness	100	0
No. 8. Space mainly covered where examined, but apparently occupied by clays and soft sandstones, altogether perhaps 80 to 100 feet in thickness	100	0
No. 9. *a.* Massive whitish and yellowish sandstones, with casts and impressions of a peculiar Fucoid, *Avicula*, *Cardium*, *Trapezium*, &c., 45 feet. *b.* Yellowish sandstone with many bivlaves, 25 feet. *c.* Massive whitish sandstone, with *Avicula*, *Tellina*, &c., &c., 30 feet	100	0
No. 10. Yellowish and light-gray clays, with some beds and layers sandstone	80	0
No. 11. *a.* Reddish, sandy, and pebbly clays, not well exposed, 20 to 30 feet. *b.* Conglomerate, 10 to 15 feet. *c.* Bright yellow sandstone; *Avicula gastrodes*, *Cardium*, *Tellina*, *Arcopagia, (?) Gyrodes*, *Cyprimera isonema*, *Gyrodes depressa*, *Fusus (Neptunea ?) Utahensis*, &c., &c., 50 to 60 feet. *d.* Heavy, massive, whitish sandstone, with *Ostrea soleniscus*, *Cardium*, &c., 70 to 80 feet	190	0

	Ft.	In.
No. 12. *a*. Clays and sandstones; the latter in thin layers, 55 feet.		
b. Light-gray and yellowish clay, 20 feet	75	0
No. 13. *a*. Gray conglomerate and sandstone, 42 feet.		
b. Light-yellowish and grayish clays and pebbly sandstones, 40 feet.		
c. Conglomerate, 12 to 15 feet	172	0
No. 14. Valley; no good exposures, but, probably, mainly shales and clays	600	0
No. 15. Alternations of shale and sandstone	37	0
No. 16. Coal	2	6
No. 17. Alternations of dark-bluish fire-clay, shale, gray clay, and, more or less, soft sandstone. Numerous fresh brackish water and marine types of fossils mingled together, such as *Anômia*, *Inoceramus*, *Unio*, *Cardium*, *Cyrena Carltoni*, *Neritina Bannisteri*, *Neritina (Dostia?) bellatula*, *N. (D.?) cardītiformis*, *Eulima chrysalis*, *E. inconspicua*, *Turritella spironema*, *Melampus antiquus*, *Physa*, *Valvata*, &c., &c.	48	0
No. 18. *a*. Coal, (Carltons bed,) 3 feet to 3 feet 4 inches.		
b. Coal and black shale, 1 feet 2 inches.		
c. Coal, 1 foot	5	6
[There may be a space here of 50 to 60 or more feet, occupied by unknown beds.]		
No. 19. Great, massive, light-grayish and yellowish sandstone, estimated at 220 feet	220	0
No. 20. Gray sandstone and sandy clays, with numerous *Ostrea soleniscus*	14	0
No. 21. Sandstones and clays	85	0
No. 22. Valley, showing at places sandstones and sandy clays, estimated thickness	600	0
No. 23. Light-colored sandstones and clays	90	0
No. 24. Gray, soft sandstone, with many large *Inoceramus*, *Ostrea*, *Cardium*, &c	30	0
No. 25. Gray sandstones and clays	18	0
No. 26. Whitish sandstones and sandy clays, with fragments of *Ostrea* lying loose on surface of slope	150	0
No. 27. Soft, light-gray, coarse sandstone, with some pebbles	23	0
No. 28. Valley, no rocks exposed, 300 to 380	380	0
No. 29. Soft, decomposing, light-gray, coarse sandstone, and conglomerate	200	0
No. 30. Reddish-brown conglomerate, with local streaks, and thin beds of soft, whitish sandstone, 500 to 600 feet thickness	600	0
No. 31. Whitish, soft, coarse sandstone, with more or less pebbles	60	0
No. 32. Great Echo Cañon conglomerate, (brownish tinge,) composed of pebbles, bowlders, and sandstone, 700 feet or more	700	0

By footing up this long list of subordinate beds, it will be seen that, if there are no faults or down-throws along the line of observation, there would be, including the great conglomerate near the mouth of Echo Cañon, and about 390 feet of beds below the main 11 to 13 foot coal, an aggregate of some 4,680 feet of strata embraced in the section. As already explained, however, it is not pretended that the details of this section have been worked out with the degree of precision attainable by instrumental observation, the main object in constructing it being merely to illustrate approximately the position and vertical range of fossils with relation to the coal-beds, and to give a general idea of the lithological characters of the series. It should be stated, however, that the dip and estimated distance across the strike of the strata would indicate even a greater thickness than the sum of the individual beds observed.

The dip of the beds, including the main coal (5) toward the lower part of the section, seemed not to differ much from about 8° to 10° below the horizon, to the northwestward; but it increases gradually in that direction, so that at the fourth ridge it is about 25°. Between this ridge and the mouth of the cañon we observed no marked change of dip, though there appeared to be a slight unconformability between the conglomerate and the lighter-colored beds below at this place; and this unconformity is more obvious at other points near here; while farther up, near the head of the cañon, it is very strongly marked, the discordance being, according to Mr. Emmons, as much as 25°.

Unfortunately, we have no means of ascertaining the precise distance by an air-line traversed by the section, the linear survey of the Coalville township not yet being completed. If we estimate the distance at three miles, and the mean dip at 17°, however, it would give a thickness not materially greater than the aggregate of beds noted in the section. If the distance should be as much as three and a half to four miles, however, the difference would be so great as to warrant the conclusion that we have overestimated the dip, or, what is much more probable, underestimated the breadth of some of the valleys between the ridges, and consequently the thickness of strata hidden beneath the same. As evidences of horizontal displacements of some of the ridges, however, were observed, it is possible that the discrepancy may be, in part at least, accounted for in that way.*

Mr. Emmons gives in Mr. King's report about 6,000 feet as the entire thickness of the Cretaceous series here, exclusive of the Echo Cañon conglomerate, which is apparently Tertiary. But I infer that he includes in this estimate a considerable thickness of lower strata farther up Weber River than our examinations extended.

All of the lower beds forming divisions 1 to 6, inclusive, of this section are seen in a low hill, or rising space, directly on the southeastern margin of Coalville, flexed around so as not to conform to the general dip and strike of the strata between this vicinity and Echo Cañon; their strike being nearly north and south, and their dip nearly westward, some 14° below the horizon. About two miles to the northeastward, however, and at a higher elevation, coal-mines have been opened on the main bed forming No. 5 of the section, that show this bed and the overlying sandstone and other strata, conforming there with the general dip and strike of the beds between there and Echo Cañon. Between these mines and Coalville, the highly fossiliferous strata forming the division No. 3, which we know properly holds a position below the main coal-bed, occur some hundreds of feet north of a right line between these mines and the coal-mine directly at Coalville, in the same bed; thus

* Along Grass Creek we observed some curious indications of lateral displacements. This creek cuts very obliquely through some of the ridges, which do not correspond on opposite sides. That is, the ends of the ridges on opposite sides of the creek do not coincide exactly, those on one side ending opposite intervening valleys between those on the other, as if there had been a fracture along the course of the creek, and a lateral displacement of the strata on one or both sides of the same.

appearing as if they really hold a higher horizon in the series than the main coal (5) of the section. At this place these more fossiliferous beds are seen in a ridge, abutting directly against the lighter-colored, more massive sandstones of division 9, forming the first ridge. In following this ridge along in a southwesterly direction we come suddenly to a point where the more massive, lighter-colored sandstones of division 9 end, and we pass, almost by a single step, upon the thinner, more fossiliferous layers of division 3; the two divisions coming as abruptly together as if their strata had been sawed off and placed end to end against each other. Here the strike of the strata of these two divisions is nearly the same, and the dip also of both is northwestward, but those of division 3 dip at a somewhat higher angle than division 9.

This lateral displacement of portions of these lower strata is very puzzling, and had led to the conclusion that they belong above the horizon of the main coal. We were so fortunate, however, as to find them cropping out at points within a mile to the southeastward of the coal-mine in the main bed, directly at Coalville, readily recognizable by their characteristic fossils and lithological characters, and yet clearly dipping under the division 4, which was, in the same way, traced along the outcrops to where it is distinctly seen to dip under the main coal, directly at Coalville. There can, therefore, be no question whatever in regard to these beds holding a position beneath the main coal-bed; that is, the lowest coal represented in the section here given.

The determination of the position of these beds beneath this coal is a matter of some little interest, because it shows that in viewing this series in the ascending order, we start with a succession of highly fossiliferous beds, containing a group of forms, among which we recognize the Cretaceous and older genus *Inoceramus*, represented by the well-known Cretaceous species *I. problematicus*. The other fossils found in these beds seem to be all new species, though several of them are undistinguishable from forms found in the beds far above the main coal. The *Turritella* and *Modiola*, from this locality, that I at one time thought probably identical with Cretaceous species from California and Texas, came from these beds; and although later comparisons have satisfied me that they are new species, they are certainly very closely allied to the Cretaceous forms with which I had compared them.

Although nearly all the fossils from these beds are certainly marine types, a few of them, such for instance as two or three species of *Neretina* and one of *Melampus*, indicate that streams of fresh water probably flowed into the sea, bay, or inlet in which the marine forms lived, from close-lying land, during the deposition of these rocks.

The local displacement of portions of the lower beds of the section at Coalville, mentioned above, doubtless caused the impression at one time entertained, that the dark-colored clay (division 7 of the section) containing *Inoceramus problematicus*, and perhaps fragments of *Ammonites*, seen in some of the excavations there, probably held a position beneath the main coal, (division 5.) An inclined shaft, however, in course of excavation directly at Coalville, during the past summer, demonstrates in the clearest and most satisfactory manner that its position is above the horizon of the sandstone forming the roof of this coal, as the shaft passes first down through some 50 or more feet of this clay before it strikes the sandstone immediately over this coal. Large quantities of this clay were observed lying near the top of the shaft, when we were at the locality, and numerous specimens of *Inoceramus problematicus* were to be seen in it.

Of course no attempt has been made to illustrate, in the accompanying section, this fault and local displacement of the lower beds of the same, observed here at Coalville, because the fracture runs so nearly parallel to the section that it could not be done.

At one place on the southeastern side of the first ridge, almost exactly at the point where the fault already mentioned crosses, some coal was found in a drift excavated into the side of the hill, perhaps 80 to 90 feet above the horizon of Weber Valley. As this coal, however, was soon found to end abruptly, on following it in, it is probably only a detached portion of the main bed, (5,) thrown that far out of its natural position with relation to the other strata, by the fault cutting through the whole. As suggested by Mr. Emmons, however, it could certainly be found again at a lower position on the same side of the ridge, provided the search should be made, on the northeastern side of the line of fracture. Its position, however, on the other side of the fault, would be on the opposite or northwestern side of the ridge, since that end of the ridge is composed of beds really belonging below the horizon of this coal. It is probable, however, that if bodies of this coal exist on the northwest side of this ridge, near the line of fracture, they would be found so much broken up and distorted as to be of little practical value.

Some facts observed at the locality gave origin to the suspicion that possibly the whole of that portion of the first ridge on the northeastern side of the fault may really be only a down-thrown part of the second ridge, or even that both this and the second ridges might be downthrows of the third; though the subordinate beds composing these ridges do not seem to correspond closely enough to warrant this conclusion.

The fault, or lateral displacement, mentioned in the first ridge, is also strikingly manifest in the second; the lateral movement there being more than 100 feet, precisely as if the whole ridge had been cut across by a gigantic saw, and the strata on the southwest side of this division slipped that far to the northwestward, or the portion on the northeast side as far southeastward. Evidences of this fracture are to be seen in the other ridges, and I have no doubt that it cuts through the whole to Echo Cañon, and possibly far beyond in a north or northwesterly direction, not exactly but more or less nearly at right angles to the trend of the ridges and strike of the strata.*

Divisions 14, 15, 16, and 17 were not seen well exposed on the line of the section, or even on the east side of Weber River, though they are doubtless exposed at some localities on that side. On the west side of the river, however, at Mr. Carleton's coal-mine, about two miles in a southwesterly direction from Coalville, and at a higher elevation, these beds were cut through by a drift excavated into the side of the hill horizontally, nearly in the direction of the dip, which is there to the northwestward about 20° below the horizon. Coal, however, has been found at, or very nearly at, this horizon on the east side of the river; while the great massive sandstone composing division 18 forms a precipitous escarpment above Mr. Carleton's mine, and thence extends continuously, in a northeasterly direction, to Weber River, at a point nearly opposite the third ridge on the east side, thus leaving little room to doubt that Carleton's coal and the associated beds occupy the position assigned them in the section there, as they do on the west side of the river.

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*Other similar faults, or later displacements, were also seen in the ridges at other points a mile or so farther eastward.

As the drift at Mr. Carleton's mine penetrates almost horizontally, and nearly in the direction of the dip of the beds, of course it cuts obliquely through them from below upward. Owing to the darkness in the mine, however, and the presence of timbers at places, we could not examine the beds there very carefully; but Mr. Carleton kindly gave us the following detailed statement of their thickness, order of succession, &c.:

	Ft.	In.	
A. Sandstone, forming the roof of the coal and shale, containing *Inoceramus*			
B. Coal	1	2	
C. Impure slaty coal and shale	1	0	Division 17 of Coalville section.
D. Coal of good quality	3	4	
E. Fire-clay	1	2	
F. Soft gray sandstone, *Inoceramus*, *Unio*, *Cardium*, and *Anomia*	12	0	
G. Dark-bluish, or nearly black, and lighter colored indurated clays, containing many fresh and some salt-water types of shells, such as *Physa*, *Valvata*, *Cyrena*, *Neritina*, *Melampus*, *Eulima*, *Turritella*, &c	10	0	Division 16.
H. Shale	4	0	
I. Soft rusty sandstone, with *Cardium* and fragments of other fossils	15	0	
J. Fire-clay	6	0	
K. Coal	2	6	Division 15.
L. Shale	10	0	
M. Dark sandy shale	20	0	
N. Sandstone	7	0	Division 14.
O. Iron ore		4	
P. Dark shale	6	0	

Although we could not, as stated, examine all of the beds and seams of these divisions of the section in as much detail as desired, there being no surface outcrops of the same here, we nevertheless did see nearly all of them in place, with their characteristic fossils, in passing along the drift or gallery leading to the coal, and in part immediately over the same. At some places in the mine, the clays and thin seams of coal above the coal D had fallen in, so as to expose the overlying sandstone A, and in the under surface of this we saw many casts of *Inoceramus*. In the bed F we likewise saw *Inoceramus*, *Cardium*, and imperfect examples of *Unio*, while from the dark clays G we picked a few shells, when examining this bed in the drift. Considerable quantities of the removed portions of all of these beds were also to be seen lying in heaps at the entrance of the drift, and that from each could there be readily identified by Mr. Carleton, so that we had no difficulty in referring all of the fossils found in this loose material, which had not been long exposed to the weather, to their proper beds.

It was the opinion of the miners here that the sandstone A, in which we saw casts of *Inoceramus*, in the mine, is the lower part of the massive division 18 of the section. Although this view was adopted in constructing the section, it is possible that it may be a lower bed of sandstone, separated from the base of the massive stratum 18 by 50 or 60 feet of clay or other material, as there seemed to be rather too long a slope between the base of the exposed part of the sandstone 18, seen above, and the entrance of the drift, to be filled by the beds obliquely perforated by the same; though we had no means of determining how much of the lower part of this sandstone may be hidden in this slope.

The group of fossils found in the dark indurated clay G is, in several respects, a very interesting one, not only because every species is new to science, and all of them entirely different from any yet found at any other locality, or even in any other beds at this locality, (with possibly one or two exceptions,) but on account of their modern affinities. Here we have, from beds certainly overlaid by more than 1,000 feet of strata containing Cretaceous types of fossils, a little group of forms, presenting such modern affinities that, if placed before any paleontologist unacquainted with the facts, they would be at once referred to the Tertiary. Such examples as this illustrate the difficulties with which the paleontologist sometimes has to contend, and show how very cautious we should be in deciding from the affinities of new species of fresh and brackish water types of shells (the vertical range of which is unknown) the geological age of rocks in which they are found; because species of this kind, from rocks of various ages, often closely resemble each other, while they rarely present such well-marked distinctive features as we see in marine shells from different horizons. Some of the species of *Physa*, *Cyrena*, *Neritina*, &c., for instance, from the clays under consideration, closely resemble existing species; while one or two of *Melampus* present but very slight differences from Paris Basin Tertiary species, figured by Deshayes under the name *Auricula*.

It would appear that the indurated clay containing these mixed types of shells must have been deposited in the form of fine mud, in an estuary, or possibly a larger body of salt water, into which the fresh-water shells were swept by streams flowing in from adjacent land.* There were probably here, however, during the deposition of all this great group of coal-bearing strata, as during the formation of the far more ancient Carboniferous coals, various oscillations of the earth's surface, because we have every reason to believe that every bed or seam of coal, even if only a few inches in thickness, was formed in marshes, by the growth and accumulation of vegetable matter, at or a little above the sea-level, while we find marine types of fossils through most of the intervening strata; showing that after the accumulation of the material of each bed and seam of coal, there was a subsidence, and a return of the sea.

Above the horizon of Mr. Carleton's mine, we only saw marine types of fossils, though there may be other beds containing fresh-water shells higher in the series. As already explained, we saw in the sandstone supposed to be the lower part of division 18, in Mr. Carleton's coal-mine, casts of one or more species of the marine genus *Inoceramus*. We also saw higher in that division, on the east side of Weber River, casts of the marine genus *Cardium*; while in some thinner beds of sandstone and clays forming division 19, just above 18, there occur, on the east side of the river, numerous casts and shells of a peculiar oyster I have called *O. soleniscus*.

This oyster, which, as already stated, occurs at several horizons far down in the series, is very peculiar, and easily recognized by its unusually narrow, elongated, and generally quite straight form. At the locality mentioned above, on the east side of the river, many examples of it

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* It is evident that these fresh-water shells could not, however, have been transported very far, because, although quite thin, they are not water-worn, but seem to have been deposited in an unbroken condition. Many of them, however, are found in a crushed condition, evidently from pressure during the consolidation of the clay.

were seen, presenting a curious and puzzling appearance. They had grown crowded together by thousands, beak downward; while, in most cases, the shell itself was dissolved away, leaving only the internal casts, often 12 to 13 inches in length and only about 2 inches in breadth, standing side by side, with their longer diameters at right angles to the plane of the bed in which they were enveloped. At first it was rather difficult to comprehend what they could be, but on drawing some of them that were loose from the cavities they were found to be the internal casts of this peculiar oyster, showing the muscular scars quite distinctly. In a few instances, however, some of these specimens also retain the shell itself entire.

The highest horizon in this great series of beds at which fossils were seen *in situ* was in division 23 of the section, (fourth ridge.) Here we found in a light-grayish, soft sandstone numerous casts and broken shells of a large *Inoceramus*, with fragments of *Ostrea* and casts of a *Cardium*. The *Inoceramus* found here is a suborbicular, rather compressed or moderately convex species, with a rather short hinge and regular concentric undulations. It agrees well with Upper Missouri specimens we have always referred to *I. nebrascensis*, Owen, from the Cretaceous, excepting that none of the specimens found are quite so large as Owen's type; the size being about intermediate between *I. Sagensis*, and *I. nebrascensis*, Owen, which, however, may be only varieties of one species. The fragments of *Ostrea* and casts of *Cardium* found in the same association were too imperfect for satisfactory identification, but seemed to be very like forms found far below this horizon in other beds.

Along a slope formed by division 25 loose fragments of *Ostrea* were observed, that appeared to be the same form found associated with the *Inoceramus* and *Cardium*, in division 23, but none were seen in place.

Beyond this, toward Echo Cañon, as we ascend in the series the same light-grayish colors prevail in the sandstones and intercalated beds of conglomerate, for perhaps five or six hundred feet or more before we come to the great brownish conglomerate of the cañon. These lighter colored sandstones, however, are coarser and less coherent than most of those below the division 26. We looked carefully for fossils in these beds, but found no traces of organic remains of any kind; and, judging from the coarseness of the material, it is probable that it was rapidly deposited during the prevalence of physical conditions unfavorable to animal life.

The same was also evidently the case, even in a far more marked degree, during the deposition of those huge, massive beds of brownish conglomerate, at Echo Cañon, (divisions 29 to 31, inclusive, of the section,) which are so coarse as to present the appearance of consolidated drift. These beds are mainly composed of water-worn rocks of every size, from that of small pebbles to bowlders from 6 to 10 inches in diameter, the larger sizes more frequently predominating. The interstices are filled with arenaceous matter, and the whole firmly cemented together. So far as examined, near the mouth of the cañon, a large majority of these pebbles and bowlders were found to be very hard, light-grayish siliceous rock, apparently metamorphosed sandstone, though a few of igneous origin were occasionally seen. The whole formation is so massive that it would often be difficult to see in it any evidences of stratification, if it were not for occasional seams and lenticular bodies of intercalated sandstone along certain horizons. These have a deep reddish-brown color, and, as they are liable to weather out, where exposed, they leave lines of cavities that impart to the surface of precipitous exposures a stratified appearance. The coloring matter by which the whole formation is tinged brownish-red evidently comes from these intercalated seams of sandstone, and the same material forming the paste of the conglomerate; because the pebbles and bowlders themselves forming the main body of the same, when washed, often retain little of this ferruginous tinge.

Of course we can scarcely hope to find organic remains in such a formation as this, which must have been deposited by the action of powerful currents of water, in which mollusks or other organisms could not have lived; and if, by any chance, their shells or other solid parts should have been placed there, they would probably have been ground to powder by attrition among the rolling pebbles and bowlders and whirling sands. If any traces of fossils, however, exist in any part of this formation, it is among the seams and intercalated beds or lenticular masses of sandstone, or local bodies of finer material, that they most probably occur.

This immense massive conglomerate not only composes the towering walls of Echo Cañon—at places forming perpendicular, or even overhanging escarpments, 500 to 800 feet in height—but also rises into mountain masses on the west side of Weber River near the mouth of the cañon. Opposite Coalville, on the same side, five miles farther up, it likewise forms the upper part of the mountains above the Cretaceous; while south of Coalville, on the east side of the river, it is developed in such great force as apparently to form much of the entire mass of the mountains seen there. I am not sure that we saw its entire thickness exposed at any one place, but it probably attains a thickness of 2,000 feet in places.

That this great conglomerate formation is of Tertiary age, as suggested by Dr. Hayden, Mr. King, and Mr. Emmons, I know of no reason to question. This view not only accords with the fact of its position above such an extensive series of Cretaceous rocks, but with its non-conformability with the same, as well as with its remarkably coarse material. The line of separation between the two formations is probably that separating divisions 29 and 30 of our section—that is, all below that line probably belongs to the Cretaceous—though we did not find any fossils in place above division 23, and those found there were certainly Cretaceous types.

When referring the coal series at Coalville to the Cretaceous, in Mr. King's and Dr. Hayden's reports, I called attention to the very unusual entire absence, so far as known, of the genera *Ammonites*, *Scaphites*, *Baculites*, and all of those various other *Cephalopoda*, as well as of many other types, so generally at once distinguishing marine Cretaceous rocks from those of Tertiary age. At the same time, however, I noticed the presence of several species of *Inoceramus*, one of *Anchura*, and one of *Gyrodes*, genera that do not occur in more modern rocks than those belonging to the Cretaceous period; and it was on this evidence, and the specific affinities of some of the other types, that I was led to refer this series to the Cretaceous. The genus *Cyprimera*, Conrad, (and probably several other genera yet only known in the condition of casts,) may now be added to the list of Cretaceous types found in this series; while the species of *Cyprimera* discovered here is so nearly like *C. depressa*, from the Cretaceous of North Carolina and Mississippi, as to leave doubts whether it may not really be the same. We also now have the well-known Cretaceous species *Inoceramus problematicus*, from both above and below the main coal-bed at Coalville; while another larger *Inoceramus*, from far above all the coal here, is apparently identical, specifically, with an Upper Missouri Cretaceous species.

As I have, however, mentioned faults and lateral displacements of the strata here, it may be thought by some who are yet incredulous in regard to the Cretaceous age of these coals that these disturbances of the strata may have given origin to erroneous conclusions respecting the positions of the beds containing the Cretaceous types with relation to the coals. This, however, is simply impossible, because these fossils occur, as elsewhere stated, both above and below the coal-beds, even in local exposures, where all the strata, and included coal-beds, can be clearly seen conformable and in their natural positions with relation to each other. Consequently it would not, in the slightest degree, weaken the force of the evidence, even if we should admit any conceivable amount of disturbance of the beds, or even if we were to suppose the whole vast series of beds had been bodily tilted up and completely inverted, (of which condition of things there is no evidence,) because, even in that case, we would still have unquestionable Cretaceous types both above and below the coal-beds.

In the reports above cited, I stated some reasons for supposing this whole group of Cretaceous rocks to belong to a more recent member of that system than any of the recognized subdivisions of the Upper Missouri Cretaceous. The facts observed at the locality last season, however, seem to demonstrate that this is not the case. For instance, we found toward the lower part of the section, both above and below the main coal-bed, *Inoceramus problematicus*, a widely distributed species that is very characteristic of the Niobrara and Benton groups of the Upper Missouri, which there occupy positions below the middle of the series; and, so far as I know, this species never occurs in this country above this horizon.* Again we found, far above this, in division 23 of the section, numerous specimens of a larger *Inoceramus*, which, if not really identical with one of those forms, is scarcely distinguishable from *I. Sagensis* and *I. Nebrascensis* of Owen, which occur in the later members of the Upper Missouri series. From these facts, it is more probable that we have here, at and near Coalville, representatives of the whole Upper Missouri series, with possibly even lower members, farther up Weber River, than any of the known Upper Missouri subdivisions of the Cretaceous. If this is so—and there seems to be little reason to doubt it—the marked difference observed between almost the whole group of fossils found here, and those of the Upper Missouri Cretaceous, would seem to indicate that there was no *direct* communication between the Cretaceous seas or gulfs of that region and those in which these Utah beds were deposited. Differences of physical conditions, however, probably also played an important part in the production of this diversity of life, since it is evident from the great predominance of clays and other fine materials in the Cretaceous beds of the Upper Missouri, that they were deposited in comparatively deeper and more quiet waters than those in Utah, in which coarse sandstones, with occasional pebbly beds, predominate.

Although the Coalville coals, and indeed all of those of this entire region of country, belong, (as might be expected from their comparatively modern age,) chemically speaking, to the brown-coal series, they are of unusally good quality, being generally as hard, black, compact, and shining as the far older Carboniferous coals. They burn much like bituminous coal, being, in fact, semi-bituminous. As they contain more

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*For the information of European geologists, not familiar with the details of our geology, it should be stated that the entire Upper Missouri Cretaceous series belongs to the upper part of that system.

water, however, their heating properties are not equal to those of the older Carboniferous coals, while they are more liable to crumble from exposure and handling. Still, when we take into consideration the great scarcity of wood throughout immense areas of this internal part of the continent, the thickness and extent of some of the beds, and their proximity to the Pacific Railroad, it will readily be understood that these mines must be of great value.

The main bed (division 5 of the section) must contain practically inexhaustible quantities of coal, and has a moderately firm roof of sandstone. Some difficulties, however, will be met with at places, in mining it, on account of faults and dislocations of the strata, but not greater than in coal-mining in other disturbed districts.

It is also evident that in mining these coals, great care should be taken not to allow the refuse thrown from mines to accumulate at the entrance, in contact with the outcrop of the coal-bed in place; because this refuse coal, as thus exposed to the weather, is liable to take fire spontaneously, and ignite the coal in the mine, causing great trouble and loss, not always so much from the amount of coal consumed as from filling portions of the mine with suffocating gases and smoke, as well as from causing the falling in of the overlying strata.

At Spriggs's mine, directly in Coalville, the strata, as already explained, do not conform to the general dip, and strike on the other side of Chalk Creek, a little north and east of here, the strike being nearly north and south, and the dip but little north of west, about 14° below the horizon. The rising up of the beds here is almost coincident with the western slope from a little plateau of 30 to 40 feet elevation above the valley on the southeast margin of the town. Formerly the mine here was worked by drifts or galleries, following the coal directly from the surface under the inclined sandstone, (division 6,) which forms, at places, the surface of the slope from the little plateau. Fire, however, was communicated from the burning slack coal at the entrance of the mine, to the outcrop of the coal-bed, and burned under, causing the sandstone to fall in, and filling parts of the mine with smoke and gases, which were escaping from cracks in the fallen-in sandstone and overlying earth when we were there.

Whether on account of inconvenience caused by the burning coal, or for other reasons we did not learn, they were, when we were at the locality, sinking a highly inclined shaft, commencing a little above the base of the slope mentioned, and cutting down obliquely through the clay of division 7 and division 6, to strike coal-bed some distance below the bottom of the valley.

The dip of the strata here must cause the coal to plunge beneath the valley, and, if there are no faults or fissures, to pass under Weber River, at a vertical depth of between 300 and 400 feet. It is therefore possible, as suggested by Mr. Emmons, that there may be much trouble with water in working this bed far beneath the surface here, unless the heavy bed of impervious clays (division 7) may prevent water from this source from percolating down to the coal-bed.

The other mines, two to two and a half miles farther northeastward, on the same bed, and at considerable higher elevations, will probably be less troubled with water. Indeed, there is little reason for doubting that slightly inclined tunnels might be started, at much lower horizons on this bed, between the mines now worked there and Coalville, and extended in a northwesterly direction, so as to drain themselves and all the mines on this bed above.

Of the mines over on Grass Creek, some four or five miles northeastward of Coalville, we only visited one, owned, I believe, by Mr. Joseph Young, one of Brigham Young's sons. This mine is situated in the bottom of Grass Creek valley, or cañon; and as it seems to be exactly on the line of strike of the other mines between it and Coalville, and does not differ very materially in strike, dip, and thickness, there can scarcely be any doubt that it is in the same bed of coal. This view is also supported by the fact that the coal is immediately overlaid by a sandstone like that seen over the mines between here and Coalville, and at Coalville; while we saw in this sandstone apparently the same oyster observed in that forming the roof of Spriggs's mine at Coalville.

The mines in the higher part of the series, although in thinner beds than the main one far below, must be of considerable value. That owned by Mr. Carleton, on the west side of Weber River, in division 17 of the section, affords a good quality of coal. The thickness of the bed is about 3 feet 4 inches, with one foot of black shale and impure coal above it, and over this 1 foot and 2 inches of coal. Where the shale is firm enough not to require much timbering to hold it up, it can probably be left as a roof to the mine; but where the shale is thin and friable, the whole thickness, including the upper 1 foot seam of coal, up to the sandstone, will have to be taken out. Indeed it is possible that the shaly parting between the two may become, at places, sufficiently carbonaceous to serve for the supply of fuel for machinery at the mine, and in that case it would be the best economy to work the whole thickness. The ridge at this mine extends apparently without break for two miles or more, and it seems probable that the coal is equally accessible throughout the whole extent.

Bear River.—On Sulphur Creek, near Bear River, in Western Wyoming, there are to be seen some very interesting exposures of Cretaceous rocks, including valuable beds of coal. These exposures are directly on the Union Pacific Railroad, and evidently belong to the same horizon as the coal series at Coalville, Utah.

As long back as 1860 the strata, including the coal here, were referred to the Cretaceous by the writer and Mr. Henry Engelmann, in a paper on Colonel Simpson's collections.* They were also referred to the same age by Mr. King, Mr. Emmons, Dr. Hayden, and myself in 1870.† There is, however, also here, associated with the above-mentioned beds, another quite distinct formation, containing an entirely different group of fossils, consisting of a mingling of both fresh and brackish water types, which I have always considered most probably of lower Eocene age.

While on an excursion to Wyoming and Utah during the past summer, accompanied by Dr. Bannister, we availed ourselves of the opportunity to stop at the Bear River locality to examine the rocks and collect fossils, and from our notes, observations, and collections, I have prepared the accompanying section of the strata exposed there. Most of these beds, it will be seen, are thrown up into a nearly vertical posture, with an approximate north and south strike; and the section, which is a little more than one mile in length, crosses the strike at right angles from east to west. Commencing at the right hand, or eastern end of this section, and going westward, we meet with the following strata:

* Proceed. Acad. Nat. Sci., Philad., Apr., 1860, p. 130.
† Mr. King's and Dr. Hayden's Reports for 1870.

SECTION OF THE ROCKS EXPOSED ON SULPHUR CREEK, NEAR BEAR RIVER, WYOMING.

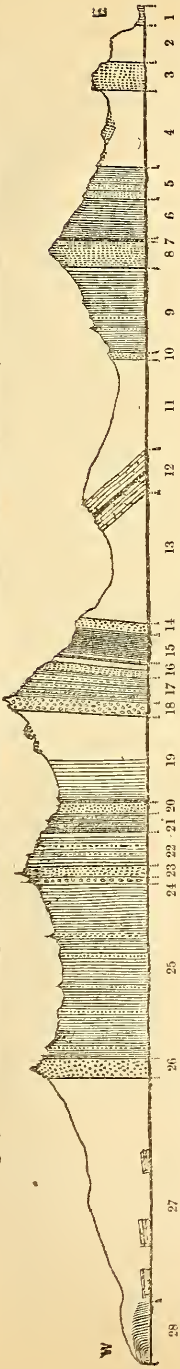

Fig. 53. Section on Sulphur Creek near Bear River. Elevation of base line about 7,000 feet above tide.

	Ft.	In.
No. 1.—Black shale, only seen in bottom of Sulphur Creek, thickness unknown.		
No. 2.—Slope apparently occupied by clays, thickness perhaps 100 feet or more	100	0
No. 3.—Soft light grayish sandstone, nearly vertical	90	0
No. 4.—Covered space, probably occupied by clays, but showing some sandstone that may or may not be in place; perhaps room enough for 250 to 300 feet	300	0
No. 5.—Two or three rather heavy beds of light yellowish gray sandstone, separated by clays, probably occupying some of the space included in division 4. Near the lower part two layers 15 to 18 inches each, of sandstone, containing *Ostrea soleniscus*, *Trapezium micronema*, &c. Altogether 90 to 100 or more	100	0
No. 6.—Greenish and bluish gray sandy clays, with some dark shale at places	100	0
No. 7.—Bed of good coal, said to be 7½ feet in thickness	7	6
No. 8.—Heavy massive bed of light colored sandstone, about 90 feet in thickness, standing nearly vertical, with some 3 to 5 feet of sandy clay between it and the coal of division 7	95	0
No. 9.—Gray sandy shales with alternations of sandstone and clays......................	255	0
No. 10.—Light gray sandstone	20	0
No. 11.—Slope and unexposed space, perhaps 200 yards or more across.		
No. 12.—Light gray sandstones and clays, including a bed of good coal, said to be 7½ feet in thickness; all dipping south-southeast 55° below horizon; and the sandstone above the coal containing many casts, *Inoceramus problematicus*, with a few casts of *Cardium* and undetermined univalves; altogether showing about..................	150	0
No. 13.—A valley or depression showing no rocks, perhaps 150 yards across.		
No. 14.—Ferruginous sandstone in thin layers, dipping north-west about 80° below horizon	40	0
No. 15.—Bluish laminated clays with, at top, (left or west side,) a two-foot layer of sandstone, containing fragments of shells not seen in a condition to be determined.....	125	0
No. 16.—Clays and sandstone below, (20 feet;) gray and brown pebbly sandstone above, (25 feet)	45	0

	Ft.	In.
No. 17.—Brownish and bluish clays, with some beds of white, greenish, and brownish sandstones	115	0
No. 18.—Hard gray conglomerate, standing nearly vertical, and forming crest of hill about 350 feet high	40	0
No. 19.—Slope showing above some masses of conglomerate, like that of division 18, perhaps not in place, with, at places below this, some reddish clays; altogether space enough for 500 to 600 feet in thickness	600	0
No. 20.—Greenish-white sandstone	40	0
No. 21.—Brownish clays and sandy layers	60	0
No. 22.—Brownish clays and beds of sandstone, the latter light gray below	110	0
No. 23.—Whitish sandstone—forms crest of hill about 220 to 240 feet in height	40	0
No. 24.—Conglomerate and some red clays	20	0
No. 25.—Brownish and reddish clays with a few distantly separated thin beds and layers of gray sandstone, altogether 750 to 800 feet in thickness	800	0
No. 26.—Gray sandstone in place, apparently connected with some masses (that *may* not be in place) so as to include space enough for 60 to 80 feet—forms crest of a hill	80	0
No. 27. A long space of perhaps 260 yards or more, with only a few low exposures of light-gray sandstone, showing a slight westward dip.		
No. 28. Numerous thin seams and layers of dark carbonaceous shales, with harder thin bands of various colored argillaceous, arenaceous, and calcareous matter, including a few very thin streaks of coal; the whole being highly charged with vast numbers of fresh and brackish-water shells, such as species of *Unio*, *Corbicula*, *Corbula*, *Pyrgulifera*, *Viviparus*, *Melampus*, &c. Dip nearly east, about 75° below the horizon; thickness 175 to 200 feet exposed	200	0

This section has been constructed rather with the view of giving a general idea of the upheaved and confused condition of the strata, and (so far as can be done) of the relations of the undoubted Cretaceous beds containing workable beds of coal here, to the fresh and brackish-water formation at its western end, than as an illustration of minute details. The elevations, as well as the horizontal distances between exposures, are only given from estimates carefully made at the locality; while the thickness of the subordinate beds can scarcely be regarded as more than approximately correct, as they are not all sufficiently well exposed directly along the line of the section, to show their exact limits, and our examinations were not extended very far laterally. It is believed, however, that the section will be found sufficiently accurate to serve the purpose for which it is given.

That the strata in which the workable beds of coal occur here (divisions 1 to 12, inclusive) belong to the Cretaceous, has, as already explained, been well known for some years past. It is also evident that this formation belongs to the same series as the Coalville coals. The evidence of this is not only the general correspondence of the lithological characters of the rocks at these localities, but the presence here of some of the same species of fossils found associated with the coal beds at Coalville. Three of these fossils, *Ostrea soleniscus*, *Trapezium micronema, and Inoceramus problematicus*, are also peculiar forms that can be identified with the fullest confidence.

All of that portion of the well-marked Cretaceous series here forming divisions 1 to 10, inclusive, along with an important bed of coal, it will be seen, stands in very nearly a vertical posture. On going a little farther westward, however, across a lower space, showing no rocks, we come to another Cretaceous exposure, (division 12 of the section,) consisting of thin layers of light colored sandstone, including a workable bed of coal, all dipping at an angle 55° below the horizon, in a nearly south-southeast direction. In this sandstone, above the coal, numerous casts of *Inoceramus problematicus*, and a few other Cretaceous fossils occur.

That the bed of coal found in this last mentioned outcrop, although said to agree with the bed 7 in thickness and other characters, is really not a part of the latter thrown over from above, or flexed and thrust up from beneath, is almost beyond doubt; because the rocks in which it is included do not agree lithologically with those immediately associated with the bed 7, while none of the fossils filling the sandstone of division 12 were seen in any of the rocks directly associated with the coal 7.

It therefore appears to be quite evident that there are at least two distinct beds of coal in the Cretaceous rocks here. Exactly how the beds forming division 12, with their included coal, connect with the other Cretaceous strata, included in the divisions 1 to 10, we cannot very clearly explain. The probability is, however, that they, and possibly other associated strata hidden under the soil, were originally tilted with the other Cretaceous beds, (1 to 10,) to a vertical posture at the time of the upheaval, and then fell over to the present inclined condition. We observed no evidence whatever that they correspond to any part of the series included in the same section farther west.

If only the strata already mentioned (1 to 12 inclusive) at this locality are Cretaceous there would then be, exclusive of other beds that may be hidden in the spaces 11 and 13, about 1,213 feet of rocks seen here that are certainly of Cretaceous age.

West of the out-crop of division 12, we have first another lower space of probably about 450 feet, in which no exposures of rock in place were seen. Then we come suddenly to a great series of sandstones, clays, conglomerates, &c., more than 2,000 feet in thickness, (forming divisions 14 to 26, inclusive of the section,) all standing in a vertical posture, excepting the beds from 14 to about the 18th, all of which lean slightly to the eastward of an exact perpendicular. Whether or not all of this great series, from division 14 to 26, should also be included in the Cretaceous along with those forming the eastern portions of the section, we were unable to determine, because we saw no organic remains in any of these beds, excepting a few undeterminable fragments of shells in the upper layer of division 15. The fact, however, that these strata stand so very nearly conformable to the well-marked Cretaceous beds, from 1 to 10, would rather favor the conclusion that they belong to the same system of rocks, though it would not necessarily demonstrate that this is the case.

West of division 26, we come to a space of about 260 yards or more, in which no rocks were observed in place, excepting a few low out-crops of light grayish sandstone, but little above the base line of the section. These are almost horizontal, or show only a slight inclination below the horizon toward the west; being thus strikingly unconformable to all of the other strata of the section. We saw no fossils in these beds, but they are almost certainly Tertiary.

Immediately on the west of the last-mentioned outcrops, and nearly in contact with one of them, there is exposed, in a cut made for the passage of the railroad, one of the most interesting series of beds (division 28) anywhere to be seen on the whole line of the Union Pacific Railroad.* This cut is about 150 to 200 yards in length, and passes through the strata nearly at right angles to their strike. The beds thus exposed consist of numerous thin seams of dark and light grayish colors alternating, so as to present a banded or striped appearance, the darker bands being more or less Carbonaceous, or even in some cases containing thin streaks of coal; while the lighter layers are more arenaceous, calcareous, or argillaceous. All of these beds and seams are tilted up so as to dip nearly eastward at an angle of about 75° below the horizon, being thus not exactly conformable to any of the other divisions of the section, though apparently upheaved at the same time. They contain immense numbers of fossil shells, belonging to a few species of fresh and brackish water types, some of which are closely allied to European Lower Eocene species.

Toward the western extremity of this cut the upper ends of the strata are suddenly flexed westward, as if they had been struck, after their upheaval, by an iceberg, or some other tremendous force, coming from the east. There is no evidence, however, that this flexure was produced by any agency of this kind; on the contrary, it is almost certainly a mere fragment, as it were, of one of the folds of the strata, caused by the powerful forces to which they have been subjected, by the combined action of upheavals and lateral pressure.

This division of the section, I have always referred provisionally to the Lower Eocene, though I have, at the same time, intimated that it may yet be found to belong more properly to the Upper Cretaceous. I will return to this subject again, however, in another place, further on, when speaking of Tertiary collections.

In regard to the coal beds 7 and 12, in the Cretaceous formation here at Bear River, I should think that there can scarcely be any reasonable doubt that they will be of considerable value. The mines had, however, apparently been worked but little, and as nothing had been done in them for some time before our visit, the entrances were partly filled by the falling of the adjacent rocks and shale, so that we could not examine them very carefully. We were informed by Mr. Thorpe, however, the owner of the property, that each of the beds seen there is 7½ feet in thickness, and that the coal is of excellent quality. It is doubtless similar to that mined in the same formation at Coalville. The mines are exceedingly convenient to the railroad, which passes along so close to that in the bed 7, that the miners' carts can run out upon a platform at the entrance of the mine and tip directly into coal-cars on the railroad; while the opening into the other bed, 12, is only about 100 to 150 yards from the road.

Below Gallatin City.—The fossils from near the Missouri River, below Gallatin City, Montana, belong clearly and beyond doubt to the Cretaceous, and about to the horizon of the Fort Benton group or subdivision of the Upper Missouri Cretaceous series. A few of the bivalves appear to belong to the fresh or brackish water type, *Veloritina*, but all of the others are marine forms. It is an interesting fact that a *Trigonia*, in this collection, is so near *T. Evansi* from the Cretaceous beds of Vancouver's Island, that no reliable differences can be seen from the imperfect specimens found. So far as I have been able to de-

* For a very minutely detailed section of this cut, prepared by H. R. Durkee, esq., one of the engineers of the Union Pacific Railroad, see Dr. Hayden's report of 1870, p. 153. It only illustrates the beds seen in the cut, however, without showing their relations to the other beds seen in our section.

termine, none of the species from this locality seem to be certainly identical with any of those from any of the recognized subdivisions of the Upper Missouri Cretaceous, but some of them occur at other localities along with the characteristic forms of the Benton group.

Cinnabar Mountain.—The species from Cinnabar Mountain, Yellowstone Valley, belong, almost certainly, to the same horizon as those from Missouri River below Gallatin, the species of *Trigonia* mentioned from that locality being the same found at this. There can be little doubt in regard to these fossils belonging to the Fort Benton group of the Cretaceous, because I recognize among them *Scaphites ventricosus*, one of the most characteristic fossils of that horizon.

Bridger Peak.—The few things from east foot of Bridger Peak, (four miles from Fort Ellis,) Montana, are nearly all mere casts in a bad state of preservation, but, so far as I have been able to determine, none of the species appear to be identical with any of those known from the recognized subdivisions of the Upper Missouri Cretaceous; though, from their general facies, there is still little room to doubt that they belong to the Cretaceous system. They are certainly not Tertiary.

Colorado Springs.—A small collection from Colorado Springs, Colorado, evidently belong to the horizon of the Fort Pierre group of the Upper Missouri Cretaceous series.

Rock Creek.—The collections found by Professor Lesquereux on Rock Creek are all Cretaceous forms from the horizon of the Niobrara division of the Upper Missouri.

Fort Harker.—Those collected by him from near Fort Harker are also Cretaceous, and from the horizon of the Fort Benton group.

Bitter Creek series.—Along Bitter Creek, (a small tributary of Green River, in Wyoming,) from Black Butte northwestward to Salt Wells Station on the Union Pacific Railroad, and at Rock Spring and some other points west of Salt Wells, there is an extensive series of rocks, in regard to the age of which somewhat different opinions are entertained. For a detailed description and sections of this formation the reader is referred to Dr. Bannister's report, forming a following section of this volume, my object here being merely to say a few words mainly respecting the age of this group. In general terms it may be briefly described as a vast succession of rather soft, light-yellowish, lead-gray, and whitish sandstones, with seams and beds of various colored clays, shale, and good coal, the whole attaining an aggregate thickness of more than 4,000 feet.

The invertebrate fossils hitherto found at different horizons in this series present a mingling of fresh, brackish, and salt-water types, such as *Goniobasis*, *Viviparus*, *Corbicula*, *Corbula*, *Ostrea*, *Anomia*, and *Modiola*. All of these genera are found represented, either directly in the same bed, or very nearly so, near the very top of the series at Black Butte Station, in Division E of Dr. Bannister's section. At Hallville, three miles farther west, and 1,600 to 1,800 feet lower in the series, in Division K of the same section, a *Corbicula*, and another form like a *Corbula*, both scarcely, if at all, distinguishable from species found in the higher beds at Black Butte, occur in a black slate over a bed of coal. Near the same horizon, at Point of Rocks, seven or eight miles farther down Bitter Creek, great numbers of a fine large oyster also occur, above the fourth (or still higher bed) of a series of beds of coal, seen in the face of a nearly perpendicular precipice, about 300 feet above the bottom of the valley on the north side. Three or four miles west of this, and at a horizon probably 500 feet lower, in Division M, of Dr. Bannister's section, there is a bed 15 to 18 inches in thickness, almost entirely composed of millions of shells of *Anomia* and *Ostrea*, together with a few of *Corbula*, *Corbicula*, *Modiola*, and *Goniobasis*, all apparently of different species from (but some of them very closely allied to) those found higher in the series. Again, at Rock Springs, perhaps twelve miles farther westward, and not far below the horizon of the last-mentioned localities, we found numerous specimens of *Corbula*, *Ostrea*, *Corbicula*, *Modiola*, and *Goniobasis*, all associated in the same bed, the species being again distinct, excepting probably the *Corbicula* and *Ostrea*, from those found at any of the other localities, though the *Corbula* and *Goniobasis* are of the same type as those found at Black Butte.

At Black Butte Station, in the bed containing most of the shells already mentioned as occurring there, we found, along with numerous specimens of beautiful impressions of leaves of dicotyledonous trees, some large bones of a huge reptilian.* We also observed nearly all through this formation impressions of the leaves of the higher types of dicotyledonous trees, in some instances belonging to the same genera as those composing our existing forests of the temperate zone; also fragments of fan-palm leaves, and the stems of marine plants.†

From such a group of organic remains, it seems scarcely to admit of doubt that this formation was deposited in a body of water, which, although salt enough to permit the existence of some marine types, was still probably so tempered by the influx of the streams that brought in the land and fresh-water remains, as to be at least unfavorable to the extensive development of marine life. The presence of numerous beds and seams of coal also indicate that there were alternate elevations and depressions of this whole region during the deposition of this formation. That is, if we admit the most generally accepted theory that such deposits of coal were formed by the growth, on the spot, of vegetation in marshes at, or a little above, the sea-level. Because we find some marine or brackish water types between nearly all the coal-beds, thus showing that after the accumulation of the material of each bed of coal, it was again covered by salt, or at least strongly brackish, water.

It is not necessary, however, to suppose that each elevation was equal to the preceding subsidence, because the accumulation of sedimentary matter during the interval probably largely compensated for the sinking, so that the elevations may have been comparatively very slight to bring the bottom again slightly above the sea-level. At any rate, whatever theory we may adopt in regard to the formation of such coals, it appears exceedingly improbable that the coal beds of this region were formed by the drifting together of the trunks and fragments of trees and other vegetation; because, although we sometimes see small fragments of this coal showing woody structure, as we do in those of the old Carboniferous period, they are not in any proper sense lignite, so far as structure is concerned, but seem to have been mainly formed by the growth and accumulation of smaller kinds of vegetation, and are as persistent, compact, and homogeneous as any of the old bituminous varieties.

From near Salt Wells southeastward to Black Butte Station, this

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* On hearing of these discoveries from some friends from the East, to whom I had mentioned the same at Salt Lake City, Professor Cope visited the locality on his return home, some time in August, 1872, and dug out more of the bones of the reptilian, which he soon after described in a paper sent on to the Philosophical Society, as the type of a new genus of Dinosaurians, under the name *Agathaumas sylvestris*, and expressed the opinion that it proves the rock to be Cretaceous.

† All of the remains of plants collected from this and other formations by the Survey, have been ably reported on by Professor Lesquereux.

formation shows a gentle eastward dip, which causes it to pass under another very similar series of strata, to which Dr. Hayden has applied the name Washakie group. In the latter, so far as our present knowledge extends, only fresh water and land types of fossils have yet been found, and we have always regarded it as being of Tertiary age. Exactly where the one ends and the other begins we did not see; though the Bitter Creek series certainly come eastward to division E of Dr. Bannister's section, at Black Butte, as we found its characteristic molluscan remains there in the same bed containing the reptilian bones.

Between Black Butte and Bitter Creek Stations (separated by a distance of only about six miles by a right line east and west) we observed no marked change of lithological characters, from the Bitter Creek series to the Washakie group, while the two series seemed to be conformable in dip. Although our observations in this interval were too limited to warrant a positive opinion on that point, we left Black Butte Station under the impression that the brackish-water types of the Bitter Creek series probably extend little, if any, higher in the series, or farther eastward, than the tops of the hills near Black Butte.

At Salt Wells station, which is situated in an anticlinal, owing to the rising of the strata, as we come westward, (see Dr. Bannister's section,) a lower series of rocks comes up from beneath the Bitter Creek beds. This lower group consists of thin layers of grayish and drab slabby sandstones, and shales with, at places, some appearances of coal in the upper part. It seems to be conformable with the Bitter Creek series, and probably belongs to the Cretaceous, though we saw no fossils in it. From exposures seen near Salt Wells, there would appear to be 700 to possibly 1,000 feet of these lower rocks here, above the valley.

In going westward from Salt Wells station we soon observe a reverse of dip, and the Bitter Creek beds again appear, dipping westward or northwestward. At, and near Rock Springs, extensive coal-beds occur in this formation, and here we found associated with or near one of these beds the fresh, brackish, and salt-water types of shells already mentioned. The dip of the strata here is to the northwestward, at an angle of 10° to 12° below the horizon, so that a short distance farther west the whole group passes under a great series of whitish, greenish, and at places reddish laminated clay of Tertiary age, forming Dr. Hayden's Green River group, and rising into hills 700 to 800 feet in height above the valley. The strata of this latter group are distinctly unconformable to those of the Bitter Creek series, their dip being only 2° to 3° westward.

But, returning to the question respecting the age of this Bitter Creek series, it may be stated, in the first place, that Mr. Emmons evidently regarded it as Cretaceous, as may be seen from his remarks in Mr. King's report, published in 1870; while Dr. Hayden favored the conclusion that it is a marine Tertiary group, or a transition series between the Tertiary and Cretaceous, in his reports of that and the following years.

The only fossils I had ever seen from this formation, previous to visiting the region during the past summer, were two species of *Ostrea* and one of *Anomia* from Point of Rocks; and two shells, one, or possibly both, related to *Corbicula*, from Hallville. Those from Point of Rocks I referred to the Cretaceous, placing them in the Cretaceous list, in Dr. Hayden's report of 1871. This I did, mainly because there were among them no fresh-water, or strictly brackish-water types; while up to this time we know of no Tertiary of exclusively marine origin in all this internal region of the continent. I was also, in part, influenced in making this reference by the similarity of one of the oysters to a Cretaceous species found in California, while the *Anomia* likewise closely resembled a Texas Cretaceous shell, described by Roemer under the name of *Ostrea anomiæformis*, which certainly seems not to be a true oyster. The two shells from Hallville, however, I referred to the Eocene, not only because they are very closely allied to Eocene brackish-water forms from the Paris Basin, (peculiar depressed and elongated forms of *Corbicula*, ?) but because I was not aware at the time that the Hallville mines occur in the same formation as the Point of Rock beds, nor even within fifty to seventy-five miles of the same locality. Hallville is not laid down on any map I have even yet seen, and I was entirely ignorant of its position, both geologically and geographically, with relation to Point of Rocks; and as the species were new, I had no other guide than their affinities, which would certainly place them in the Tertiary.

On visiting these localities, however, last summer, I was somewhat surprised to find that the Hallville mines are only some seven or eight miles from Point of Rocks, and belong to the same geological formation. A careful examination also soon rendered it evident that all of the rocks, for 1,600 to 1,800 feet or more above the Hallville coal-beds, up to and including the stratum in which we found the large reptilian remains at Black Butte, and for even a little greater thickness below the Hallville horizon, certainly belong to the same group or series of strata; and that fresh and brackish-water types of fossils occur along with salt-water forms, at all horizons, wherever we found any organic remains throughout this whole series.

As we discovered in these rocks between three and four times as many species of fossils as had been previously known from the same, it becomes a matter of some interest to consider the whole with regard to their bearing on the question as to the age of the group. The reptilian remains found at Black Butte, near the top of the series, have, as elsewhere stated, been investigated by Professor Cope, and by him pronounced to be decidedly Dinosaurian and, therefore, indicative of Cretaceous age; on the other hand, the fossil plants from the same beds have been studied by Professor Lesquereux, who informs me that they are unquestionable Tertiary types. My own investigations having been confined to the invertebrates, it is of these chiefly that I will speak here. In the first place, it will be seen that all of these yet known belong to a few genera of mollusks, represented by some twelve or fourteen species. And just here it may be stated that, although partly committed in favor of the opinion that this formation belongs to the Cretaceous, and still provisionally viewing it as most probably such, I do not wish to disguise or conceal the fact that the evidence favoring this conclusion to be derived from the mollusks alone, as now known, is by no means strong or convincing. The genera are probably all common, both to the Cretaceous and Tertiary, as well as to the present epoch, unless *Leptesthes* and *Veloritina*, which have been separated subgenerically from *Corbicula*, may be distinct *genera*, the European representatives of these being mainly, if not entirely, Tertiary forms, while they do not appear to include living species. *Goniobasis* is also not known in either Cretaceous or Tertiary rocks of the Old World; but then it is an American type, greatly developed among our existing mollusca, as well as in the far western Tertiary rocks, and we can scarcely doubt that it will be found in unquestionable Cretaceous beds there, even if some of the imperfect specimens already known from the same are not such. It should be remembered, however, that even the specimens I have referred to this genus from the Bitter Creek beds are not in a condition to show the aperture, beyond doubt, to possess the characters of *Goniobasis*.

The entire absence among the fossils yet known from this formation of *Baculites*, *Scaphites*, *Ancyloceras*, *Ptychoceras*, *Ammonites*, *Gyrodes*, *Anchura*, *Inoceramus*, and all of the other long list of genera characteristic of the Cretaceous, or in part also extending into older rocks, certainly leaves its molluscan fauna with a strong Tertiary facies. Nor can we quite satisfactorily explain this away on the ground that the water in which this series of rocks was deposited partook too much of the character of that of an estuary, to have permitted the existence of any of these marine genera, because we do find in it the genus *Ostrea*, *Anomia*, and *Modiola*, which probably required water salt enough to have permitted the existence of *Inoceramus*, *Anchura*, and *Gyrodes*, if not of some or all of the genera mentioned above. Indeed, at Coalville, we find *Inoceramus* associated with some brackish-water types, and the additional Cretaceous genera, *Cyprimera*, *Anchura*, *Gyrodes*, &c., in closely-associated beds.

When we come to consider the invertebrate fossils yet known from this formation, in their specific relations, we find all, with possibly two or three exceptions, new to science and different from those yet found either at Bear River, Coalville, or indeed elsewhere in any established horizon; so that we can scarcely more than conjecture from their specific affinities to known forms as to the probable age of the rocks in which we find them. Considered in this respect their evidence, however, is conflicting. Two of the species of *Corbula*, for instance, (*C. tropidophora* and *C. undifera*,) are most similar to species found in the brackish-water beds, at the mouth of Judith River on the Upper Missouri, that we have always considered Lower Tertiary; though there are some reason for suspecting that they may be Upper Cretaceous. A *Corbicula*, both from the Black Butte and Point of Rocks localities, is even so *very* nearly like *C. cytheriformis* from the Judith River beds, that I have referred it doubtfully to that species.

Again, the species *Anomia gryphorhynchus*, found so abundantly at Point of Rocks, in the same bed with the above-mentioned *Corbicula* and *Corbula tropidophora*, so closely resembles a Texas Cretaceous shell described by Roemer under the name *Ostrea anomiæformis*, that I am strongly inclined to suspect they may be the same; though whether identical or not, at least our shell is certainly not an oyster, as it has its muscular and cartilage scars precisely as in *Anomia*, while its beak is never marginal, and it has no ligament area. In all of these, (and indeed in all other characters,) the Texas shell, as illustrated by Roemer, seems to agree precisely with ours, excepting that he represents it as having only one central muscular scar, instead of three. In many of our specimens, however, the two smaller of these scars are very obscure, and might be easily overlooked. It is true he figures a nearly flat valve without any byssal perforation, and a convex one, as opposite valves; and, if they are such, the shell would certainly not be an *Anomia*. Among a large collection of our shells, including thousands of specimens, however, I have not yet seen a single perforated valve, though they vary much in convexity, some of the valves being nearly as depressed as the one Roemer figures as the upper valve, supposing it to be an oyster. If these depressed specimens in our collection are opposite valves to the convex ones, then the shell would neither be an *Ostrea* nor an *Anomia*, but would almost certainly fall into Morris and Lycett's genus *Placunopsis*, which, so far as known in Europe, is a Jurassic group. Consequently, if our shell should fall into that genus, it would, when viewed in connection with its associates, and all the other known facts, furnish a strong argument in favor of the formation being at least as old as the Cretaceous. There are good reasons, however, for believing these depressed specimens, as well as the convex ones, are all upper valves of the same shell, only modified in convexity by accidental circumstances of station, as their slight obliquity as seen, for instance, in a look at the interior of both, is found to be in the same direction, instead of the reverse, as would be the case if they were opposite valves of the same shell; while among thousands of specimens no example of a depressed and a convex valve united has been seen, nor have any been found that would come near fitting together.

On the other hand, the Corbiculas are decidedly Tertiary in their specific affinities, as well as in their subgeneric; *C. fracta*, for instance, and *C. crassatelliformis*, from the Hallville mines, being very closely allied to Paris Basin Tertiary forms, the first-mentioned species being the type of a sub-genus, so far as known, peculiar to the Tertiary elsewhere. The same may also be said of *C. cytheriformis*, which also seems to belong to a group (*Veloritina*) peculiar to the Tertiary in Europe.

But the most surprising fact to me, supposing this to be a Cretaceous formation, is, that we found directly associated with the reptilian remains at Black Butte, a shell I cannot distinguish from *Viviparus trochiformis*, originally described from the Lignitic formation at Fort Clark, on the Upper Missouri, a formation that has always been regarded as Tertiary by all who have studied its fossils, both animal and vegetable. The specimen mentioned does not show the aperture, nor all of the body volution; but, as far as can be seen, it agrees so exactly with that very peculiar species in size, the form and proportions of its volutions, the slopes of its spires, its surface markings, the nature of its suture, and, in fact, in every respect so far as can be seen, that I have scarcely any doubt of its identity with the same.

The occurrence of this last-mentioned species here, along with a Cretaceous type of reptilian, and a *Corbicula* apparently identical with *C. cytheriformis* of the Judith River brackish-water beds, together with the presence of Corbulas very closely allied to Judith River species, at lower horizons in this series, and the occurrence of some vertebrates of Cretaceous affinities at the Judith River localities, would certainly strongly favor the conclusion, not only that this Judith formation, the age of which has so long been in doubt, is also Cretaceous; but that even the higher fresh-water lignite formation at Fort Clark and other Upper Missouri localities may also be Upper Cretaceous instead of Lower Tertiary.

That the Judith River beds may be Cretaceous, I am, in the light of all now known of the geology of this great internal region of the continent, rather inclined to believe. But it would take very strong evidence to convince me that the higher fresh-water lignite series of the Upper Missouri is more ancient than the Lower Eocene. That they are not is certainly strongly indicated, not only by the modern affinities of their molluscan remains, but also by the state of the preservation of the latter. Indeed, these shells (*Planorbis*, *Viviparus*, *Goniobasis*, *Physa*, &c.) are found loose, as they fall from the incoherent sand in great numbers, so entirely free from adhering matrix, either internal or external, and so little changed, that any one not familiar with the existing species of the country would naturally think them merely dead shells of the same, picked up along the shores of the streams. The entire flora of this Upper Missouri lignite group has also always been considered, by the highest authorities on that department of paleontology, unquestionably Tertiary.

From the foregoing remarks it will be seen that our present information in regard to the age of the Bitter Creek series may be summarily stated as follows:

1. That it is conformable to an extensive fresh-water Tertiary formation above, from which it does not differ materially in lithological characters, excepting in containing numerous beds and seams of coal.*

2. That it seems also to be conformable to a somewhat differently composed group of strata (1,000 feet, or possibly much more in thickness) below, apparently containing little if any coal, and believed to be of Cretaceous age.

3. That it shows no essential difference of lithological characters from the Cretaceous coal-bearing rocks at Bear River and Coalville.

4. That its entire group of vegetable remains (as determined by Professor Lesquereux) presents exclusively and decidedly Tertiary affinities, excepting one peculiar marine plant, (*Halymenites*,) which also occurs thousands of feet beneath undoubted Cretaceous fossils, at Coalville, in Utah.†

5. That all of its animal remains yet known are specifically different from any of those hitherto found in any of the other formations of this region, or, with perhaps two, or possibly three exceptions, elsewhere.

6. That all of its known invertebrate remains are mollusks, consisting of about thirteen species and varieties of marine, brackish, and fresh-water types, none of which belong to genera *peculiar* to the Cretaceous or any older rocks, but all to such as are alike common to the Cretaceous, Tertiary, and present epochs, with possibly the exception of *Goniobasis*, (which is not yet certainly known from the Cretaceous.)

7. That, on the one hand, two or three of its species belong to sections or subgenera (*Leptesthes* and *Veloritina*) apparently characteristic of the Eocene Tertiary of Europe, and are even very closely allied to species of that age found in the Paris Basin; while, on the other hand, one species seems to be conspecific with, and two congeneric with, (and closely related specifically to,) forms found in brackish-water beds on the Upper Missouri, containing vertebrate remains most nearly allied to types hitherto deemed characteristic of the Cretaceous.

8. That one species of *Anomia* found in it is very similar to a Texas Cretaceous shell, and perhaps specifically identical with it; while a *Viviparus*, found in one of the upper beds, is almost certainly identical with the *V. trochiformis* of the fresh-water Lignite formation of the Upper Missouri; a formation that has always, and by all authorities, been considered Tertiary.

9. That the only vertebrate remains yet found in it are those of a large reptilian, (occurring in direct association with the *Viviparus* mentioned above,) which, according to Professor Cope, is a decidedly Cretaceous type, being, as he states, a huge Dinosaurian.

It thus becomes manifest that the paleontological evidence bearing on the question of the age of this formation, so far as yet known, is of a very conflicting nature; though aside from the Dinosaurian, the organic remains favor the conclusion that it is Tertiary. The testimony of the plants, however, on this point, although they doubtless represent what would be in Europe considered clearly a Tertiary flora, is weakened by

* See Mr. Bannister's section, farther on.

† This fossil, however, I am informed by Professor Lesquereux, likewise occurs at numerous localities in Colorado and elsewhere, in beds he regards as decidedly Tertiary.

the fact that we already know that there is in Nebraska in clearly Cretaceous rocks, a flora that was referred by the highest European authority to the Miocene. I do not know, however, how far Professor Lesquereux's opinion that the Bitter Creek plants are Tertiary may rest upon specific identifications among them of forms known to occur in well determined Tertiary rocks elsewhere.

TERTIARY AGE.

*Brackish-water beds of Bear River.**—In redemption of the promise made, I now return to the consideration of the age of the brackish-water beds of Bear River, (division 28 of sec. —, on p. —.) These have always been regarded by me provisionally as Lower Eocene, not only because their included fossil remains were closely related to forms occurring in the Eocene lignite beds and deposits of the Paris Basin and the mouth of the Rhone, but also because none of them belonged to characteristic Cretaceous types. If, however, the beds of Bitter Creek and the Judith River should finally prove to be Cretaceous, the brackish-water beds in question must probably be relegated to the same epoch, though they are not known to hold any species in common with the Bitter Creek beds, and but one with those of Judith River. Their approximate conformability with Cretaceous beds, indicating disturbance and upheaval at the same time, favors this conclusion. I may add that I have not been wholly without the suspicion that they might prove to be Cretaceous, and in a report to Mr. Clarence King, published in his report on the geological survey of the fortieth parallel, (vol. 3, p. 466,) I summed up my conclusions in the following terms:

> While I am therefore willing to admit that facts may yet be discovered that will warrant the conclusion that some of these estuary beds, so widely distributed here, should be included rather in the Cretaceous than in the Tertiary, it seems to me that such evidence must either come from included *vertebrate* remains, or from further discoveries respecting the stratigraphical position of these beds with relation to other established horizons, since all the molluscan remains yet known from them (my own opinions are entirely based on the latter) seem to point to a later origin.

This paragraph has been misunderstood by Professor Cope,† who has brought it into context with the statement respecting the age of the Bitter Creek coal strata, and asserted that the nearest approximation to the point of identification of the Bitter Creek strata with the Cretaceous were thus made by myself, and conveyed the impression that no positive reference had been made of any of the Bear River beds to this period. This, however, as has been shown elsewhere, had been done in the most unequivocal manner with regard to the deposits of marine coal at Bear River City, Wyoming, as well as at Coalville, Utah.

I had intended to make more extended remarks on the several Tertiary deposits referred to, and to have given lists of fossils from them, but sudden illness, and the necessity for sending copy without further delay to the Public Printer, have compelled the relinquishment for the present of such design.

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* Until some decidedly Cretaceous fossils have been somewhere found in or above these beds, they may be left in the lower Eocene. Our discovery of a group of fresh-water shells as modern in appearance as these (though all different species) at Coalville, far down in the Cretaceous, shows how cautious we should be in deciding such questions.

† Proceedings American Philosophical Society. Extras dated in MSS. February 7, 1873.

LISTS OF FOSSILS COLLECTED.

SILURIAN SPECIES.

EAST SIDE OF GALLATIN RIVER, ABOVE GALLATIN CITY, MONTANA.

First or upper division.

Names.	Remarks.
1. *Lingulepis*.*	
2. *Conocoryphe*	Merely fragments.
3. *Bathyurus* (?)	Merely fragments.
4. *Asaphus* (?)	Merely fragments.

Second division.

5. *Acrotreta*.	
6. *Lingula*	A very small shining species.

Third division.

7. *Acrotreta subconica*, Kutorga.†	
8. *Iphidea sculptilis*, Meek	See description in this report.
9. *Hyolithes gregaria*, (*Theca gregaria*, M. and H.)	Mere cast, but agrees in size and form with this species.
10. *Agnostus bidens*, Meek ‡	
11. *Conocoryphe* (*Conocephalites*) *Gallatinensis*, Meek	See description in this report.

* Two specimens only of this fossil are contained in the collection. These have exactly the outline, and agree well in most other respects with a form Professor Hall has referred, doubtfully, to the shorter valve of *L. pinnæformis*, Owen, from the horizon of the Potsdam. It also shows the same radiating striæ seen on exfoliated specimens of that species, and has its beak truncated, as in Fig. 15, pl. 6, Regents' Sixteenth Report on State Cab, N. H., New York; though casts of the internal markings, as seen through the translucent shell, seem not to present a flabelliform appearance, as in Professor Hall's figuie cited, but have the same elongated trilobate outline seen in the other valve of *L. pinnæformis*.

† This little shell seems to be very similar to Kutorga's species, but it has the ventral valve more elevated than *A. gemma*, Billings, and the false area marked by a distinct mesial furrow, said not to be defined in latter. The larger specimens measure 0.15 inch from the front to the apex of the ventral valve and 0.11 inch in breadth. The beak of this valve is pointed, and generally bent slightly forward. The surface is a deep brownish color, shining as in *Lingula*, and marked by minute lines of growth. It is quite probable that a direct comparison of specimens would show our species to be distinct from the Russian shell. If so, I would propose to call the species *A. attenuata*.

‡ Resembles *A. pisiformis*, Linn., (sp.,) but has a proportionally shorter pygidium, more truncated between the posterior points; while its mesial lobe is shorter, higher, and surmounted by a prominent node anteriorly, and more flattened and pointed behind, without any traces of a mesial transverse furrow. Its head is still more nearly like that of *A. pisiformis*, but wants the mesial furrow extending forward from the glabella to the anterior margin. Its glabella is most prominent behind, where it shows a tendency to swell into a little node. Surface finely granular.

12. *Conocoryphe* .... Undetermined fragments.
13. *Bathyurus* (?) *Haydenii*, Meek... Described in this report.
14. *Bathyurus serratus*, Meek...... Described in this report.

Fourth or lowest division.

15. *Cruziana* *....................
16. *Lingula*, or *Lingulepis* .... Imperfect specimens.
17. *Conocoryphe* .... Fragments.
18. *Bathyurus*, or *Asaphus*......... Fragments.

FLAT-HEAD PASS, MONTANA.

Names.	Remarks.
1. *Bathyurellus* (*Dikelocephalus* ?) *truncatus*, Meek.............	Described in this report.
2. *Bathyurellus*, (*Asaphiscus* ?)	Described in this report.

NEAR MALADE CITY, NORTHERN UTAH.

Names.	Remarks.
1. *Camerella Calcifera*, Billings.†	
2. *Orthis hippolite*, Billings. (?)‡	
3. *Orthis*..........................	Very finely striated and like *O. electra*, Billings.
4. *Orthis*..........................	A larger and more compressed species.
5. *Euomphalus*(?) *trochiscus*, Meek§.	
6. *Euomphalus* (?) *rotuliformis*, Meek.	
7. *Euomphalus*, or *Ophileta*.	
8. *Agnostus Josepha*, Hall (?).‖	
9. *Conocoryphe*	Fragments of perhaps several species.
10. *Bathyurellus* (*Asaphiscus*) *Bradleyi*, Meek	Described in this report.
11. *Bathyurus Saffordi*, Billings...	Only the pygidium, but agrees exactly with Canadian specimens sent by Mr. Billings.

* The name *Cruziana*, d'Orbigny, 1842, (Voy. dans l'Amer. Merid., t. 3, part 2d, p. 30,) having priority over *Rusophycus*, (*Ryssophycus*,) Hall, 1852, will have to be retained for these curious fossils.

† The specimens are all separate valves, more or less broken, or partly hidden in the matrix; but so far as can be seen they certainly agree well in size and all external characters with Mr. Billings' species, with possibly the exception of having a somewhat wider and deeper mesial sinus and more prominent mesial fold.

‡ Agrees pretty nearly with the Canadian shell, though its mesial sinus is somewhat wider and deeper. It may be distinct, but the specimens are too imperfect for satisfactory comparison.

§ These have been described in the Proceedings of the Academy Natural Sciences, Philadelphia, Ap., 1870, p. 61, and will be figured in Mr. King's report.

‖ The specimens of this little trilobite seem to agree closely with Professor Hall's species, excepting in some of the minute and apparently variable details of the mesial lobe of the head and pygidium. So far as I have been able to see, however, it would also seem not to have the posterior lateral angles of the cheeks armed with little projecting points, as in the Wisconsin species. If these little spines do not exist in our specimens, (none of which are in a condition to remove all doubts on this point,) they would almost certainly belong to a distinct species, in which case I would propose for the name *Agnostus Maladensis*.

12. *Bathyurus*, or *Dikelocephalus*	Fragments.
13. *Bathyurellus* (*Dikelocephalus* (?) *truncatus*, Meek	Described in this report. Occurs also at Flat-Head Pass.
14. *Asaphus* (*Megalaspis* (?) *goniocercus*, Meek	Described in this report. Occurs at Flat-Head Pass.

WEST FACE OF BIG HORN MOUNTAIN, HEAD BUFFALO FORK.

Names.	Remarks.
1. *Conocoryphe*, and, perhaps, *Dikelocephalus**	Mere fragments.

CARBONIFEROUS SPECIES.

OUTLET OF MYSTIC LAKE, MONTANA.

Names.	Remarks.
1. *Zaphrentis*	A small species.
2. *Zaphrentis*	Fragment of a large species apparently of this genus.
3. *Ptilodictya* (*Stictopora* ?) *dictyota*, Meek†	
4. *Ptylodictya*	A merely branching species.
5. *Fenestella*	One or two species.
6. *Hemipronites crenistria*, Phillips	Rather more finely striated than usual.
7. *Chonetes*	An abundant medium sized species with very fine, dichotomous, radiated striæ, crossed by very minute concentric striæ; spines of cardinal margin, five on each side of beak.
8. *Productus longispinus*, Sowerby	A small form, apparently agreeing with Sowerby's species.
9. *Productus scabriculus*, Martin (?)	Specimens fragmentary.
10. *Rhynchonella*.	
11. *Spirifer*, (*Martinia*)	Of medium size.
12. *Spirifer* (*Martinia*) *lineata*, Martin.	
13. *Spirifer*	Similar to some varities of *S. increbescens*, Hall, which Mr. Davidson thought not distinct from *S. bisulcata*.

* The only part in the collection certainly known to belong to this species is the pygidium. This has much the general appearance of the corresponding part of a trilobite, figured by Mr. Billings, under the name of *Asaphus quadraticaudatus*, (Paleont., Canada, p. 271, Fig. 258,) but its lateral margins are straighter and its mesial lobe proportionally longer, with only three to five segments that pass straight across, instead of eight or nine arching forward. Its lateral lobes show three or four short segments, instead of only one, while they and the lateral margins show no traces of the striæ seen on Mr. Billings's species. Its lateral and posterior flattened margins are more suddenly defined from the swell of the lateral lobes.

† An anastomosing species, with divisions about 0.10 to 0.12 inch in breadth, by 0.04 to 0.05 inch in thickness, and connecting so as to form a reticulated structure, with fenestrules of a more or less oval form, about 0.24 inch in length by 0.16 inch in breadth. Pores small, with slightly raised margins, having the usual quincuncial arrangement, and forming six to eight longitudinal rows; non-poriferous margins rather sharp, and of moderate breadth.

14. *Spirifer*	With hinge-line much extended. and smaller and more numerous costæ then the last, being much like *S. biplicatus*, Hall, from the horizon of the Waverley Group, Ohio.
15. *Spirifer Mysticensis*, Meek.*	
16. *Retzia.*	

CAÑON, EAST SIDE OF MADISON RIVER, MONTANA.

Names.	Remarks.
1. *Platycrinites*	Detached base.
2. *Poteriocrinites.*	
3. *Hemipronites crenistria*, Phillips.	Some finely striated varities found at Mystic Lake.
4. *Strophomena analoga*, Phillips.	
5. *Productus semireticulatus*, Martin.	
6. *Productus longispinus*, Sowerby (?)	Same as No. 8 of list from Mystic Lake.
7. *Productus scabriculus*, Martin (?).	Same as No. 9 of list from Mystic Lake.
8. *Chonetes*	Same as No. 7 of list from Mystic Lake.
9. *Rhynchonella*	Same as No. 10 of list from Mystic Lake.
10. *Retzia*, (fragments)	
11. *Spirifer*	Same as No. 13 of list from Mystic Lake.
12. *Spirifer Mysticensis*, Meek.	
13. *Spirifer* (*Martinia*).	
14. *Terebratula*, (fragments)	
15. *Platyceras*	An arcuate conical species.
16. *Euomphalus*, (fragments of large species.)	
17. *Pleurotomaria.* (?)	

BRIDGER PEAK, NEAR FORT ELLIS, MONTANA.

Names.	Remarks.
1. *Lithostrotion*	A compound species with small corallites.
2. *Hemipronites crenistria*, Phillips (?)	Same variety as No. 6, Mystic Lake list.
3. *Hemipronites*	A much more finely striated species.
4. *Productus longispinus*, Sowerby (?).	Same as No. 8, Mystic Lake, and 6, Cañon, east side Madison River.

CAMP NO. 19, AUGUST 2, 1872, IDAHO TERRITORY.

Names.	Remarks.
1. *Lophophyllum.*	
2. *Zaphrentis.*	

* A medium sized, very transverse species, with mucronate lateral extremities, and 12 to 15 simple, radiating costæ on each lateral slope of each vale; mesial sinus mode, extended to the beak, with one rib in its bottom, and rarely faint traces of another on one or both sides of this toward the front; cardinal area, of moderate height, well defined, and more or less arched with the beak. Resembles *S. bimesialis*, Hall, (Iowa Report,) in size and form, but wants the lamellose imbricating concentric striæ seen on that species.

3. *Michelinia* .... Small irregular corallites.
4. *Syringopora.*
5. *Chonetes* .... Same as No. 7, Mystic Lake.
6. *Productus* .... Like *P. scabriculus*, same as No. 9, Mystic Lake.
7. *Hemipronites crenistria*, Phillips.
8. *Spirifer*, (*Martinia*) .... Same as No. 10, Mystic Lake, and No. 13, East Madison River.
9. *Spirifer.*
10. *Euomphalus*, (fragments.)

BLACK-TAIL DEER CREEK, MONTANA.

Names.	Remarks.
1. *Hemipronites crenistria*, Phillips (?)	Same as at Mystic Lake; Cañon, East Madison River, &c.
2. *Chonetes*	Same as No. 7, Mystic Lake; No. 8 Cañon, East Madison River, &c.
3. *Rhynchonella*	Rather small plicated, subtrigonal; very abundant species.
4. *Spirifer lineatus*, Martin.(?)	
5. *Spirifer*	Same as No. 12, Mystic Lake.
6. *Spirifer*	Same as No. 14, Mystic Lake.

NORTH GROS-VENTRES BUTTE, WYOMING.

Names.	Remarks.
1. *Zaphrentis.*	
2. *Hemipronites crenistria*, Phillips (?)	Same as at Mystic Lake, east side Madison River, Bridger Peak, &c.
3. *Spirifer*	Same as No. 12 at Mystic Lake, &c.
4. *Spirifer*, (*Martinia*)	Same as No. 10 at Mystic Lake, &c.

FLAT-HEAD PASS, MONTANA.

Names.	Remarks.
1. *Zaphrentis*	A small arcuated turbinate form.
2. *Syringopora.*	
3. *Hemipronites crenistria*, Phillips (?)	Same as at Mystic Lake, Gros-Ventres Butte, &c.
4. *Rhynchonella*	Fragment rather large, strongly plicated species.
5. *Spirifer*	Same as No. 12, Mystic Lake, &c.

NORTH SIDE HENRY'S LAKE, IDAHO.

Names.	Remarks.
1. *Hemipronites crenistria*, Phillips (?)	Same variety as at Mystic Lake, &c.
2. *Productus scabriculus*, Martin (?) sp.	Do. do.
3. *Spirifer*	Same as No. 12, Mystic Lake, &c.
4. *Terebratula.*	

CAÑON WEST OF GALLATIN RIVER, MONTANA.

Names.	Remarks.
1. *Chætetes*	Very slender ramose species.
2. *Zaphrentis.*	
3. *Syringopora.*	

4. *Platycrinites*	Merely the elliptic disk of the column
5. *Fenestella.*	
6. *Hemipronites crenistria*, Phillips (?)	Same as at Mystic Lake, &c.
7. *Strophomena analoga*, Phillips..	Same as from cañon, East Gallatin River.
8. *Chonetes*	Same as at Mystic Lake, &c.
9. *Productus semireticulatus*, Martin....................	Same as at east side Madison River.
10. *Productus*	Small hemispherical species.
11. *Productusl ongispinus*, Sowerby(?)	Same as from Mystic Lake Cañon, East Madison River, &c.
12. *Rhynchonella*	Same as from Mystic Lake.
13. *Retzia.*	
14. *Spirifer Mysticensis*, Meek	Same as from Mystic Lake, &c.
15. *Athyris* or *Martinia.*	
16. *Spirifer*	Same as No. 12, Mystic Lake.
17. *Euomphalus.*	

LYON HILL, OPHER, EAST CAÑON, UTAH.

Names.	Remarks.
1. *Fenestella*	Very like *F. plebeja*, McCoy, and like one at Old Baldy.
2. *Chœtetes*	Slender ramose.
3. *Crinoids*	Joints of columns.
4. *Productus semireticulatus*, Martin (?)	
5. *Rhynchonella.*	
6. *Phillipsia ?*	Fragments of pygidium.

SWAN VALLEY, IDAHO.

Names.	Remarks.
1. *Syringopora* (?)	Very imperfect, but looks like *Syringopora.*
2. *Aviculopecten* (?)	Very small smooth species, like this genus, but may be an *Entolium.*
3. *Bivalve*	Small, undetermined.
4. *Rhynchonella.*	
6. *Spirifer.*	

"OLD BALDY," NEAR VIRGINIA CITY, MONTANA.

Names.	Remarks.
1. Marine plant, like *Fucoides caudagalli.*	
2. *Zaphrentis excentrica*, Meek.*	

* A large, slightly curved, short turbinate species, with fossula on the dorsal side; septa about seventy of principal series, which extend inward so as to leave a moderately broad, smooth space at the bottom of the calyx near the dorsal side, while as many more shorter and more slender ones alternate with the larger; tabulæ transverse, very closely arranged, and occupying a wide excentric space; surrounding vesicular zone sometimes very wide on ventral side; epitheca unknown. (For full description and figures see Mr. King's Report Survey Fortieth Parallel.)

3. *Zaphrentis*	A small, slightly curved species, with fossula ventral.
4. *Michelinia*	Like *M. tenuisepta*, Phillips' (species.)
5. *Chætetes*	Slender ramose species
6. *Platycrinites* (?)	Arms and fragments of columns.
7. *Platycrinites Haydeni*, Meek.*	
8. *Pentremites symmetricus*, Hall	As far as can be determined from the specimens, it seems to agree well with *P. symmetricus*.
9. *Pentremites Godonii*, Defrance (?)	
10. *Poteriocrinites Montanaensis*, Meek. †	
11. *Erisocrinus* (?)	Body only, apparently of a species of this genus.
12. *Ptilodictya*.	
13. *Fenestella*	Very delicate; like *F. plebeja*, McCoy.
14. *Ptilopora*.	
15. *Strophomena analoga*, Phillips.	
16. *Orthis resupinata*, Martin.	
17. *Chonetes*	A medium-sized, very finely striated species.
18. *Productus semireticulatus*, Martin, (species)	A small, sulcated, strongly arcuate, and produced variety, apparently of this species.
19. *Productus Altonensis*, N. & P.	
20. *Productus scabriculus*, Martin (?)	
21. *Productus Prattenanus*, Norwood.	
22. *Productus cora*, d'Orbigny (?)	This agrees with European shells, referred to d'Orbigny's species; but is more finely striated, and much more produced, than d'Orbigny's type.
23. *Productus*	A narrower, strongly arched, much produced species, marked by small, very obscure concentric wrinkles, and very small, slightly elongated, raised points, that may have supported minute spines.
24. *Hemipronites crenistria*, Phillips, (species.)	
25. *Camarophoria*	Very similar to *C. globulina*, Phillips.
26. *Athyris subtilita*, Hall.	

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* A small species, with a cup-shaped body, rounded below to a circular attachment for the column; body-plates smooth, or obscurely granular, and joined by slightly grooved sutures; arms twenty, slender, each dividing once on the second piece above their origin on the very small second radials, composed each of a single series of small pieces, (as in *P. nodobrachiatus*, Hall, Iowa Report, p. 542,) bearing pinnules alternately on their inner lateral ends.

† A small species with an elongate obconical body, composed of smooth plates, and supported on a round column; arms long, slender, apparently simple above their origin on the last radials, and composed of small pieces, every third one of which bears, alternately on opposite sides, a long pinnule.

Names.	Remarks.
26. *Spirifer lineatus*, Martin, (species.)	
27. *Spirifer*	Like some forms of *S. increbescens*, Hall.
28. *Spirifer triradialis*, Phillips (?)*	
29. *Spiriferina octoplicata*, Sowerby	May be the same as *S. Kentuckensis*, Shum.
30. *Retzia vera*, Hall (?)	
31. *Terebratula arcuata*, Swallow (?)	Almost certainly the same as *T. bovidens*, Morton.
32. *Terebratula*	A small species possibly identical with *T. turgida*, Hall.
33. *Astartella Newberryi*, Meek (?)	I can see no difference in the single specimen examined, from the Ohio species.
34. *Cypricardina*	Has the external appearance of the genus.
35. *Platyceras*.	
36. *Pleurotomaria sphærulata*, Conrad	The specimen agrees well with depressed varieties of Mr. Conrad's species from the western coal-measures.
37. *Euomphalus*	Fragments of cast of a large species.
38. *Phillipsia*	Fragments.

DIVIDE BETWEEN ROSS FORK AND LINCOLN VALLEY, MONTANA.

Names.	Remarks.
1. *Zaphrentis Stansburyi*, Hall (?)	
2. *Cyathophyllum subcæspitosum*, Meek.†	
3. *Lophophyllum* or *Cyathaxonia*	Perhaps more than one small species.
4. *Syringopora*.	
5. *Platycrinus*	Body only, of a very small globose species.
6. *Pentremites Bradleyi*, Meek.‡	
7. *Pentremites Godoni*, Defrance (?)	
8. *Pentremites conoideus*, Hall.	

* A very abundant, gregarious little shell, closely resembling *S. triradialis*, var. *sexradialis*, as illustrated by Mr. Davidson, excepting that the largest of hundreds of specimens are less than one-fourth the size of well-developed individuals of that form. It also differs in being constantly wider than long, instead of the reverse, and in having the beak of its ventral valve always proportionally shorter; while it shows a faint sulcus along the mesial fold toward the front, and a corresponding very slight ridge in the bottom of the sinus of the other valve. I think it probably a new species. If so, it may be called *S. agelaius*.

† I have figured and described this species in Mr. King's unpublished report. Its corallites are long, cylindrical, more or less flexuous, and loosely branching instead of growing in compact, fasciculated, or asterform masses, as in *C. cæspitosum*, Goldfuss. It has a more developed, more transversely wrinkled, and less striated epitheca (when not worn) than Goldfuss's species.

‡ A small species like *P. Koninckiams*, Hall, but shorter below, and having its pseudambulacra more deeply excavated along the middle, with their pore pieces more transverse.

9. *Pentremites subconoideus*, Meek.*
10. *Melonites* ....A single, very thick, hexagonal, interambulacral plate, with outer surface a little convex, and granlar.
12. *Hemipronites* ....Very small or only about one-half inch in diameter, with a high triangular area.
13. *Productus* ....About half an inch in diameter, very gibbous; beak narrow, strongly incurved; surface smooth, or apparently so.
14. *Productus* ....Like *P. biserialis*, Hall.
15. *Productus semireticulatus*, Martin, (species).................Large and well developed.
16. *Productus longispinus*, Sowerby. Of usual size.
17. *Rhynchonella macra*, Hall (?)
18. *Rhynchonella, mutata*, Hall (?)
19. *Athyris* ....Small, and like *Ath. hirsuta*, Hall.
20. *Retzia Vernieuiliana*, Hall
21. *Spirifer* ....Very small, like a miniature *S. opimus*, H.
22. *Spiriferina* ....Like *S. spinosa* (*Spirifera spinosa*, H.,) but smaller, and apparently without spine-bases.
23. *Terebratula turgida*, Hall.
24. *Nucula Shumardii*, Hall.
25. *Macrodon* (?)
26. *Cypricardina Indianensis*, (*Cypricardella Indianensis*, Hall.)
27. *Cypricardella plicata*, Hall (?)
28. *Cypricardella subelliptica*, Hall (?)
29. *Nuculana nasuta* (*Nucula nasuta*, Hall ?)
30. *Conocardium Meekianum*, Hall (?)
31. *Platyceras* ....One or more small species.
32. *Euomphalus Spurgenensis*, Hall.
33. *Naticopsis* ....Like *Naticopsis Carleyi* (*Natica Carleyi*, Hall.)
34. *Bellerophon* ....Two small, smooth species.
35. *Holopea* ....Fragments of very small species.
36. *Pleurotomaria* ....Very small.
37. *Cythere* ....Very near *C. carbonaria*, Hall.
38. *Spirorbis annutata*, Hall.
39. *Phillipsia* ....Fragments of small species.

JURASSIC SPECIES.

NEAR LOWER CAÑON OF YELLOWSTONE RIVER.

Names. Remarks.

1. An *Echinoid* ....Mainly a cast of small species of an undetermined genus.

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* A very small, obconic species, much produced below the pseud-ambulacral areas, which are very short, or almost confined to the summit, as in *Codaster*, though it is a true *Pentremite*.

2. *Ostrea* .... Small specimens, of perhaps two or three species.
3. *Gryphæa* .... A small species of form of the *G. dilatata*.
4. *Camptonectes* .... Specimen imperfect; may be *C. bellistriata*, M. and H.
5. *Pecten* .... Part of a valve of a rather large, strongly costate species. Not a true typical *Pecten*.
6. *Pinna* .... Near *P. opalina*, Quenstedt.
7. *Gervillia Montanænsis*, Meek.*
8. *Gervillia* .... Somewhat larger than the last, but not costate.
9. *Mytilus* .... Has angular umbonal slopes, and only concentric markings.
10. *Modiola* (*Vulsella*) *subimbricata*, Meek.†
11. *Modiola* (*Vulsella*) .... A shorter, wider, and less arcuate species than the last.
12. *Trigonia Americana*, Meek.‡
13. *Trigonia Montanaensis*, Meek.§
14. *Crassatella* (?) .... It has the external appearance of this genus, but may belong to some other.
15. *Crassatella* (?) .... Internal casts apparently of species of this genus.
16. *Cucullæa* .... Casts.
17. *Astarte* (?) .... A small shell like some of the Jurassic species sometimes referred to this genus.
18. *Unicardium* .... Casts apparently of a species of this genus.
19. *Myacites* (*Pleuromya*) *subcompressa*, Meek.||

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* A medium-sized, very oblique species, with posterior ear flattened and of moderate size, angular at the extremity, and equaling, on the hinge line, about half the length of the valves; body portion of the valves rather slender, nearly straight, or a little arched, ranging at an angle of 28° to 30° below the hinge line, in the left valve convex, in the right flattened, or less convex than in the other. Surface of both valves marked by fine concentric striæ, and a few stronger furrows of growth, crossed on the body part of the left valve, by a few slender radiating costæ, separated by wider spaces.

† This is very like *Modiola imbricata*, Sowerby, as illustrated by Morris and Lycett, in their Monogr. Moll. Gr. Oolite, Pl. IV, Fig. 2, excepting that its anterior ventral portion, in front of the umbonal ridges, is more prominent, and its posterior basal extremity more produced and narrowed. It is much less like Sowerby's original figure of that species.

‡ A fine species of the type of *T. costata* of the Old World, but differing from that and the other allied forms, in having the radiating costæ of the corselet, or posterior dorsal region, all of uniform size.

§ Of the type of *T. signata*, Agassiz, but differing in its proportionally shorter form, with smaller nodiferous costæ, while it has a row of nodes down the anterior lateral region of each valve, nearly as in *T. navis*, Lamarck.

|| Resembles some varieties of *Pleuromya ferruginea* and *P. impressa*, Agassiz, but has the anterior end shorter and more truncated, the concentric ridges of less regularity, and the slight concavity extending from the beaks to the anterior basal margins of the valves, either entirely wanting or very feebly marked. I have fully described and illustrated this shell in the unpublished paleontological part of Mr. King's report.

20. *Pholadomya Kingii*, Meek.*
21. *Goniomya Montanaensis*, Meek.†
22. *Ammonites* .... Mere fragments.

SPRING CAÑON, MONTANA.

Lower bed.

Names.	Remarks.
1. Plants	Fragments of the same forms seen at Devil's Slide, Yellowstone River.
2. *Plicatula*	An imperfect valve-impression of one valve seen in the matrix.
3. *Camptonectes*	Same as No. 4, near Lower Cañon, Yellowstone.
4. *Pinna*	Same as No. 6, near Lower Cañon, Yellowstone, being very like *P. opalina*, Quenstedt.
5. *Mytilus*	Same as No. 9, from Lower Cañon, Yellowstone.
6. *Modiola (Vulsella) subimbricata*, Meek	Same as No. 10, from Lower Cañon, Yellowstone.
7. *Trigonia Americana*, Meek.....	Same as No. 11, from Lower Cañon, Yellowstone.
8. *Myacites (Pleuromya) subcompressa*, Meek	Same as No. 19, from Lower Cañon, Yellowstone.

Upper bed.

9. *Ostrea* .... A small undetermined species.
10. *Camptonectes.*
11. *Rhynchonella.*

NEAR FORT HALL, IDAHO.

Lower bed.

Names.	Remarks.
1. *Pseudomonotis (Eumicrotis) curta*, Hall, (sp.)	Very small and in great numbers.

Upper bed.

2. *Terebratula.*
3. *Mytilus.*

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* An elongate-oblong species, quite convex in umbonal region, with beaks moderately prominent, incurved, and placed near the rounded anterior end. The posterior end is more narrowly rounded and moderately gaping. The narrow radiating costæ are wanting on the ends and posterior dorsal region; the anterior ones (which descend vertically from the beaks) are most widely separated, while those farther back are more closely arranged and more oblique.

† Elongate-oblong, moderately convex, anterior margin regularly rounded, posterior truncated, dorsal and ventral margins nearly parallel, beaks depressed, and placed near the anterior end. Surface having wrinkles or costæ starting from before the beaks and passing obliquely backward and near half way to the base, where they die out, or become very obscure, and curve horizontally backward to meet others passing down the posterior dorsal slopes.

4. *Myophoria* .... Mere casts, apparently of this genus.
5. *Macrodon* .... Mere casts, apparently of this genus.
6. *Myacites* .... Mere casts, apparently of this genus.

DEVIL'S SLIDE, CINNABAR MOUNTAIN, YELLOWSTONE RIVER.

Names.	Remarks.
1. *Gryphæa calceola*, Quenstedt, var.	
2. *Cucullæa*	Internal cast, apparently of this genus.
3. *Camptonectes*.	
4. *Trigonia elegantissima*, Meek.*	
5. *Corimya Montanaensis*, Meek.†	
6. *Myacites (Pleuromya) subcompressa*, Meek.	
7. *Pholadomya*.	
8. *Ammonites*.	

CRETACEOUS LIST.

NEAR THE MISSOURI RIVER, BELOW GALLATIN, MONTANA.

Names.	Remarks.
1. *Ostrea anomioides*, Meek.	
2. *Trigonia*	Nearly allied to *T. Evansi*, Meek. Same as No. 3, from Cinnabar Mountain.
3. *Corbicula (Veloritina) inflexa*, Meek.	
4. *Corbicula (Veloritina)*	Like the last, excepting that its beaks are more oblique, more nearly terminal, and more depressed. May be a variety of same.
5. *Corbicula (Veloritina)*	A small and proportionally shorter form.
6. *Cardium*	A rather small, nearly circular species, with fine radiating striæ.
7. *Inoceramus*	Fragments.
8. *Pharella* (?) *Pealei*, Meek.	
9. *Avicula*	Small species.
10. *Avicula* (?)	Small; of the type of *A. raricosta*, Reuss.
11. *Modiola*	Small, smooth species.
12. *Mytilus*	Casts.
13. *Tellina*	Casts.
14. *Corbula*.	
15. *Anchura*	Rough mold in matrix.

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* A small species of the type of *T. costata*, but having the concentric or horizontal costæ on the sides of the valves very delicate, closely arranged, and but slightly larger than the radiating ones on the posterior dorsal region, or corselet. The valves are rather compressed, about one-fourth longer than wide, and have the posterior umbonal slopes acutely angular.

† This is *very* similar to some varieties of *C. glabra*, Agassiz, but it is a smaller, proportionally shorter, and more convex shell, with the anterior margins just in front of the beaks more excavated.

COLORADO SPRINGS, COLORADO.

Cretaceous, No. 4.

Names.	Remarks.
1. *Inoceramus*	Fragments of casts.
2. *Callista* (?)	Fragments.
3. *Anisomyon alveolus*, Meek.	

LAST FOOT OF BRIDGER PEAK, FOUR MILES NORTH OF FORT ELLIS, MONTANA.

Names.	Remarks.
1. *Ophioderma* (?) *Bridgerensis*, Meek.*	
2. *Gryphæa*	Obscure casts of a small species.
3. *Avicula*	Casts.
4. *Pinna*	A rather large, narrow species, with longitudinal costæ.
5. *Inoceramus*	Fragments of casts.
6. *Crassatella*	Casts.
7. *Panopæa* (?)	Fragments.
8. *Pholadomya*	Fragments.
9. *Turritella*	Casts.
10. *Gyrodes*.	

CINNABAR MOUNTAIN, YELLOWSTONE VALLEY, MONTANA.

Names.	Remarks.
1. *Ostrea*	Casts of a small species.
2. *Inoceramus*	Fragments of casts.
3. *Trigonia*	Of Cretaceous type, nearly allied to
4. *Corimya*	*T. Evansi*, Meek.
4. *Corimya*, or *Thracia*	Casts of a small species.
5. *Baculites*	A small slender species, like *B. asper*, Morton.
6. *Scaphites ventricosus*, Meek.	

ROCK CREEK.

Names.	Remarks.
1. *Inoceramus*.	
2. *Ammonites percarinatus*, H. and M.	
3. *Ammonites*, (undetermined sp.)	
4. *Scaphites Warrenanus*, M. and H.	
5. *Scaphites larviformis*, M. and H.	
6. Scales and other fragments of fishes.	

* A small Ophiurian, with disk depressed, nearly circular, and only 0.17 inch in breadth, showing on the dorsal side ten ovate-sutrigonal radial plants, that are joined together over the inner ends of the arms, so as to form five pairs; arms small, or only about 0.75 inch in length, and at their inner ends 0.06 inch in breadth; middle row of arm-pieces on the dorsal slide, slightly wider than long, and hexagonal in form; marginal pieces about as large as the middle ones, seen somewhat edgewise from above, and bearing a row of very small, short spines. Ventral side unknown. The specimen is not well preserved. Perhaps I should call it *Ophiolepis Bridgerensis*.

FORT HARKER.

Names.	Remarks.
1. *Inoceramus problematicus*, Schloth.	
2. *Baculites*?	Small, slender species.

LIST OF FOSSILS FROM THE CRETACEOUS COAL SERIES AT COALVILLE.

Names.	Remarks.
1. *Ostrea soleniscus*, Meek.* (*a*)	
2. *Ostrea Wyomingensis*, Meek. (?) (*a*)	
3. *Anomia*, (undetermined sp.)	
4. *Avicula* (*Pseudoptera*) *rhytophora*, Meek. (*a*)	
5. *Avicula* (*Pseudoptera*) *propleura*, Meek. (*a*)	
6. *Avicula gastrodes*, Meek. (*a*)	
7. *Inoceramus problematicus*, Schlotheim.	
8. *Inoceramus*, (undetermined sp.)	
9. *Inoceramus*, (undetermined sp.)	
10. *Pinna*, (undetermined sp.)	
11. *Modiola* (*Brachydontes*) *multilinigera*, Meek.*	
12. *Cardium curtum*, M. and H.	
13. *Cardium subcurtum*, Meek.†	
14. *Lucina*, (undetermined sp.)	
15. *Macrodon*, (undetermined sp.)	
16. *Unio*, (undetermined sp.)	
17. *Trapezium micronema*, Meek. (*a*)	
18. *Cyrena Carltoni*, Meek. (*a*)	
19. *Corbula*, (two undetermined sp.)	
20. *Cyprimera subalata*, Meek.‡	
21. *Cyprimera* (?) *isonema*, Meek.	
22. *Tellina* (?) *modesta*, Meek. (*b*)‖	
23. *Tellina* (*Arcopagia*) *Utahensis*,* Meek.	
24. *Martesia*, (undetermined sp.)	
25. *Gyrodes depressa*, Meek. (*b*)	
26. *Neritina* (*Neritella*) *Bannisteri*, Meek. (*a*)	
27. *Neritina* (*Neritella*) *pisum*, Meek. (*a*)	
28. *Neritina* (*Neritella*) *pisiformis*, Meek. (*a*)	

* Species marked with (*a*) are fully described in another part of this report.

† This is very similar to *C. curtum*, M. and H., but smaller, with posterior umbonal slopes, rounded instead of angular, and the posterior dorsal region behind the umbonal slopes not so flattened and more distinctly costated.

‡ I have described this species in Mr. King's unpublished report. It is *very* like *C. depressa*, Conrad, from the Cretaceous (Ripley Group) of North Carolina and Mississippi, excepting that its beaks are less flattened and a little farther forward, and its posterior dorsal outline, or slope, less straightened. Its anterior margin is also a little less narrowly rounded in outline. I have not seen its hinge, but cannot doubt, from its external characters, that it belongs to Mr. Conrad's genus *Cyprimera*. It may even prove to be only a variety of the North Carolina species.

‖ The species followed by (*a*) are fully described in another part of this report. Those folowed by (*b*) are described in Mr. King's unpublished report.

29. *Neritina* (*Dostia* (?) *bellatula*, Meek. (*a*)
30. *Neritina* (*Dostia* (?) *cardeiformis*, Meek. (*a*)
31. *Eulima* (?) *inconspicua*, Meek. (*a*)
32. *Eulima chrysalis*, Meek. (*a*)
33. *Eulima funicula*, Meek. (*a*)
34. *Turritella Coalvillensis*, Meek. (*a*)
35. *Turritella spironema*, Meek. (*a*)
36. *Turritella* (*Aclis* (?) *micronema*, Meek. (*a*)
37. *Admete* (?) *rhomboidea*, Meek. (*a*)
38. *Anchura fusiformis*, Meek. (*b*)
39. *Fusus* (*Neptunea*) *Gabbi*, Meek. (*a*)

BEAR RIVER CITY, CRETACEOUS.

Names.	Remarks.
1. *Ostrea soleniscus*, Meek	Two thin layers almost composed of it.
2. *Inoceramus problematicus*, Schloth (?)	Occurs in great numbers.
3. *Inoceramus*.	
4. *Trapezium micronema*, Meek.	
5. *Corbicula securis*, Meek.	
6. *Corbicula æquilateralis*, Meek.	
7. *Cardium*.	

FOSSILS OF THE BITTER CREEK COAL SERIES, WYOMING.

Names.	Remarks.
1. *Ostrea Wyomingensis*, Meek*	Point of Rocks.
2. *Ostrea arcuatilis*, Meek†	About two miles north of Hallville, and at a considerably higher horizon; also at Black Butte, still higher, and three or four miles farther eastward.
3. *Ostrea*	Two miles below Point of Rocks, associated with *Anomia* (?) *gryphorhynchus*. Smaller and smoother than the last.
4. *Anomia gryphorhynchus*, Meek*.	Same as last.

* See descriptions in another part of this report.

† This is constantly smaller, narrower, and usually thinner and deeper than *O. Wyomingensis*, and never has its lateral margins, toward the beaks, dilated and horizontally flattened, as in that species. It also differs in being sometimes curved up, or arcuate, along its entire length, almost like a *Gryphæa*, though it is often straight without any curvature of the beaks. Its surface only shows rather obscure marks of growth. It is a form I have long been familiar with from this region, and have sometimes referred to as resembling *O. glabra*, M. & H., of the Upper Missouri. A comparison of the better specimens found last summer, with *O. glabra*, shows it to be quite different, in being much more attenuate at the beaks, and in having a larger and longer ligament area. I am aware that the establishment of species in the genus *Ostrea* is unsatisfactory, but it seems desirable to have a name by which this form can be designated.

5. *Modiola*	Rock Spring and Black Butte, striated species.
6. *Corbicula Bannisteri*, Meek*	Black Butte Station.
7. *Corbicula* (*Veloritina*) *cytheriformis*, M. & H. (?)	Point of Rocks and Black Butte.
8. *Corbicula* (*Leptesthes*) *fracta*, Meek	Hallville, just over coal-bed.
9. *Corbicula* (*Lept.*) *fracta*, var. *crassiuscula**	Black Butte, saurian bed.
10. *Corbicula* (*Leptesthes*) *crassatelliformis*, Meek	Hallville, with *C. fracta*, in shale over a bed of coal.
11. *Corbula crassatelliformis*, Meek†	Black Butte Station, in saurian bed.
12. *Corbula tropidophora*, Meek*	Two miles below Point of Rocks.
13. *Corbula undifera*, Meek*	Rock Spring.
14. *Goniobasis insculpta*, Meek*	Rock Spring and Point of Rocks.
15. *Melania* (*Goniobasis*?) *Wyomingensis**	Black Butte saurian bed.
16. *Vivipara trochiformis*, M. & H. (?)	Black Butte saurian bed.

TERTIARY SPECIES.

BEAR RIVER, ESTUARY BEDS.

Names.	Remarks.
1. *Unio priscus*, M. & H.	
2. *Unio belliplicatus*, Meek.	
3. *Corbicula* (*Veloritina*) *Durkeei*, Meek.	
4. *Corbula pyriformis*, Meek.	
5. *Corbula Engelmanni*, Meek.	
6. *Goniobasis chrysalis*, Meek.	
7. *Viviparus Conradi*, M. & H.	
8. *Melantho* (*Campeloma*) *macrospira*, Meek.	
9. *Rhytophorus priscus*, Meek.	

* See descriptions in another part of this report.

† This shell seems to have *exactly* the form, and surface characters of *Corbicula* (?) *crassatelleformis*, found flattened between the laminæ of the shale over one of the coal-beds at Hallville, much lower in the series. It is decidedly thicker, however, and certainly has the hinge characters of *Corbula*. It is true, I have not seen clearly the hinge of the Hallville specimens, but so far as it can be made out it seems to give indications of a different structure. Still, I suspect that good specimens from each locality would show that they are not only both Corbulas, but that they are specifically identical, though it will be better to keep them separate for the present.

DESCRIPTIONS OF NEW SPECIES OF FOSSILS.

SILURIAN FORMS.

Iphidea (??) *sculptilis*, Meek.

This fossil presents very much the general appearance of the ventral valve of an *Acrotreta*, being rounded on one side and truncated on the other, with the apex moderately prominent, and marginal on the truncated or posterior side, (viewing it as an *Acrotreta*,) and with the truncated side inclined backward. It measures 0.11 inch in breadth, and about the same in length, with a direct height to the apex of 0.05 inch. Its surface has a black shining appearance, indicating a phosphatic composition like *Lingula*, and is marked by slender, interrupted, rather distant, radiating raised lines, crossed by finer, much more crowded, and very regular, sharply-defined, concentric striæ. So far as can be seen, there seems to be no perforation in the apex.

On first looking at these little shells, which occur associated with a well-defined *Acrotreta*, I had not the slightest doubt that they belonged to a depressed species of that genus. By cutting away the hard rock, however, from the flattened side, corresponding to the area of *Acrotreta*, I found that there seems to be there a wide, open, triangular foramen, so large that only a *very* narrow, slightly flattened margin, representing a false area, is seen inflected on each side. This I have seen in the only two specimens in the collection showing this side; and if there is nothing deceptive about it, the shell would certainly belong neither to *Acrotreta* nor to *Iphidea*. It can only be referred to Mr. Billings's genus *Iphidea*, even provisionally, on the supposition that, in cutting away the hard rock from the truncated side representing the false area in that genus, I may have also cut away the prominent pseudo-deltidium, characteristic of that group. In that case, however, the pseudo-deltidium would be proportionally much wider than in Mr. Billings's type, as the opening is decidedly wider, as we see it in our shells, than the false deltidium in his species. This difference, however, might be only specific.

It is quite probable that, when specimens showing clearly all the characters of this shell can be examined, it will be found to belong to an undefined genus, either of the *Brachiopoda*, or of some other group. In this case I would propose for this genus the name *Micromitra*.

I confess, however, that in closely examining these little fossils, I have not been entirely without the suspicion that they may be the terminal pieces of some extinct group of the *Chitonidæ*. The inflected character, however, of the margins, like a very contracted false area, on each side of the opening of the flat side of the shell, is against this conclusion; but even if they are the terminal pieces of some chitonoid type, the chances are still strongly in favor of its being a new genus, for which the name suggested would be equally as appropriate as for a *Brachiopod*.

Locality and position.—East side of Gallatin River, Montana; primordial zone.

ASAPHUS (MEGALASPIS ?) GONIOCERCUS, Meek.

Pygidium rather small for a species of this genus, moderately depressed, trigonal in outline, with breadth and length about as 7 to 9; posterior lateral margins slightly convex in outline, and converging rapidly to the posterior extremity, which terminates in an abruptly attenuated, slightly recurved, pointed projection, the under side of which is flat, and the upper convex; mesial lobe much depressed, or very slightly higher than the lateral, and quite obscurely defined by the nearly obsolete dorsal furrows, about three-fourths as wide anteriorly as the lateral, and tapering backward and becoming obsolete before reaching the posterior extremity, in internal casts showing sometimes faint traces of nine or ten very obscure segments; lateral lobes gently convex, and sloping off gradually to an obscure undefined furrow, or shallow impression, near the posterior lateral margins, which are thus made to appear as if provided with a slightly-depressed border, usually appearing quite smooth, or with faint traces anteriorly of one or two segments, but in some specimens, when examined carefully in an oblique light, traces of six or eight segments may be seen. Surface smooth.

Length of pygidium, 0.74 inch; breadth, 0.94 inch; convexity at the front, 0.16 inch.

The only part in the collection known to belong to this species is the pygidium. This is very remarkable for its trigonal form and pointed posterior extremity, much as we see in *Dalmanites*. It wants the usually well-defined dorsal furrows and segments, however, of that genus; which smoothness gives it the aspect of *Asaphus*. The specimens from which the description was drawn up are probably young individuals, as there are fragments in the collection of an *Asaphus* of larger size that may belong to this species. If an *Asaphus* at all, the form of its pygidium would indicate relations to the group *Megalaspis*, one species of which (*M. heros*, Dalmann, sp.) has a similarly-formed pygidium, but with more numerous and very much more strongly-defined segments. I am not aware, however, that any species of that group has hitherto been found in this country.

Locality and position.—Near Malade City, Utah, from Lower Silurian beds of the age of the Quebec Group. Professor Bradley.

BATHYURUS SERRATUS, Meek.

Cephalic shield rather distinctly convex, semicircular, being nearly twice as wide as long, regularly rounded in front, straight across behind, and having the posterior lateral angles terminating in small, short, backward-pointing spines; lateral margins provided with a narrow, slightly-thickened border, (sometimes becoming nearly obsolete just in front of the glabella,) defined by a shallow narrow furrow. Glabella quite convex, with its highest part near the middle, strongly defined by the dorsal furrows, cylindrical in form, extending very nearly to the anterior margin, and apparently without lateral furrows; neck-segment well defined by a distinct furrow passing entirely across, distinctly arched upward and a little backward in the middle, where it bears a small tubercle, or possibly sometimes a short little spine, directed upward and backward; continuation of neck-furrow along the posterior margin of cheeks rather wide and deep; fixed cheeks comparatively wide and convex, but lower than the glabella, rounding off rather abruptly laterally. Eyes of moderate size, but little arched, ranging nearly parallel with each other;

placed remote from the glabella, and about their own length from the posterior margins of the cheeks; palpebral lobes very small, and lower than the fixed cheeks; movable cheeks sloping abruptly laterally; facial sutures not clearly seen anteriorly, but apparently cutting the margin nearly on a line with each eye; while behind they are directed at first obliquely outward and backward, after which they curve backward so as to cut the posterior margin of the head, just within the inner edge of the little posterior lateral spines.

Thorax consisting of seven segments; mesial lobe narrow, rather prominent, and gradually tapering; lateral lobes depressed or flattened; pleuræ with broad, rounded furrows.*

Pygidium nearly semicircular, or about three-fifths as long as wide, regularly rounded behind, and rather straight across in front, excepting laterally, where the anterior margin rounds backward somewhat; quite convex, but not so much so as the cephalic shield. Mesial lobe prominent, cylindrical, equaling five-sixths of the entire length of the pygidium, with an abrupt posteriort ermination, rather decidedly more prominent than the lateral lobes, and showing about four obscurely-marked segments. Lateral lobes sloping off laterally and behind, where they are provided with a flattened, somewhat thickened margin, that is armed by six very short, small serrations on each side, directed obliquely backward; each showing four very obscurely-defined, broad, depressed segments that do not extend out upon the flattened and serrated margin.

Surface of both cephalic shield and pygidium showing, under a magnifier, a slight granular appearance, as if covered by minute projecting unequal grains, with smaller pits scattered among them. Obscure traces of striæ are also sometimes seen around the margin of the cheeks.

Judging from the imperfect specimens seen, a medium-sized entire specimen of this species was probably a little over 1 inch in length, by a breadth of 0.70 inch, and a convexity of near 0.20 inch.

The cephalic shield and pygidium here described are not positively known to belong to the same species; but judging from the fact that they occur associated together, and agree well in size, convexity, propositions, and particularly in the peculiar kind of surface-granulations, there is little room for doubting that they really belong to the same trilobite. This conclusion is also strengthened by the fact that no other cephalic shield and pygidium in the collection, not known to belong to other species, correspond with them in these respects.

The pygidium resembles one figured by Mr. Billings in his Palæozoic Fossils of the Canadian Survey, page 405, Fig. 384, and doubtfully regarded by him as belonging to a *Dikelocephalus*; but the serrations of the margin in our species are smaller and less prominent, the middle lobe less elongated, more obtuse behind, and has its segments much less distinctly defined; while the segments of its lateral lobes are also much more obscure. Its anterior lateral angles are also more rounded off. From the similarity of the two, however, there can be little doubt that they are allied species of the same genus, in which opinion Mr. Billings fully concurs on examining casts of our species sent to him.

It is almost beyond doubt that a pygidium figured by Angelin, under the name *Corynexochus spinulosus*, (see Palæontologia Scandinavien, Pl. xxxiii, Fig. 11,) belonging to the same genus as our trilobite; and this raises the question whether I ought not to refer our species to that

* The specimen from which these characters of the thorax are taken consists of a mold of the interior of the mesial, and a part of one of the lateral lobes, the glabella, and one of the fixed cheeks, with a part of the pygidium. It does not show the free ends of the pleuræ.

genus; his species *spinulosus*, not only being his first one, but the *only* one that he refers to his new genus, without a mark of doubt. On the other hand, the question is complicated by the fact that his typical species is founded on a separate head, divested of the movable cheeks, and the detached pygidium alluded to above, which may, or may not, belong to the same species or genus as the head; while in the text, he places a mark of doubt after the reference to the figure 11 of the pygidium, thus showing, as one would think, that he only refers it doubtfully to the species *spinulosus*. Yet, it is evident that the name *spinulosus* was suggested for his first species by this pygidium, which is armed with small spines, while no spines are known to be connected with the head. But another difficulty arises from the fact that his *generic* name *Corynexochus* seems to have been suggested by the prominent clavate character of the glabella of the head figured by him.

For this latter reason, and the fact that the pygidium is only connected by him doubtfully with the head, probably most authorities would view the species to which the head belongs (in case the pygidium appertains to another form) as type of the genus. If we adopt this view, it would be somewhat doubtful whether our species could be properly referred to Angelin's genus, since its glabella is merely cylindrical, and not quite as long as the head, instead of widening out anteriorly to nearly twice its posterior breadth, and apparently slightly overhanging the anterior margin, as in the head figured by Angelin.

If the difference in the form of the glabella mentioned above should not be of generic importance, and there should be no well-defined differences in the abdominal parts of Angelin's type, (the abdomen of which is unknown,) then our species would have to be referred to the same group, and take the name *Corynexochus serratus*. It is, however, also very closely allied to *Bathyurus*, Billings, in most of its known characters. After examining casts of our species, Mr. Billings writes that he would not be willing to separate it generically from *B. extans*, the type of his genus; though he admits that some differences in the abdominal parts, to which I had called his attention, are rather marked. These are the presence of only seven body-segments in our type, instead of nine, as in *B. extans*, and the other known species of *Bathyurus*; while the plural furrows in our species are very broad and rounded, instead of narrow and sharply cut as in typical *Bathyurus*. The serrated, or spinuliferous character of the pygidium, in the form under consideration, is another difference, though probably of less importance. Mr. Billings, however, writes that he has several new species (all from the Lower Potsdam) showing this character; which fact would seem to argue that there may be a group characterized in part by this peculiarity.

From all the facts, I should certainly be disposed to separate our type at least sub-generically from *Bathyurus*, were it not for the doubts that still remain in regard to its relations to *Corynexochus* of Angelin, which, I should have remarked, would have to take precedence over *Bathyurus*, if founded on a congeneric type, because it was published in 1854, and *Bathyurus* in 1859.

Locality and position.—East side of Gallatin River, above Gallatin City, Montana Territory. Potsdam Group of the primordial zone.

BATHYURUS ? HAYDENI, Meek.

General form oval, rather depressed; outline of cephalic shield unknown. Glabella narrow subcylindrical, most convex near the middle, rather well defined by the dorsal furrows, about twice as long as wide, with the anterior end sometimes apparently very slightly expanded; neck segment projecting somewhat backward, rounded in outline behind, and nearly as high in the middle as the glabella in front of it; neck furrow narrow, rather well defined, passing entirely across, and continued much wider and deeper across the posterior margin of each cheek; lateral furrows consisting of four pairs, the posterior pair commencing a little behind the middle and extending very obliquely backward and inward to a point about the breadth of the neck furrow in advance of the same, where they either become obsolete, or apparently sometimes almost connect across by a shallow transverse furrow; succeeding pairs in front very short and transverse, the anterior ones being sometimes rather obscure; fixed cheeks moderately wide, or equaling, at the posterior end of the eyes, half the breadth of the glabella opposite the same point, rather convex, but lower than the glabella; palpebral lobes very narrow, or merely appearing as little slightly raised rims at the margins of the fixed cheeks, from which they are separated by a linear furrow. Eyes, as determined from the palpebral lobes, about two-thirds as long as the breadth of the glabella, slightly arched, and somewhat converging forward, situated their own length in advance of the posterior margin of the head, and two-thirds this distance at their posterior ends from the glabella. Facial suture in front of the eyes unknown, but behind them, directed at first for a very short distance nearly backward, then curving abruptly outward, parallel to the posterior margin of the cheeks, and extending nearly to the posterior lateral angles, where they curve obliquely backward and outward so as to cut the posterior margin near these angles.

Thorax consisting of nine segments; axial lobe very narrow, or only about two-thirds as wide as each of the lateral, tapering gradually backward, and moderately convex; lateral lobes flattened, and lower than the axial; pleuræ broadly and deeply furrowed, and having their free ends apparently falcate.

Pygidium intermediate between semicircular and semielliptical, its length being about two-thirds its breadth, while its posterior margin is rounded in outline, and its anterior nearly straight across; mesial lobe as narrow, proportionally, as that of the thorax, convex, tapering very gradually backward, and nearly reaching the posterior border, showing five or six well-defined segments, with space enough for one or two more behind those; lateral lobes flat, with five or six broadly furrowed segments that extend to, but not upon, a very narrow, slightly thickened and flattened, smooth margin.

Entire surface smooth, or only showing very fine granulations under a magnifier.

Length of an entire specimen 1.15 inches, breadth about 0.70 inch.

Although I refer this species, provisionally, for the present, to the genus *Bathyurus*, I really do not think that it properly belongs to that genus, as illustrated by the typical species *B. extans*. In the proportional size of its head, thorax, and pygidium, as well as in the number of its body segments, it agrees with that genus; and its glabella, though narrower and more strongly as well as somewhat differently lobed, is not otherwise very different; while, so far as known, its facial sutures seem to agree in most respects. The general flatness of the whole animal, however, as well as the narrowness of its axis, and particularly the different type of its large rounded pleural furrows, (those of *B. extans* being narrow and regular,) are strongly marked features, which, with the differences mentioned in its glabella, seem to separate it from that genus.

In the narrowness of its axis, and the nature of its pleuræ and pleural furrows, it agrees exactly with *Conocoryphe*; and even in its cylindrical glabella, and, indeed, in most of the characters of its head, so far as known, it agrees pretty well with some species of the section *Ptychoparia*, (see *Conocor.* (*Ptychoparia*) *striatus*, Fig. 7, Pl. xiv, Barrande's Trilobites of Bohemia.) The comparatively large size of its pygidium, however, and especially its much smaller number of body segments, (9 instead of 14,) at once separates it from any section of that genus as now understood. In some of its characters it seems to show affinities to certain types of *Ogygia*. That is, in the general flatness of its form, its narrow axis, and the form and furrows of its glabella; but it differs in having nine instead of only eight body segments; while its pleural furrows are of a different type, and its eyes are smaller, much less arcuate, and more remote from the glabella. Its facial sutures, although not clearly seen in any of the specimens, in front of the eyes, were probably, judging from some indications, not so diverging anteriorly.

If further comparisons should show it to be generically, or subgenerically, distinct from all of the groups mentioned, as I believe it to be, it may be designated by the name *Bathyuriscus*.

The specific name is given in honor of Dr. F. V. Hayden.

Locality and position.—East side of Gallatin River, above Gallatin City, Montana. Potsdam or Primordial group.

BATHYURELLUS (ASAPHISCUS) BRADLEYI, Meek.

The best specimens of this species I have seen, consist of the central parts of the cephalic shield, separated from the movable cheeks. These parts may be described as follows:

Glabella moderately and evenly convex, nearly oblong or truncato-subconical in outline, being a little narrower at the front than behind, and truncated anteriorly, with the anterior lateral angles rounded; exclusive of the neck segment, one-sixth to one-seventh of its length longer than wide; sides slightly convex in outline or nearly straight, and converging gently forward from near the middle, well but not deeply defined by the dorsal furrows, which are narrow, and continue around the front; lateral furrows wanting, or apparently sometimes very obscurely indicated by two or three pairs of extremely faint indentations. Neck furrows narrow, but distinct, extending entirely across, and continued more strongly defined across the posterior margins of the cheeks. Neck segment rather wide in its antero-posterior diameter, and flattened in this direction, but transversely arched so as to be nearly as high at its middle as the glabella. Anterior extension or limb, moderately produced, or equaling one-third the length of the glabella, (exclusive of the neck segment,) sloping gently forward from the anterior end of the glabella for about half way to the front, where there is thus formed a transverse furrow from which it rises obliquely forward in the form of a nearly flat marginal rim. Palpebral lobes comparatively large, or constituting all there is of the fixed cheeks, lunate, or sub-semicircular in form, depressed below the horizon of the glabella, from which they are only separated by the dorsal furrows, each occupied by a lunate slightly convex central portion, (which might be viewed as minute fixed cheeks,) separated from the outer margin by a shallow furrow. Eyes, as determined by the palpebral lobes, about four-sevenths as long as the glabella, exclusive of the neck segment, moderately arcuate, and ranging parallel to each other, and to the longer axis of the glabella, their posterior ends extending back nearly as far as the position of the neck furrow. Facial suture starting from the anterior ends of the eyes, close in to the dorsal furrows and diverging forward to the transverse furrow of the anterior extension or limb, where they are a little wider apart than the widest portion of the glabella, while beyond this they appear to curve a little inward as they approach the anterior margin. Posteriorly they curve parallel to the posterior margins of the cheeks, as far as they have been traced. Surface smooth.

Length of cephalic shield, 0.90 inch; length of glabella, exclusive of neck segment, 0.53 inch; length including same, 0.65 inch; breadth of glabella at widest part, 0.45 inch; length of palpebral lobes, 0.33 inch.

I refer this species merely provisionally, for the present, to the group *Asaphiscus*,* because I am only acquainted with it in the condition of fragments. Its glabella is slightly more convex and rather decidedly less conical than in the type of that group; while its eyes are larger and closer in to the dorsal furrows defining each side of the glabella, and its neck furrow narrower and rather more sharply defined. There may be more important differences in other parts, if we had the means of comparison; but as those mentioned seem to be all such as may be merely specific, it most probably belongs to the group.

At a first glance this species reminds one of the figure of *Bathyurus capax*, Billings, which was also founded upon the corresponding parts of the head. It may be at once distinguished, however, by the greater extension of its anterior margin in front of the glabella, as well as by its larger palpebral lobes (and consequently the eyes also) being situated farther back, and much closer inward to the sides of the glabella.

Locality and position.—Near Malade City, Northern Utah. Quebec group of the Lower Silurian.

CONOCORYPHE (PTYCHOPARIA) GALLATINENSIS, Meek.

Cephalic shield approaching semicircular. Glabella conical-subovate, nearly three-fourths as long as the cephalic shield, widest just in front of the neck furrow, where its breadth about equals four-fifths of

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* This group is founded on *Asaphiscus Wheeleri*, a new species discovered by Lieutenant G. M. Wheeler, of United States Topographical Engineers, in the primordial rocks near Antelope Springs, Utah. It is nearly allied to *Bathyurellus*, Billings, and will, it is thought by that gentleman, include a part of the species referred by him provisionally, from imperfect specimens, to the same. It differs, however, from the typical forms of that genus, in having its conical glabella *decidedly depressed*, and the margin of the head in front of it, first convex and sloping forward into a deep transverse mesial furrow, then rising in the form of a convex margin to the front. The mesial lobe of its pygidium is also proportionally longer, and the free margins of the same much narrower and less flattened and alate. It probably only forms a subgenus under *Bathyurellus*. From *Asaphus*, with which it agrees in general form and proportions, it differs in its decidedly conical, well-defined glabella, without lateral furrows or lobes, the extended and transversely furrowed character of the anterior margin of its head, its less arcuate eyes placed more remote from the glabella; and particularly in having nine body segments, instead of only eight. As in *Asaphus*, its pleuræ are distinctly furrowed, but they are more pointed than is usual in that genus, though not falcate. Its surface is smooth.

The generic and specific characters will be given in full, with illustrations, in Lieutenant Wheeler's Report.

Several American species with a similar depressed, conical glabella, without traces of lateral furrows or lobes, have been described from more or less complete specimens of the head, under the name *Conocephalites*. It is evident, however, from its smaller number of body segments, large pygidium, and differently formed plural grooves, that *Asaphiscus* is entirely distinct from that group.

its length, rounded anteriorly, rather distinctly convex, and well defined by rather deep dorsal furrows that are continued around its front; lateral furrows, (as seen in casts of the interior,) consisting apparently of three to four pairs, the posterior pair starting at one-third to one-half the length of the glabella in advance of the posterior side of the neck segment, and ranging obliquely backward and inward, but not connecting across the middle;* succeeding furrows very obscure, or in part (anterior ones) obsolete, short, and nearly transverse, or but slightly oblique; rostral margin equaling about one-half the length of the glabella, exclusive of the neck segment, sloping at first forward from near the furrow around the front of the glabella to a deep, nearly mesial, transverse furrow, from which it rises obliquely forward in the form of a slightly convex, or somewhat flattened border, that is, a little arched transversely; neck segment arched so as to be nearly or quite as high in the middle as the glabella; neck furrow well defined entirely across, but deepest on each side, and continued deeper, and sharply defined across the posterior margins of the cheeks; fixed cheeks comparatively wide, or more than half the breadth of the glabella near its middle, rather distinctly convex, but lower than the glabella, bearing well-defined ocular ridges that extend, with a slight curve, outward and a little obliquely backward from near the anterior end of the glabella to the front of the eyes; free cheeks unknown; palpebral lobes very narrow, or only appearing as little raised rims on the margins of the fixed cheeks, from which they are defined by small furrows. Eyes, as determined from the palpebral lobes, about half as long as the breadth of the glabella, from which they are rather remotely situated near their own length in advance of the posterior margin of the cheeks, moderately arched and somewhat converging forward. Surface nearly smooth, or only finely granular. Other parts unknown.

Entire length of cephalic shield, 0.43 inch; breadth of cephalic shield, unknown; length of glabella, including neck segment, 0.31 inch; breadth of glabella, 0.22 inch; breadth across cheeks and glabella, between anterior ends of eyes, 0.46 inch.

This species is evidently closely allied to *Conocoryphe* (*Conocephalites*) *teucre*, Billings, and *C. Billingsi*, Shumard, but differs from both rather decidedly in not having the lateral furrows of its glabella curved backward, the middle and anterior ones being nearly transverse, while none of the specimens show any traces of the tubercle on the neck segments seen in those species. Such a difference would also almost certainly be found to be accompanied by others of equal or greater importance if we had the means of comparing other parts.

Among the associated specimens there are several others, consisting of the glabella, fixed cheeks, and rostral margin, that agree well with the typical specimens of the species here proposed, excepting that they have the glabella somewhat more convex, and the rostral margin in front of its transverse furrow flattened and horizontal, or even slightly sloping forward, instead of a little convex, and rising obliquely forward. The lateral furrows of the glabella in these are usually obscure, but nearly as in the typical form, excepting that I have not been able to make out clearly more than three pairs. The fourth, or anterior, pair, however, are exceedingly obscure, or nearly obsolete in the typical form.

Another variety or species agrees with the last, excepting in showing a few very scattering, much coarser, projecting granules over the sur-

* Often there appears to be a small, obscure tubercle at the outer end of each of the posterior lateral furrows of the glabella, just within the dorsal furrows.

face, four pairs of them forming two longitudinal rows along the glabella, while the entire surface between these is very minutely granular as in the last.

There are also numerous other smaller specimens agreeing with the last two, excepting that they show generally but the most feeble traces of lateral furrows in the glabella.

It is possible that some of these specimens may differ specifically from the type of the species here proposed, but I am at present inclined to regard them all as only different varieties and ages of the same.

One of the specimens associated with the others consists of portions of the cephalic shield crushed, and most of the thorax consisting of twelve of the body segments. This shows the axial lobe to be narrower than the lateral, quite convex, gradually tapering posteriorly, and rather strongly defined by the dorsal furrows. The lateral lobes are depressed, sloping outward from the middle, and composed of rather strongly furrowed pleuræ, the furrows extending straight outward at right angles to the axis. It does not show the form of the free ends of the pleuræ. Surface nearly smooth, or only very minutely granulated. This specimen may or may not belong to the species here named.

If the name *Conocephalites* should be retained, with the limits usually allowed this group of trilobites, of course our species would have to be called *Conocephalites Gallatinensis*. As *Conocephalus*, first proposed by Dr. Barrande, had been previously used for a genus of insects, however, and Corda had proposed the name *Conocoryphe* before Dr. Barrande changed his name to *Conocephalites*, it seems to me that Corda's name will have to stand. It will also be observed that there are two strongly-marked types included in the genus by Dr. Barrande. That is, one without eyes, and having the facial sutures forming such very different curves as to give the free and fixed cheeks, as well as the frontal limb, entirely different outlines and proportions from those of the other type, which has well-developed eyes. The first of these groups is represented by *C. Sulzeri* and the latter by *C. striatus*. Corda, however, separated these types into two distinct genera, placing *C. Sulzeri* in his genus *Conocoryphe* and *C. striatus* in his genus *Ptychoparia*. I have not his work at hand for reference, but I infer from Dr. Barrande's citations that the two species mentioned were so arranged by Corda that they may each be regarded as typical of one of these groups. If so, it certainly appears that both of his names ought to be retained, at least in a subgeneric sense. In this case it will be observed that nearly all of the numerous species hitherto described in this country would fall into the group *Ptychoparia*, as they all, with perhaps the exception of *C. Matthewi*, Hartt, and one or two others, seem to have been provided with well-developed eyes, and agree in other respects generically with *C. striatus*. Adopting this view, the name of my *C. Kingii* becomes *C.* (*Ptychoparia*) *Kingii*, and so on through nearly the whole list of American species yet known.

Locality and position.—East side of Gallatin River, above Gallatin City, Montana, Potsdam or Primordial Zone.

CRETACEOUS FORMS.

OSTREA SOLENISCUS, Meek.

Ostrea soleniscus, Meek, 1870; Hayden's Geological Report, Wyoming, &c., page 296, List Cretaceous species.

Shell attaining a large size, becoming rather thick in adult examples, generally straight, greatly elongated, and comparatively very narrow, with parallel lateral margins. Lower valve with moderate internal concavity, and having the appearance of a little gutter, or elongated trough; beak usually nearly straight, rather obtusely pointed, and more or less distorted by the scar of attachment; ligament area of moderate size, strongly striated transversely, and provided with a large, deep longitudinal furrow; surface apparently only with moderately distinct marks of growth. Upper almost nearly flat externally, but nearly as concave as the other within; beak usually a little truncated; ligament area marked with strong transverse striæ, and having its mesial ridge very prominent, and occupying as much as one-third its breadth; surface as in the other valve, or perhaps a little smoother.

Length of adult examples about eighteen inches; breadth of same about 2.50 to 3 inches.

Although not a very uncommon species, I have seen no entire specimens of this remarkable shell. It will be readily known by its unusually narrow, elongated, and generally straight form. The shell is usually found broken into several pieces, but casts of the internal cavity are not unfrequently met with entire. One of these now before me is nearly one foot in length and only 2 inches in breadth. It often had a curious habit of growing in groups of three shells, attached to each other by the backs of their beaks. I have seen large numbers of them closely arranged, or nearly in contact with each other, at Coalville, all with their beaks downward, or at right angles to the planes of the sandstone strata. When found where it has grown isolated, the shell is sometimes arched to one side.

Locality and position.—This species ranges through nearly the whole thickness of the Cretaceous sandstones near Coalville, Utah, and is also found in the Cretaceous coal-bearing sandstones at Bear River City, Wyoming, as well as in a sandstone ridge of same age on Union Pacific Railroad, a few miles east of the latter locality.

OSTREA ANOMIOIDES, Meek.

Shell rather small, very thin, depressed-plano-convex, and without any visible scar of attachment, varying from ovate to circular; rounded or sometimes a little straightened on the hinge margin; beaks scarcely projecting beyond the outline of the cardinal margin. Lower valve very shallow; cartilage pit unusually small, shallow, and short. Upper valve almost perfectly flat; cartilage attachment even shorter than that of the other valve, and slightly convex on its inner margin. Muscular scars unknown; surface of both valves with small regular concentric wrinkles most distinctly marked on the central region.

Greatest diameter of one of the largest oval specimens, 1.70 inches; breadth, 1.40 inches; convexity, 0.23 inch.

This species is remarkable for the thinness of the shell, the slight concavity of the under valve, and the flatness of the upper, as well as for its rounded or slightly straightened cardinal margin, and the absence of any scar of attachment, or of any traces of muscular impressions within. These external characters, and the regular small concentric wrinkles, give the exterior of the lower valve of circular specimens somewhat the appearance of a *Lucina* or *Dosinia*; while in other individuals it looks more like an *Anomia* or *Placuna*.

Locality and position.—Missouri River, below Gallatin City, Montana. Cretaceous.

AVICULA (PSEUDOPTERA) PROPLEURA, Meek.

Shell, as determined from a left valve, obliquely ovate-subtrigonal, moderately convex along the oblique umbonal slope in front of the middle, and compressed cuneate behind; posterior margin with its general outline nearly vertical and slightly straightened along the middle, thence extending obliquely upward and a little forward, with a very faint sinuosity above, to the hinge, which it meets at an obtuse angle, while it rounds rather abruptly into the more or less rounded base below; anterior margin ranging obliquely backward and downward nearly parallel to the umbonal slope, faintly retreating near the middle, and from this upward to its connection with the anterior end of the hinge, projecting slightly in the form of a small, short, flattened auricle, that is less than rectangular at its extremity above, and undefined by any marginal sinus below; hinge-line of moderate length, but not extending quite as far back as the margin of the valve below it; posterior dorsal region flattened, though not forming a proper alation; beak rather pointed, scarcely rising above the hinge, rather oblique and placed very near the anterior end of the hinge, but not quite terminal. Surface ornamented by moderately distinct lines of growth which, on the anterior part of the valve, are crossed by seven or more slender raised radiating lines, and one stronger rib that extends along the umbonal slope so as to give it a slightly angular appearance, while very faint traces of fine radiating striæ are sometimes seen on other parts of the valve. Right valve and hinge, and interior of both valves, unknown.

Height, measuring at right angles to the hinge, 0.90 inch; length of hinge, about 0.75 inch; greatest antero-posterior diameter parallel to hinge, about 0.85 inch; length, measuring from the beak obliquely to the most prominent part of the posterior basal margin, 1.20 inches; convexity, about 0.23 inch.

This species appears to belong to a group of American and European Cretaceous aviculoid shells that seem to me to be sufficiently distinct from the typical forms of *Avicula* (*Pteria*) and *Meleagrina* to stand together, at least as a separate subgenus. They differ from the typical forms of *Avicula* in having no extended alations or defined byssal sinus in either valve, as well as in presenting a peculiar, more or less obliquely rhombic, or subtrapeziform outline. The hinge and interior of these shells are unknown to me, but the former seems not to be provided with a gaping cardinal area, the cardinal edges being thinner and compressed. *Avicula anomala*, of Sowerby, (1836,) as illustrated by d'Orbigny, in Palont. Francaise, Ter. Cret., Tome iii, Pl. 392, may be regarded as the type of this section, for which I would propose the name *Pseudoptera*. It includes in addition to *Avicula* (*Pseudoptera*) *anomala*, Sowerby, *Avicula* (*Pseudoptera*) *raricosta*, Reuss, and *Avicula* (*Pseudoptera*) *fibrosa*, Meek and Hayden.

The two species here described are only referred to this group provisionally, as their right valves are not yet certainly known. There are some reasons, however, mentioned farther on, for suspecting that this valve may have a deep byssal sinus in one, if not both, of these species. If this should be found to be the case, they cannot be properly referred to the above-mentioned group, but would fall into a group for which Stoliczka has proposed the name *Electroma*, typified by the recent species *Avicula smaragdina*, Reeve, and thus have to take the name *Avicula* (*Electroma*) *propleura*, and *A.* (*Electroma*) *rhytophora*. Should Scopoli's name *Pteria*, however, replace *Avicula*, as I believe the rules of nomenclature will require, and the section to which these shells belong, properly fall into that genus, either as a subgenus or otherwise, then the name *Pteria* will have to be substituted for *Avicula* in connection with these species.

Locality and position.—Coalville, Utah; from white sandstone, 250 feet above the lower heavy bed of coal, mined at that place.

AVICULA (PSEUDOPTERA) RHYTOPHORA, Meek.

Shell, as determined from a left valve, but slightly oblique, rhombic-suboblong, and nearly twice as high as wide in adult examples, but proportionally broader and subtrigonal in young specimens; moderately convex, the greatest convexity being toward the anterior side, along the umbonal slope, which appears to be angular, thence cuneate posteriorly, and more or less deflected inward anteriorly; hinge line very nearly equaling the greatest antero-posterior diameter, and ranging at an angle of about 70° to the umbonal axis; posterior margin nearly straight, or a little convex in outline along the middle, where it ranges at an angle of about 100° to the hinge margin, but curving a little forward above, so as to connect with the latter at a somewhat more obtuse angle, while below it curves gracefully downward and forward into the narrowly rounded or somewhat angular base; anterior margin a little sinuous in outline in the middle, with a general direction nearly parallel to that of the umbonal slope, but compressed nearly rectangular, and projecting a little beyond the beak above, the projecting part not having the character of an ear or distinct lobe, though defined by a shallow depression extending from the beak obliquely downward and backward to the slightly sinuous central region; beak very nearly terminal, moderately oblique, and rather compressed. Surface with more or less distinct lines of growth, and near the hinge margin well-defined, regular, vertical ridges or wrinkles, that seem not to be exactly parallel to the lines of growth. Right valve not certainly known.

Height of right valve, 3.20 inches; antero-posterior diameter along hinge line, 1.90 inches; height about half way down parallel to hinge, two inches; convexity, 0.70 inch.

This species will be readily distinguished from the last, not only by its much larger size and less oblique and broader form, but also by the strong vertical wrinkles along its hinge margin. It likewise seems to be entirely without any traces of the radiating costæ seen on the anterior side of that species, and has its posterior margin much more nearly vertical above, and slightly convex in outline, instead of a little sinuous there. Its umbonal slope, in the only left valve seen, seems to be decidedly angular, though this may be partly, if not entirely, due to an accidental fracture and bending of the valve along that line. It looks, however, like a natural angle, with some little nodes or projecting points along its crest. In general form it presents much the outline of some of the large Myalinas of the western coal-measures, such as *M. ampla* and *M. subquadrata*, but it differs not only in its angular umbonal slope, less curved beaks and wrinkled dorsal margin, but in having its anterior margin flattened and a little extended beyond the beak in front, instead of being concave in outline there, thus not leaving the beak quite terminal, as we see in *Myalina*.

I am not quite sure that I have seen the right valve of this shell, though one of the same general outline, and of corresponding size, that was observed in a large mass of rock at the locality, was believed to belong to this species.* It was nearly flat and smooth, excepting fine lines of growth, and, if I mistake not, had a tolerably deep, well-defined, byssal notch. If it really belonged to this shell, the species can hardly go properly, as already stated, into the group *Pseudoptera*, the type of which has no traces of a byssal sinus in either valve.

Locality and position, same as last.

AVICULA OXYTOMA (?) GASTRODES, Meek.

Shell (as determined from a left valve) attaining a moderately large size, subtrigonal in general outline, rather distinctly convex, and having a very slight backward obliquity; basal outline very profoundly rounded, the deepest or most prominent part being in advance of the middle; posterior margin moderately sinuous below the wing, from the extremity of which it ranges obliquely forward and downward, rounding regularly into the base below; anterior margin strongly and subangularly sinuous under the wing, thence descending with a slight forward obliquity and rounding rather abruptly into the base; hinge margin longer than the height of the valve, the antero-posterior diameter of which (at any point below) it also decidedly exceeds, ranging nearly at right angles to the vertical axis of the shell; beak distinctly convex, rising above the hinge margin, strongly incurved, without obliquity, and situated less than one-third the length of the hinge margin from the extremity of the anterior wing, which is subtrigonal in form, somewhat convex, a little rounded at the extremity, and very strongly separated from the abrupt shell of the umbo by a deep rounded concavity extending from the beak obliquely to the marginal sinus below; posterior wing longer and more compressed, narrower, and more angular than the other; both wings, particularly the posterior one, projecting decidedly beyond the margin of the valve below. Surface only showing more or less distinct lines of growth. (Right valve unknown.)

Height of left valve, 1.50 inches; length of same below the wings, about 1.30 inches; length of hinge line, 1.90 inches; convexity, (of left valve alone,) 0.40 inch.

I have not yet seen the hinge of this shell, or its left valve, and therefore have some doubts in regard to which of the sections of the old genus *Avicula* it would most properly fall into. If the right valve is (as I am inclined to think the case) nearly flat, with a deep, sharply-cut, byssal sinus, and its beak not distinct from the hinge margin, it will probably fall into a little group for which I some time back proposed the name *Oxytoma*, typified by *Avicula Munsteri*, Bronn. It differs remarkably from typical species of *Avicula* in its erect form, its umbonal axis being inclined a little backward, instead of strongly forward. From *Pseudomonotis*, with which it agrees in its erect form and the elevated, strongly incurved beak of its right valve, it differs very strongly in having decided, well-developed ears, both in front and behind. Dr. Stoliczka thinks the characters of the genus *Pseudomonotis* should be extended so as to include *Oxytoma*. Should this view prevail, the name of our species would probably become *Pseudomonotis* (*Oxytoma*) *gastrodes*. It seems to me, however, that *Oxytoma* stands more nearly related to *Avicula* proper than to *Pseudomonotis*, as typified by the Permian species *P. speluncaria*, so that if we unite *Oxytoma* to *Pseudomonotis*, I cannot see why we might not, on the same principle, take another step of the

* The specimen was broken to fragments in trying to detach it from the mass of rock.

kind and restore both to *Avicula*, which I am certainly not inclined to do, though I regard *Oxytoma* as a subgenus under *Avicula*.

I use the name *Avicula* here, as elsewhere, subject to the change that it is probable the rules of nomenclature will demand in the restoration of the older name *Pteria*, which would require the name of our species to be written *Pteria gastrodes*, if it falls into that group.

Locality and position.—Cretaceous sandstones of Coalville, Utah.

MODIOLA (BRACHYDONTES) MULTILINIGERA, Meek.

Modeola Pedernalis, Meek, 1870; Hayden's Geol. Report, Wyoming, &c., List Cretaceous fossils, page 297, (not Roemer.)

Shell rather above medium size, obliquely arcuate-subovate; valves strongly convex along the umbonal slopes, thence cuneate posteriorly, and abruptly curved inward below the middle in front; posterior margin forming a broad, regular, convex curve, from the end of the hinge downward to the anterior basal extremity, which is very narrowly and abruptly rounded; anterior margin ranging obliquely backward and downward to the narrow basal extremity, and strongly sinuous along the middle, above which it projects more or less beyond the umbonal ridge, so as to form a moderately prominent, somewhat compressed protuberance; hinge margin nearly or quite straight, ranging at an angle of 50° to 60° above an imaginary line drawn from the beaks to the most prominent part of the basal outline, and equaling about half the greatest oblique length of the valves; beaks nearly terminal, rather compressed, very oblique, and scarcely rising above the hinge margin; umbonal slopes prominent and more or less strongly arcuate. Surface ornamented by fine lines of growth, crossed by regular radiating lines that are very fine, and crowded on the anterior part of the valves, but become coarser above and behind the umbonal ridge, the largest being near the dorsal side, where they bifurcate so as to become very fine, and curve more or less upward before reaching the cardinal margin.

Greatest length, measuring from the beaks obliquely from the beaks to the most prominent part of the basal margin of a large specimen, 1.90 inches; greatest breadth at right angles to the same, 1 inch; convexity, 0.76 inch.

On first examining some imperfect casts of this shell, brought by Dr. Hayden from near Coalville, Utah, I was led to think it probably the form described by Dr. Roemer from Texas, under the name *Modiola Pedernalis*, to which I referred it provisionally, in making out the list of Cretaceous fossils for Dr. Hayden's report of 1870. Further comparisons of better specimens collected during the past summer at the same locality, however, have satisfied me that it presents well-marked and constant differences from the Texas shell. In the first place, it is distinctly more arcuate, so much so, that when placed with its hinge line in a horizontal position, the outline of its posterior margin, instead of forming an oblique backward descending curve, ranges nearly vertically. Again, the most prominent part of its posterior basal margin is very narrowly rounded, instead of forming a regular curve. Its umbonal ridges are likewise more prominent, more arched, and extend down to the narrowly rounded posterior basal extremity. The lobe-like projection of the upper part of its anterior margin, under the beaks and in front of the umbonal ridge, also differs in being proportionally much smaller than in Dr. Roemer's species, in which it forms about one-third of the entire valve, as seen in a side view; while in our shell it scarcely forms more than one-sixth. Of course the specimens are more or less variable in these characters, but the two forms can always be readily distinguished when good examples can be had for comparison.

In its more arcuate form, our shell agrees more nearly with *Modiola ornata*, Gabb, from the Cretaceous rocks of California; but that shell differs very markedly in having its beaks decidedly less, nearly terminal, and a more decided and much more prominent lobe in front of them. Another important difference is to be observed in the radiating striæ, which on the anterior side of our shell are very minute and closely crowded; while on that part of Mr. Gabb's species, they are as large and distant from each other as on any other part of the valves.

If Scopoli's name *Volsella* should be adopted for this genus, as there are some reasons for believing may be the case, this change would require the name of this species to be written *Volsella multilinigera.*

Locality and position.—Cretaceous sandstones, near Coalville, Utah, first ridge, No. 14.

TRAPEZIUM MICRONEMA, Meek.

Shell attaining a rather large size, elongate trapeziform, the length being a little more than twice the height, which is about one-third greater than the convexity; anterior margin very short and round; posterior margin obliquely truncated above and narrowly rounded below; base nearly straight, or faintly sinuous along the middle, rounding up rather abruptly at each end; dorsal margin long, straight, and parallel to the base; beaks depressed nearly or quite to the horizon of the dorsal margin, and located one-sixth the entire length of the valves from the anterior margin; umbonal slopes prominently rounded from the beaks obliquely backward and downward nearly to the posterior basal extremity, while below this convexity a shallow concavity extends from each beak obliquely backward to near the middle of the basal margin. Surface ornamented with numerous very fine, regular, crowded, thread-like radiating lines.

Length, 2.28 inches; height, 1.21 inches; convexity, 0.90 inch.

I know nothing of the hinge of this shell, and merely place it in the genus *Trapezium* from external characters. Its form and surface-markings, however, are such as to leave little room for doubts in regard to its relations to that genus or *Coralliophaga.*

NOTE.—Since describing, in Dr. Hayden's Report of 1870, (page 301,) an elongated shell, from Utah, under the name *Pachymya* (?) *truncata*, I have been led, by further comparison, to think it far more probably belongs to the genus *Trapezium*, and remove it provisionally to that genus under the name *T. truncata.* In the same way I would remove another shell, described by me in that report as *Tapes Wyomingensis*, to Dr. Stoliczka's genus *Baroda*, under the name *Baroda Wyomingensis.*

Locality and position.—Cretaceous coal-bearing sandstones at Bear River City, on Sulphur Creek, Wyoming.

CORBICULA (VELORITINA) INFLEXA, Meek.

Shell longitudinally ovate, a little less than two-thirds as high as long, moderately convex; posterior extremity rather narrowly rounded, or apparently sometimes faintly subtruncated; anterior very short, subtruncated, or more or less sinuous in outline, just in advance of the beaks, on the abrupt forward slope above, and rather abruptly rounded below; basal margin semi-ovate, or semi-elliptic; dorsal margins inflected and forming a long convex slope from the umbonal region posteriorly; beaks rather depressed, oblique, incurved, and placed near the anterior end; umbonal slopes not prominently rounded; surface merely showing fine, rather obscure marks of growth; anterior muscular impression rather strongly defined and obliquely ovate; posterior muscular impression larger and obscure; pallial line showing a deep, angular, ascending sinus; posterior lateral teeth of hinge very long, linear, and nearly or quite smooth; anterior short; cardinal teeth very oblique.

Length of a specimen, a little under medium size, 1.35 inches; height, 0.39 inch; convexity, 0.68 inch.

This species is more depressed and elongated than any of those hitherto described from the far-western localities, excepting one or two from the coal formations on Bitter Creek, Wyoming, from which it differs in having its beaks placed farther forward. It will also be readily distinguished from those shells, as well as from all of the other species of the genus yet known, from any of our rocks, by having an angular, ascending, and comparatively deep sinus in its pallial line, almost like that seen in many types of the *Veneridæ*. This character is so strongly marked that it was not until I had succeeded in getting a tolerably clear idea of the nature of the hinge that I could believe the shell related to the group to which I have referred it. As was pointed out by Mr. Tryon, some years back, the existing American species of *Cyrena* and *Corbicula* have the pallial line more or less sinuous; while in nearly all of those from foreign countries it is simple. I have also ascertained that nearly all the extinct North American species yet known have the pallial line sinuous. The sinus, however, is usually shallow and rounded, or obtuse, in our fossil species; that of the shell here under consideration being unusually deep and angular.

Locality and position.—Near Missouri River, below Gallatin City, Montana, where it occurs, associated with *Trigonia*, *Inoceramus*, *Cardium*, *Ostrea*, and other marine Cretaceous fossils.

CORBICULA CYRENA (?) SECURIS, Meek.

Shell (as determined from internal casts) ovate-subtrigonal, moderately convex in the central and umbonal regions, and cuneate behind; anterior end short, with its margin regularly rounded from below the beaks into the base; posterior margin apparently a little truncated, with a slight backward obliquity from the posterior dorsal slope to the posterior basal extremity, which rounds abruptly into the ventral margin; dorsal outline declining rather distinctly backward from the beaks; basal margin forming a semi-elliptic or semi-ovate curve; beaks prominent, gibbous, located about one-third the length of the shell from the anterior margin, and rather strongly incurved; posterior umbonal slopes somewhat prominently rounded; muscular impressions shallow. (Surface and hinge unknown.)

Length, 1.67 inches; height, 1.47 inches; convexity, about 1.15 inches.

The only specimen of this species yet known being merely a cast, it is not possible to determine from it, with certainty, the generic characters of the shell. It agrees, so nearly, however, in general appearance, with *Corbicula Durkeei*, from the estuary beds near the same locality, that I was at first inclined to believe it might be that species. A careful comparison, however, with that shell, both as represented by internal casts, and by specimens showing the exterior, leaves no doubt that it is at least specifically distinct. A marked character seen in all the numerous specimens of *C. Durkeei* is the very strong inflection of the margins of the valves along the posterior dorsal slope, causing a profound wide sulcus from the beaks nearly or quite to the posterior basal extremity, where the two are united. This character alone will distinguish that shell from the form here under consideration, which shows nothing of the kind. Another well-marked difference is also observable in the muscular impressions; the anterior one in *C. Durkeei* being very deep, while in the species here described it is so shallow as only to leave rather faint marks of its outline on internal casts.

Locality and position.—Cretaceous sandstones, including the coal at Bear River City, (Sulphur Creek,) Wyoming Territory.

CORBICULA ÆQUILATERALIS.

Shell (as determined from an internal cast) subtrigonal, and nearly, or quite, equilateral, rather convex; height about five-sixths the length; anterior and posterior extremities nearly equally, and rather narrowly, rounded; ventral margin forming a nearly semielliptic curve, the most prominent part being at the middle; beaks rather prominent, and very nearly, if not quite, central; umbonal slopes not prominently rounded; dorsal outline declining subequally from the beaks in front and rear, the posterior slope being convex in outline, and the anterior concave; muscular impressions shallow. (Surface and hinge unknown.)

Length, 1.72 inches; height, 1.45 inches; convexity, about 0.92 inch.

One specimen of this shell shows impressions in the matrix of elongated lateral teeth, like those of *Corbicula* in form; but the arenaceous material is too coarse to have defined the striations of these teeth, if any existed. Until the cardinal teeth can be seen, its relations to that genus cannot be positively determined, though I have little doubt that it belongs to that group. It will be readily distinguished from the last by its less elongated and equilateral form. These characters will also equally distinguish it from *C. Durkeei*, from the Bear River estuary beds.

Locality and position.—Same as last.

CYRENA CARLETONI, Meek.

Shell small, thin, subcircular, or with length a little greater than the height; moderately convex; anterior and posterior margins rounding from above regularly into the rounded basal outline, or with the posterior sometimes slightly straightened, both rounding more abruptly to the hinge above; beaks rather depressed, small, abruptly pointed, incurved, nearly contiguous, and placed slightly in advance of the middle; hinge line sloping very gradually from the beaks. Surface marked with moderately distinct concentric lines and furrows.

Length of a medium-sized specimen, 0.55 inch; height of same, 0.49 inch; convexity, 0.32 inch.

This shell is so very thin, and so nearly resembles a rather large *Sphærium* in form and surface characters, that I should certainly have referred it to that genus, had not a lucky blow separated the hinge of a right valve from the matrix in such a manner as to expose the teeth quite satisfactorily. This shows its hinge to have the characters of a true *Cyrena*. For so thin a shell it has quite a stout hinge. Its cardinal teeth are rather diverging, the posterior two being well developed, and each a little furrowed along the middle, while the anterior one (in this right valve) is much smaller and conical in form. The lateral teeth are of moderate size, and certainly smooth, the posterior being remote from the cardinal teeth, and the linear anterior extending back to the latter. Internal casts show the muscular and pallial impressions to be well defined, and the latter to be a little straightened, or showing a very faint tendency to form a small sinus under the posterior.

This is a rather small and an unusually thin shell for the genus *Cyrena*, being, as already remarked, much more like a *Sphærium* in these characters. It is quite abundant at the locality, but as it is only found in an indurated clay matrix, good specimens are with difficulty obtained, and from these the thin shell is very liable to break and scale off, leaving only the internal cast remaining.

Among the specimens collected there are some of a more transversely oval form and somewhat larger size than those I have regarded as the types of the species here described. These may belong to a distinct species, but they agree so nearly in all other known characters that I am at present inclined to regard them as merely a variety of the same.

Locality and position.—Carleton's coal-mine, Coalville, Utah. Cretaceous.

PHARELLA? PEALEI, Meek.

Shell elongate-oblong, or subrhombic, the length being about twice and a half the height, rather compressed; anterior margin slightly sinuous just in advance of the beaks above, and somewhat narrowly rounded below this faint sinuosity; posterior margin truncated, with a convex outline, very obliquely backward and downward, from the posterior extremity of the hinge to the prominent and very narrowly rounded or angular posterior basal extremity; hinge-line proper apparently, comparatively short, and not forming any angularity of outline at its connection with the sloping posterior dorsal margin; beaks rising a little above the hinge-margin, but rather depressed and placed about one-fifth the entire length of the valves from the anterior margin; basal margin long, slightly sinuous along most of its length; posterior dorsal slopes rather prominently rounded from the beaks obliquely to the posterior basal extremity. Surface only showing obscure lines of growth.

Length, 1.20 inches; height, 0.48 inch; convexity, 0.28 inch.

Knowing nothing of the hinge of this shell, I only refer it provisionally to *Pharella*. It does not seem to have had the extremities gaping as in that genus; but the specimen has evidently been accidentally compressed, and this may have given the valves the appearance of being closed. In general appearance it resembles *Solen Guerangeri*, d'Orbigny, which seems to belong to the genus *Pharella*. Our shell, however, evidently differs from d'Orbigny's specifically, at least in not having the posterior margins of its valves near so abruptly truncated, but rounding and sloping forward gradually into the dorsal outline above. Possibly I should call it *Modiola Pealei*.

Locality and position.—Missouri River, below Gallatin City, Montana. Cretaceous.

CORBULA NEMATOPHORA, Meek.

Shell of about medium size, ovate-subtrigonal, nearly equivalve and moderately convex, with height equaling two-thirds the length; anterior outline rounded; base semi-ovate; posterior extremity somewhat produced and subangular or minutely truncated in outline below; dorsal outline sloping from the beaks, the anterior slope being more abrupt, and slightly concave in outline above, and the posterior longer and nearly straight, with a greater obliquity; posterior umbonal slopes more or less angular in each valve, from the beak to the posterior basal extremity; beaks rather prominent, and placed about one-third the length of the valves from the front. Surface ornamented by small, regular, concentric ridges, or strong lines and furrows, both of which are more distinct on the right valve than on the left, where they are sometimes obsolete.

Length of largest specimen seen, 0.50 inch; height, 0.32 inch; convexity, 0.25 inch.

This shell agrees so very nearly with a form I have described from Hallville, Wyoming, under the name *Corbicula? crassatelliformis*, as almost to raise a doubt whether it may not be really the same species. I have not seen the hinge of the Hallville species very clearly, though some of the specimens seem to indicate that it can hardly be a *Corbula*; while those of a larger, but otherwise scarcely distinguishable form, associated with it, are distinctly seen not to have the characters of *Corbula*, but to present nearly the essential features of *Corbicula*. Even should the smaller of the Hallville species, however, prove to be a *Corbula*, I think the form under consideration, which certainly *has* the hinge of the latter genus, will be distinguished, specifically, by its smaller size, more convex valves, and more distinctly striated and furrowed surface; particularly that of its right valve. It is also not so extremely thin a shell as the Hallville species.

I also have now before me another *very* closely allied form, from Black Butte Station, Wyoming, and still more nearly like the Hallville shell referred to. So far as can be determined by comparisons with accidentally compressed, and separated valves of the Hallville shell, showing none of the hinge characters, the specimens of the Black Butte form would seem only to differ in being much thicker, and more strongly and regularly marked by concentric lines and furrows. Its decidedly inequivalve character *may* also be another difference, but it is not possible to determine from the separated and compressed valves of the Hallville species, yet seen, whether it is inequivalve or not, though it seems not to be. Compared with the form here described, and which must occupy a much lower position in the series, the specimens from Black Butte differ chiefly in being much larger, thicker shells, somewhat more abrupt on the anterior slope, with more elevated beaks. There may also be differences in the hinge and muscular and pallial impressions, which I have had no opportunity to compare.

Should this Black Butte form prove to be distinct from both of the others mentioned, it may be called *Corbula propinqua*.

Locality and position.—Near Cedar City, Southern Utah, from coal-bearing Cretaceous beds, apparently belonging to the same horizon as the lower part of the coal-series at Coalville. It occurs in great numbers, associated with *Turritella Coalvillensis*, and other forms apparently identical with Coalville species.

NERITINA (DOSTIA?) BELLATULA, Meek.

Shell small, depressed ovate, or broad slipper-shaped; apex very small, and depressed to the posterior margin, where it forms one or two minute, slightly oblique, compact turns, that do not project beyond the margin, but are sometimes even slightly overlapped by it; inner lip very broad, or shelf-like, and occupying more than half of the under side, convex and more or less thickened, with the inner margin concave in outline at the middle, and provided with a slight projection on each side, but not properly crenate or dentate; outer lip rather thick, obtuse, nearly or quite smooth, and continuous around the margins with the inner one; aperture small, and transversely semicircular. Surface polished and ornamented by fifteen to twenty light yellowish or cream-colored, simple radiating costæ, separated by shallow, bright brownish furrows of about the same breadth; lines of growth moderately distinct.*

Length, 0.31 inch; breadth, 0.25 inch; convexity, 0.12 inch.

I am in some doubt in regard to the proper disposition to make of this little shell. In most of its characters it seems to conform pretty nearly with *Dostia* of Gray, generally regarded as a subgenus under *Neritina*, Lamarck, (=*Neritella*, Humphrey.) It has a much smaller and less prominent spire, however, and a more convex and broader inner lip, than the type of that group, and also wants the crenulations of the inner lip seen in the same. In its limpet-like form, tumid, greatly-developed inner lip, and minutely coiled apex, it approaches *Velates*, Montfort; and I am not quite sure that I would not be nearer right to call it *Velates bellatula*. Still it differs from the typical form of that genus in having its apex depressed to the posterior margin, instead of being elevated and nearly central; while the margin of its inner lip wants the distinct denticulations seen in that of that shell.

Of course, if Humphrey's catalogue genera are to be adopted, on account of their priority of date over those of Lamarck and others that were accompanied by diagnoses, the name of this shell, supposing the view here adopted in regard to its affinities to be correct, would become *Neritella (Dostia) bellatula*.

Locality and position.—Carleton's coal-mine, Coalville, Utah.

NERITINA (DOSTIA?) PATELLIFORMIS, Meek.

Shell small, thick, oval or subelliptic; nucleus nearly posterior and generally more or less elevated above the posterior margin, but always lower than the middle position of the dorsal region in front of it, directed obliquely backward, and, in well-preserved specimens, minutely subspiral at the immediate more or less oblique apex; inner lip very broad, or having the form of a thick, smooth, convex septum, that extends forward more than half the length of the shell; outer lip thickened, obtuse, and smooth within; open part of the aperture small and transversely semicircular. Surface with moderately distinct lines of growth.

Length of one of the largest specimens found, 0.62 inch; breadth, 0.50 inch; height or convexity, 0.33 inch.

This form is evidently very nearly related to the last, and may possibly be a more robust variety of the same. It attains a much larger size, however, than any of the specimens of that shell I have seen, and presents a more elevated form, with a thicker and more tumid inner lip; while its nucleus is often more elevated above the margin, though not always so. At first, I thought the absence of radiating costæ on this shell would very decidedly distinguish it from the last, but on farther examination I find the costæ almost obsolete on one of the specimens of that species, though the bright brown color of the spaces between them makes the lighter interspaces quite apparent. Among the specimens of the larger form under consideration, (broken directly from the

* Of course the colors mentioned are not known to present the same *tints* in the fossil shells that ornamented them when the animal was alive.

same matrix,) I find a single small individual, showing very obscure traces of radiating brown stripes, like those occurring between the costæ of the last, (the other specimens not being in a condition to preserve marks of color.) It is possible, however, that this smaller individual, showing traces of colored stripes, may be distinct from the others. It would be rather remarkable if this and the last described species should be the same, since an interval of about 600 feet of strata occurs between the beds in which they were found; while all of the other species, so far as known, from the two horizons, are distinct, and no shell resembling these forms is known to occur in any intermediate horizon.

Locality and position.—Coalville, Utah, from the Cretaceous beneath the lower heavy bed of coal mined at that place.

NERITINA (DOSTIA?) CARDITOIDES, Meek.

Shell attaining a moderately large size, broad, oval, and depressed in form, apex posterior, and nearly or quite depressed to the margin, apparently obliquely subspiral; inner lip very broad, or forming more than half of the under side, rather thick, smooth, and nearly flat, or somewhat convex, with its straight inner margin sharp and without teeth or crenulations; outer lip thick, very obscurely crenate within, and apparently continuous with the margins of the inner one around behind; aperture transversely semicircular, and less than half the size of the under side of the shell. Surface ornamented by about fifteen simple, narrow, sharp, and subcrenate radiating costæ, separated by wider, rounded, intermediate furrows; lines of growth distinct.

Length, about 0.87 inch; breadth, 0.70 inch; convexity, 0.35 inch.

This is another curious form allied to the little species I have described under the name *N. bellatula*. When viewed from the dorsal side, as seen lying with the aperture downward, its form and strong radiating costæ give it much the appearance of the left valve of a *Cardita* or *Cardium*. The only specimen of it in the collection has its apex and posterior and lateral margins broken away, and its broad, smooth, shelf-like inner lip broken by pressure inward. Still, however, it gives a tolerably correct idea of the characters of the shell. In several respects it agrees with *Velates*, and possibly might, without impropriety, be called *Velates carditoides*. I suspect, however, that when better specimens can be examined, it will be found typical of an undescribed section, including also the little species *N. bellatula*. If so I would propose for the group the name *Velatella*. I know of no nearly allied described type.

Locality and position.—Carleton's coal-mine, Coalville, Utah. Cretaceous. I am under obligations to Mrs. Carleton, the wife of the gentleman who owns the coal-mine at which the specimen was found, for the only example of the species I have seen, which was discovered by her while we were at the locality.

NERITINA (NERITELLA) BANNISTERI, Meek.

Shell subglobose; spire much depressed, or with its apex scarcely rising above the body whorl; volutions three to four, rapidly increasing in size, so that the last one comprises nearly the entire shell, more or less flattened, and sometimes provided with an obscure linear revolving furrow above; aperture large, subovate, approaching semicircular, being a little straighter on the inner side; outer lip beveled to a thin edge; inner lip of moderate breadth, slightly concave, and flattened, with a steep inward slope, entirely smooth. Surface polished, and marked by crowded zigzag vertical bands of brown and light yellowish colors; lines of growth moderately distinct.

Height of a nearly medium-sized specimen, 0.40 inch; breadth, 0.43 inch. Some examples are as much as twice these dimensions.

Although the specimens show the pattern, or style, of the original coloration of this shell quite distinctly, the colors themselves may, of course, have been different on the living shell. Usually the zigzag markings are quite distinct on the specimens as found, but on some examples the bands are blended and become fainter, so that the surface merely presents a light brownish tinge. It is always polished, however, on all the specimens seen.

This species seems to be more nearly allied to *N. Nebrascensis*, M. & H., from Jurassic beds near the head of Wind River, than to any other form with which I am acquainted. It may be readily distinguished, however, by its more depressed spire and the slight flattening of its volutions above, as well as by its more flattened and more concave inner lip. It likewise attained a larger size than any of the specimens of that species I have seen. It is one of the most abundant shells observed at the locality, and is usually found in a better state of preservation than any of its associates.

The specific name is given in honor of Dr. Henry M. Bannister, of the Smithsonian Institution, to whom I am under obligations for valuable assistance while visiting the Rocky Mountain region during the past summer.

Locality and position.—Carleton's coal-mine, Coalville, Utah.

Neritina (Neritella) pisum, Meek.

Shell globose; spire much depressed; volutions about three, rapidly increasing in size, so that the last or body turn (which is a little depressed above) composes nearly the entire shell; inner lip broad, flattened, and smooth; aperture small and semicircular; surface nearly or quite smooth.

Height, 0.22 inch; breadth, 0.26 inch.

This little shell has much the form of the last, and I was at first inclined to think it might be the same, notwithstanding its much lower position in the series. A careful comparison, however, shows that it has a decidedly broader, flatter, and straighter inner lip, while its aperture is proportionally smaller, and quite different in form.

Locality and position.—Coalville, Utah. Cretaceous, from below the lower bed of coal.

Neritina pisiformis, Meek.

Shell small, subglobose, or obliquely rhombic, the height being slightly less than the oblique breadth; spire rather prominent for a species of this genus; volutions three to three and a half; convex; last one large, and forming most of the bulk of the shell; aperture subovate, considerably contracted by the flattened, moderately wide inner lip, which is nearly straight on its inner margin, and provided there with four small denticles, the upper one of which is largest. Surface smooth.

Height, 0.30 inch; greatest oblique breadth, 0.32 inch.

This little shell agrees so nearly in size and form with the described species, (*N. pisum*,) that they may be readily confounded, as they are found with the aperture filled with rock. A fortunate fracture of one of the specimens exposed the inner edge of its flattened columella, however, and thus enabled me to see that it is denticulated, and in this respect differs from *Neritina pisum*, which seems to be entirely without teeth. Further comparisons also show the two shells to differ in form, that under consideration having a more prominent spire and a more globose outline, being less oblique.

In size and general appearance it also closely resembles small examples of *Neritina compacta*, Forbes, from the Cretaceous rocks of India; but it is less oblique, or more globose in form, and has four denticles instead of only three on its columella. It is possible I should call it *Nerita pisiformis*, as the denticulations of its columella are rather strongly developed for a *Neritina*, in which genus the columella is usually smooth, or only finely crenate. Its general aspect, however, is more like species of the latter group.

Locality and position.—Coalville, Utah, from the Cretaceous beds below the heavy lower bed of coal mined there.

ADMETE? RHOMBOIDES, Meek.

Shell rather small, rhombic-suboval, or short subfusiform, the length being slightly more than twice the breadth at the widest part, which is near the middle; spire rather depressed-conical, subturreted; volutions five or six; convex; last one forming about three-fourths the entire bulk of the shell, and more than half of its length, widest near its upper part, and abruptly narrowed below so as to present an obliquely obovate form; suture rather deep from the convexity of the volutions; aperture narrow, subangular above and narrowed below to a small notch at the base of the truncated columella, which is provided with two small obscure plaits or folds, the lower of which is formed by the twisted margin of the truncated inner lip, while the other is placed a little farther up; outer lip sharp, with its margin slightly retreating above, and more prominent below, or near the middle. Surface ornamented by distinct vertical folds, that are usually well developed on the volutions of the spire, and around the upper part of the body whorl, but become obsolete below; moderately distinct revolving lines also mark the lower part of the body volution, but these appear to become obsolete on its upper part, and on those of the spire, as specimens are usually found.

Length, 0.37 inch; breadth, 0.21 inch; angle of spire about 58°.

I am much perplexed in regard to the proper disposition to make of this and the first two of the following species. In some of their characters, they would seem to be related to certain types of the *Mitrinæ*, such as *Vulpecula*, Blainville, (= *Vulpecula*, Klein;) while in others they appear to have affinities to the *Cancellariidæ*, being much like the genus *Admete*. Without being at all satisfied, however, that they belong properly to the latter genus, I have concluded to refer them to it, provisionally, for the present, until better specimens can be obtained for study and comparison. My present impression is, that they will prove not to belong properly to any of the established genera, when all their characters can be clearly made out. If it should be found desirable, however, to establish a new group for their reception, I would propose for it the name *Admetopsis*, from the resemblance of the shell to the typical forms of the genus *Admete*.

Locality and position.—Coalville, Utah. From Cretaceous beds beneath the lower heavy bed of coal at that place.

ADMETE? GREGARIA, Meek.

Shell small, oval, subfusiform; spire moderately prominent, conical, and apparently terminating in a pointed apex; volutions five or six, convex, sometimes showing a slight tendency to become shouldered above, last one forming about half the entire length of the shell, generally a little wider above, and narrowed and somewhat produced below; suture well defined, in consequence of the convexity of the volutions; aperture narrow, slightly longer than the spire, acute above, and narrowing to a small, well-defined sinus at the base of the truncated columella, which is provided with two small folds, one of which is formed by the twisted lower edge of the truncated columella, while the other occupies a position a little above, and passes around more obliquely; surface ornamented by comparatively rather strong, regular, vertical ridges or folds that sometimes become nearly or quite obsolete on the body volution, especially below its upper part. Crossing these folds and the depressions between them, much smaller revolving ridges and furrows may be seen on well-preserved specimens, though these are also sometimes obsolescent, excepting around the lower part of the body volution.

Length of a medium-sized adult specimen, 0.50 inch; breadth, 0.25 inch; angle of spire, about 42°.

This species will be at once distinguished from the last by its proportionally more prominent spire and less expanded body volution. It is a much more abundant shell than the last, being found often in considerable numbers clustered together.

Locality and position same as last.

ADMETE? SUBFUSIFORMIS, Meek.

Shell subfusiform, with the length nearly three times the breadth; spire elongated, conical, turreted; volutions seven or eight, convex; last turn more than half the entire length; suture well defined, in consequence of the convexity of the whorls; aperture narrow, equaling about two-fifths the entire length of the shell, angular behind, and narrowing below to a small, sharply-defined notch at the base of the truncated columella, which seems to bear two small folds near its lower part, one being formed by the twisted and truncated lower magin; inner lip a little thickened; surface ornamented by distinct, regular, vertical folds that are nearly or quite obsolete on the body volution below its upper part, and regular revolving lines quite well defined on the body turn, especially its lower part, and appear to be obsolete on those of the spire; lines of growth moderately distinct.

Length, 0.50 inch; breadth, 0.20 inch; angle of spire, about 30°.

This species differs even more strongly from the last than that form does from the species *rhomboides*, having a much more elevated spire and a proportionally smaller body volution and aperture. In ornamentation the three forms, however, are much alike. The species here under consideration shows a somewhat more thickened inner lip than I have yet seen in either of the others.

For the reasons already explained, this and the last may have to take the names *Turricula gregaria* and *T. subfusiformis*, if all three do not, as suggested further back, require to be grouped together as a new section, under the names *Admetopsis rhomboides*, *A. gregaria*, and *A. subfusiformis*.

Locality and position same as last.

TURRITELLA COALVILLENSIS, Meek.

Shell attaining a large size, elongate-conical; volutions apparently ten or more, distinctly convex, the most prominent part of those of the spire being somewhat below the middle, where they are angular; surface below the angle flattened, or a little concave, and sloping rather abruptly inward and downward to the suture, while above, to near the upper margin, where there is a shallow revolving concavity a little below the suture, it is convex; last volution probably biangular around the middle; suture well defined; aperture unknown. Surface ornamented by rather obscure revolving ridges, about five of which may be counted on each volution of the spire, one being at the lower margin immediately above the suture; another, which is also the largest, occupying the most prominent angular part of the whorl; and above this three others occur, one being above the revolving concavity, and at the immediate upper margin; lines of growth obscure and making a strong backward curve in crossing the middle of the volutions.

I have not seen specimens of this fine species sufficiently well preserved to be able to give accurate measurements, though those I have had an opportunity to examine indicate a length of not less than two inches and a fraction, and a breadth of 0.93 inch. The angle of its spire, as taken from near the middle of a large specimen, imperfect at both extremities, measures about 23°, while smaller individuals, composed of five or six of the upper volutions, show an angle of nearly 30°. It is, therefore, evidently a large, robust species, that increases rather rapidly in size from the apex.

Specimens of this species were brought in by Dr. Hayden a year or two since, and were supposed by me probably to belong to *T. Martinezensis*, Gabb, to which it is evidently related in size, form, and general appearance. Since seeing the California State collection, at San Francisco, during the past summer, however, and some additional collections from Coalville, I have become satisfied that the Utah shell is distinct from Mr. Gabb's species. In this opinion Mr. Gabb also concurs, after seeing our specimens. The most obvious difference is that our shell has the volutions constantly convex above the angle, and below the revolving concavity near the upper part, while in the California species the upper slope of the volutions is regularly concave from the upper margin to the angle. Better specimens would doubtless show other differences.

Locality and position.—Coalville, Utah. From the Cretaceous, beneath the lower heavy bed of coal.

TURRITELLA SPIRONEMA, Meek.

Shell rather small, or scarcely attaining a medium size, elongate conical; volutions about fifteen, increasing very gradually in size, moderately convex, last one rounded in the middle; aperture apparently ovate; columella rather regularly arcuate. Surface ornamented by squarish, rather regular revolving thread-like lines, with nearly equal furrows between; about five to seven or eight of the lines and furrows are seen on each of the turns of the spire, and nearly twice as many on the body whorl, where those below the middle become abruptly smaller and more crowded than those above; lines of growth obscure and gently arched in crossing the volution; suture moderately distinct.

Length of the largest specimen found, 0.82 inch; breadth of body volutions, 0.23 inch; spire nearly regular; divergence of its slopes, about 17°.

There is a slightly polished appearance of the surface of this shell that is not often seen in the true *Turritella*, and gives origin to some doubts whether it may not belong to some group allied to *Aclis* or *Menestho*. As in size and general appearance, however, it seems to correspond more nearly to *Turritella*, I have concluded to refer it provisionally to that genus until better specimens can be obtained for study and comparison. None of those yet seen show satisfactorily the exact form of the aperture.

Locality and position.—Carleton's coal-mine, Coalville, Utah. Cretaceous.

TURRITELLA (ACLIS?) MICRONEMA, Meek.

Shell small terete or elongate conical; volutions about nine, nearly flat, sometimes moderately convex, increasing gradually in size, last one rounded or obscurely subangular in the middle; suture linear to moderately distinct; aperture rhombic-subovate, angular above. Surface ornamented by fine, regular, rather crowded revolving lines, six to eight of which may be counted on each volution of the spire.

Length of the largest specimen seen, 0.50 inch; breadth, 0.18 inch; angle of spire about 19°, with slightly convex slopes.

This may not be a *Turritella*, the specimens not being in a condition to show the texture of the shell, or to give a very clear idea of its aperture and lip. It would be a rather small species for that genus, and if it possessed the delicacy of surface seen in those genera it might, perhaps, with more propriety be referred to *Aclis* or *Menestho*. The fractured lip in some of the specimens has somewhat the appearance of a slight angularity or a very small notch at the base of the aperture, but this may be due to the manner in which it is broken; if not, it would seem to present affinities to the genus *Mesalia*. It will be readily distinguished from the species I described under the name *T. spironema*, by its less attenuated form and finer and less distinct revolving lines. It is also not nearly so attenuated toward the upper part of the spire as that species.

Locality and position.—Coalville, Utah, from the Cretaceous below the lower heavy bed of coal mined at that place.

FUSUS (NEPTUNEA?) GABBI, Meek.

Shell rather small, fusiform; spine moderately prominent, conical; volutions seven or eight, convex; last one somewhat ventricose in the middle, and rather suddenly contracted below into the narrow, slightly twisted, more or less bent, and apparently moderately produced canal; suture well defined; aperture rhombic-subovate, and rather suddenly narrowed into the canal below. Surface ornamented with equal, distinct, regularly disposed varices or vertical folds, about eight of which may be counted on the penultimate volution, and less on the body-whorl, where some of them become obsolete; crossing these are also seen fine revolving lines, and, a little below the suture, apparently a shallow revolving furrow, that gives it a slightly banded appearance.

Length, including canal, about 0.87 inch; breadth, 0.40 inch; slopes of spire straight, and diverging at an angle of about 50°.

The specimens of this species contained in the collection are quite imperfect, being mainly casts, retaining more or less of the shell. From such material it is, of course, impossible to determine, with much confidence, the generic affinities of shells. I have, therefore, provisionally referred it to the genus *Fusus*, putting in parentheses the name *Neptunea*, with a mark of doubt, to indicate that I suspect it may belong to that group, with the limits assigned it by some conchologists. It seems, however, quite as probably to belong to *Tritonidea*, as understood by some. The specific name is given in honor of my friend, William M. Gabb, the paleontologist.

Locality and position.—Coalville, Utah; from Cretaceous beds below the lower heavy bed of coal mined at that place.

FUSUS (NEPTUNEA?) UTAHENSIS, Meek.

Shell of moderate size, short fusiform; spire rather depressed, conical; volutions about four; those of the spire a little convex; last one large and ventricose, rounded or very slightly flattened around the middle and contracted rather rapidly below into a narrow canal that is longer than the spire, and more or less bent to the left; aperture rhombic, angular above and narrowed and prolonged into the canal below. Surface, (as determined from a cast in sandstone,) with obscure vertical ridges, about twelve of which may be counted on the penultimate volution, while on the last, or body-whorl, they become nearly or quite obsolete. (Revolving lines probably also marked the surface of the shell, though no traces of anything of the kind are seen on the cast, excepting a shallow furrow above the suture on the volutions of the spire.)

Length, including canal, about 1.90 inches; breadth, 0.91 inch; angle of spire, about 67°.

As in the last, we have not the means of determining the generic characters of this species with any degree of certainty, and merely place it provisionally in the genus *Fusus* with *Neptunea* in parentheses to indicate that it may be found to belong to that group. It is a rather decidedly larger shell than the last, with a distinctly less elevated spire, and more obscure vertical ridge or varices.

Locality and position.—Coalville, Utah; from "Chalk Hill," considerably above the lower heavy bed of coal mined there. Cretaceous.

TURBONILLA (CHEMNITZIA?) COALVILLENSIS, Meek.

Shell elongate-conical; volutions ten or eleven, moderately convex; last one not much produced below, rounded or sometimes obscurely subangular around the middle; suture well defined; aperture rhombic-suboval, being angular above and apparently a little so below; inner lip slightly thickened, rather deeply arched, a little reflected, and closely appressed below; outer lip thin. Surface ornamented by rather strong, simple, regular, nearly or quite straight vertical ridges, crossed by regularly disposed revolving lines, (about ten or eleven of the ridges and five or six of the revolving lines being seen on each volution of the spire;) while only the revolving lines are continued below the middle of the body volution.

Length of a large specimen, 1 inch; breadth, 0.40 inch; angle of spire, from 20° to 25°.

None of the specimens of this species yet seen are quite perfectly preserved at the base of the aperture. Some of them look as if there had been a slight angularity there, while others, differing in no other respect, present appearances that leave room for doubt on this point. In some of its characters this shell reminds one of the fresh-water *Goniobasis*, to which I was at one time much inclined to refer it, and I am hardly quite sure yet that it may not have to take the name *Goniobasis Coalvillensis*. Many authors refer very similar shells to *Chemnitzia*, but it has not so large and produced a body volution and aperture as the forms to which Mr. Conrad and Dr. Stoliczka propose to apply that name.*

*The genus *Chemnitzia*, d'Orbigny, *as originally proposed*, is generally regarded as synonyms with *Turbonilla*, Risso; but d'Orbigny himself, at a later date, seems to have designed to use it for another group.

If found in any of the Palæozoic rocks, most geologists would refer it to *Loxonema* of Phillips. Whether or not the nucleus or apex of its spire was covered as in the typical species of *Turbonilla* I have been unable to determine. It is a far larger shell, however, than the species upon which that genus was founded.

Specifically, this shell seems to be related to *Turbonilla Spillmani*, Conrad, (Jour. Acad. N. S., vol. iv, new series, Pl. 46, Fig. 28,) but its vertical folds or costæ are straighter, less crowded, and less numerous, while its revolving lines are smaller and more numerous. Its aperture also certainly differs in being decidedly more angular above, and probably somewhat so below. It may likewise be compared with *Scalaria Mathewsonii*, Gabb, from Cretaceous rocks of California, from which it differs in having less convex volutions, or less rounded aperture, less crowded vertical ridges, and more distinct and coarse revolving lines.

Locality and position.—Coalville, Utah; from below the lowest heavy bed of coal at that locality. Cretaceous.

Eulima funicula, Meek.

Shell subterete or elongate-conical; spire regularly tapering from the middle of the body volution to the apex, or with very slightly convex slopes; volutions about twelve, flattened; last turn not much enlarged, subangular around the middle; suture merely linear; aperture ovate or rhombic-subovate; inner lip slightly thickened and reflected. Surface smooth.

Length, 0.65 inch; breadth, 0.20 inch; divergence of slopes of spire, about 19°.

This shell has much the appearance of a slender *Niso*, but it certainly wants the umbilicus seen in that genus; its axis not being in the slightest degree perforated. It is even more like some recent species of *Eulimella*, and may possibly have to take the name *Eulimella funicula* when its generic characters can be more clearly determined from the examination of good specimens. The best examples I have seen do not show the extreme apex of the spire, or very clearly the form of the aperture. So far as can be determined, however, its columella does not seem to present the straightness seen in *Eulimella*. I know of no closely allied Cretaceous species.

Locality and position.—Cretaceous, at Coalville, Utah.

Eulima? chrysallis, Meek.

Shell small, elongate-subconoid, or subfusiform; spire conical; volutions about eight, flattened nearly to the slope of the spire; suture nearly linear; aperture subovate; inner lip a little reflected and moderately arched; outer lip unknown; surface smooth.

Length about 0.29 inch; breadth, 0.12 inch.

I am by no means sure this is a true *Eulima*, not having seen any specimens showing very clearly the form of the aperture, or the nature of the outer lip. It has the general aspect of that genus, however, and may be placed there provisionally for the present, until better specimens can be obtained for study. It will be at once distinguished from the last, by its less produced spire, less numerous volutions, and proportionally larger body-whorl.

Locality and position.—Carleton's coal-mine, near Coalville, Utah. Cretaceous.

EULIMA ? INCONSPICUA, Meek.

Shell small, conoid-subovate; spire conical; volutions, eight or nine, a little convex and compactly coiled; suture distinct; aperture apparently subovate; surface smooth.

Length, 0.17 inch; breadth, 0.07 inch; spire with straight slope that diverges at an an angle of about 22°.

This is another form that I only refer with great doubt to *Eulima*, the specimen not being in a condition to show the exact form and nature of the aperture. It will be ready distinguished from the last by its more convex volutions, proportionally shorter spire, and more expanded body-whorl. It is probably not a *Eulima*.

Locality and position.—Same as last.

MELAMPUS ANTIQUUS, Meek.

Shell subovate, thin; spire moderately prominent, conical, and abruptly pointed; volutions, about eight; those of the spire very short and nearly flat; last one large; widest above and tapering below; suture shallow, with a slightly impressed line a little below it, around the upper margin of each volution; aperture narrow; columella and inner lip provided with four very prominent laminæ or folds, with sometimes one or two smaller ones above these, near the top of the aperture; outer lip thin and strengthened by a few tranverse ridges within. Surface showing only five obscure lines of growth and presenting a somewhat polished appearance.

Height of a small specimen, 0.43 inch; breadth, about 0.27 inch.

I have only seen very imperfect specimens of this shell, but, taken together, they give a correct idea of nearly all of its characters. Some of them are three or four times the linear dimensions of that from which the above measurements were taken.

Among the specimens from the same locality and bed, there are some very large broken examples, too imperfect for detailed description, that seem to belong to a more elongated species, with a more produced spire than that described above. This form, however, as far as its characters can be made out, appears to agree with the foregoing in nearly all other respects. If distinct, it might be called *M. elongatus*.

Locality and position.—Carleton's coal-mine, near Coalville, Utah. Cretaceous.

VALVATA NANA, Meek.

Shell small, depressed subglobose, or subdiscoidal; spire depressed; volutions three and a half, rounded; suture deep; umbilicus comparatively small; aperture rounded suboval; surface nearly smooth or only showing fine obscure lines of growth under a magnifier.

Breadth of largest specimen, 0.12 inch; height about 0.08 inch.

Compared with *V. subumbilicata*, M. and H., from the Tertiary lignites of the Upper Missouri country, this little shell will be readily distinguished, by its smaller umbilicus, more prominent spire, and more oval aperture. It also has a smaller umbilicus and a less rounded aperture than the recent *V. sincera*. Its spire is more depressed, its aperture more oval, and umbilicus rather smaller than the living species *V. tricarinata*, var. *simplex*, Say.

Locality and position.—Carleton's coal-mine, Coalville, Utah. Cretaceous.

PHYSA CARLETONI, Meek.

Shell rhombic-subovate, attaining a medium size; very thin; spire short and small; volutions about three, last one very large, or forming near nine-tenths the entire bulk of the shell; aperture unknown; surface showing rather obscure lines of growth.

Length, 0.56 inch; breadth, 0.35 inch.

The only specimen of this species I have seen is somewhat imperfect, and so connected with a portion of the arenaceous matrix that its aperture and columella cannot be seen. It seems to have most nearly resembled such recent species as *P. Lordi*, Baird, in general form. I should not have attempted to name and characterize the species without seeing the columella and aperture, had it not seemed desirable to call attention to it as the first species of the genus hitherto found in the well-marked Cretaceous strata of this country.

The specific name is given in honor of Mr. Benjamin Carleton, the gentleman who owns the coal-mine at which the specimen was found, and assisted us in collecting the fossils found at the same.

Locality and position.—Carleton's coal-mine, near Coalville, Utah, in a Cretaceous bed, associated with *Unio*, *Cardium*, *Inoceramus*, *Anomia*, *Neritina*, and other marine and fresh-water shells.

Species from the Bitter Creek series.

OSTREA WYOMINGENSIS, Meek.

Ostrea Idriaensis?? Meek, 1872. Hayden's Geological Report, Montana, &c., p. 375, (not *O. Idriaensis*, Gabb.)

Ostrea Wyomingensis, Meek, 1872; ib.

Shell attaining a moderately large size, rather compressed, subovate, or trigonal-subovate, being pointed at the beaks, and more or less rounded at the opposite extremity. Lower valve usually rather shallow; beak generally somewhat acutely pointed, undistorted, and nearly always curved upward at the extremity; ligament area comparatively small, trigonal, with the longitudinal furrow and transverse striæ well defined; posterior lateral margins flattened, and rather broad, in consequence of the lateral expansion of the imbricating laminæ of growth; muscular scar comparatively small; surface with only irregular imbricating but not strongly projecting laminæ of growth. Upper valve smaller than the other, nearly flat on the upper side and slightly concave within; beak less pointed than in the other valve, being usually a little truncated at the extremity, which is straight or nearly so; ligament area of the same size and nearly the same form as in the other valve, excepting that it is not curved, but directed obliquely upward and backward, and has its anterior margin forming a transverse ridge, as usual most prominent in the middle at the end of the mesial longitudinal ridge, which is rounded, or somewhat flattened, and continued to the point of the beak; posterior lateral margins thickened in adult shells, and only rarely showing slight traces of crenulations; surface as in the other valve.

Length of large examples from beak to anterior extremity, 6 inches; breadth, 4 inches. Average-sized specimens are generally a little narrower in proportion to length.

In Dr. Hayden's report of 1872, I referred this oyster with much doubt to *O. Idriaensis*, Gabb; but at the same time expressed the opinion that it would probably prove to be a distinct and undescribed species, and suggesting for it the name *O. Wyomingensis*, in case further comparisons should confirm this suggestion. Since that time I have had an opportunity to see many other examples of it at the locality, as well as to examine specimens of the Californian shell in the collection at San Francisco, and no longer have any hesitation in regard to the form here under consideration being specifically distinct. Its lower valve has constantly a much more pointed, produced, and upward-curved beak; while none of the large number of specimens have the hinge and beak distorted laterally, as is not uncommonly the case in that species. It has more nearly the characters of the common recent *O. Virginiana*, and *O. borealis*, but also differs from these in having the beak of its lower valve constantly more pointed and produced, as well as curved upward instead of being merely straight, or irregularly distorted. Another marked and constant difference is, that it always has its muscular scars decidedly smaller, in individuals of corresponding sizes, than we see in the recent shells; while it never shows any traces of the longitudinal ridges or plications often met with in the latter.

Locality and position.—Point of Rocks, Wyoming Territory, where it is very abundant in a thin bed just above the upper of the four beds of coal observed near the tops of the hills there. Bitter Creek series.

ANOMIA (PLACUNOPIS ?) GRYPHORHYNCHUS, Meek.

Anomia gryphorhynchus, Meek, 1871. Hayden's Annual Report, p. 375.

Compare *Ostrea anomiæformis*, Roemer, 1852. Kreid Von Texas, p. 75, tab. ix, fig. 7 *a.-e.*

Since describing this little shell in the report cited above, I have had an opportunity to examine a very large number of specimens at the locality, and after returning home; and from these collections a fuller and more accurate description is given below.

Shell (for an *Anomia*) of medium size, thin and pearlaceous, a little obliquely subovate, or more or less orbicular in outline, usually somewhat narrowed toward the beak, and more broadly rounded at the opposite margin, often rather convex, but variable in this respect; cardinal margin arcuate transversely, or very slightly truncated, scarcely thicker than other parts of the shell, and without any proper marginal cartilage-facet. Upper valve, (assuming the shell to be an *Anomia*,) in the more ventricose individuals, with the umbo somewhat attenuated and curved so as to present the appearance of the under valve of a *Gryphæa*, excepting that the obtuse immediate apex is not quite marginal. Surface usually appearing smooth, but in well-preserved specimens (especially those most depressed in form) sometimes very faint traces of fine radiating striæ, and thin raised lamellæ of growth, may be seen. No scars of attachment observed on any of the specimens.

Length and breadth of an orbicular specimen, 0.83 inch; convexity of same, 0.33 inch; breadth of an oval specimen of the same length, 0.63 inch; while there are all gradations between these extremes of form.

In first describing this species, I was unable to see any traces of muscular scars, in any of the specimens then studied, but many of those since collected show them very clearly. They are precisely as in *Anomia*; that is, there are four impressions, one small one by the side of a little submarginal cartilage pit, close up under the beak, and three others near the middle of the valve, the largest one of the latter being nearest the cardinal margin, and the two smaller ones just below the large one. These three central scars are more or less nearly circular or oval, and usually distinct from each other, but sometimes in contact or a little blended together.

As the specimens from which the foregoing description was drawn up agree so exactly with the upper valve of *Anomia*, both in all internal and external characters, it may be asked, why should there be any doubt in regard to the shell really belonging to that genus? The reason for doubt on this point is, that among thousands of perfect separate valves, not a single one with the usual perforation for the passage of a byssal plug, such as we always observe in the under valve of *Anomia*, is to be seen. While at the locality, diligent search was made, among vast numbers of well-preserved separate valves, for some traces of such a perforated valve, without success. It is true we found a few much depressed valves, some indeed quite flat, but all alike entirely without any perforation, or even emargination. These few flat valves found usually have the cardinal margin a little more truncated than the others, but agree well with them in size, general outline, texture, surface-markings, and their muscular impressions, as well as in never having their more depressed beak quite marginal. No two specimens, however, were found united in such a manner as to show that the flat and convex valves belong to the same individuals. Yet it is worthy of note that if these flat and slightly convex valves are not the opposite valves of the ventricose deeper ones, we must view all of the countless thousands of individuals, almost entirely composing a bed 18 inches to 2 feet in thickness, as upper valves only, (assuming the fossil to be an *Anomia*,) and believe that, by some unaccountable agency, these were deposited here together, without the admixture of any of the opposite valves. At one time I was inclined to think this shell might belong to Morris and Lycett's genus *Placunopsis*, which, it will be remembered, agrees with *Anomia*, excepting in having no sinus or perforation in the lower valve; and it is possible that this may be the case. There are, however, some objections to this view. In the first place, *Placunopsis* has not, I believe, been found above the Oolite, while the bed in which the fossil under consideration occurs, if even Cretaceous, must belong to the upper part of that system. Again, the flat or depressed specimens, that this view would require to correspond to the under valve of *Placunopsis*, are found, on critical examination, to have their slight obliquity in the *same direction* as that of the deeper valves, instead of the reverse, as would be the case if the two forms are the opposite valves of the same shell.*

From these facts, and the exact agreement in the number and arrangement of the muscular impressions in all of these specimens, it seems more probable that they are all the same valve of the shell, varying in their convexity in different individuals. This, it is true, would leave unexplained the cause of the entire absence of any of the opposite or lower valves, whether it be an *Anomia* or a *Placunopsis*. Still, it is well known that currents sometimes perform curious freaks, in the way of assorting from other material and depositing objects of like kinds together.

In most respects, this shell agrees so nearly with *Ostrea anomiæformis*, of Roemer, (Kreid. Von Texas, p. 75, pl. ix, fig. 7 *a–e*,) from the Upper Cretaceous of Texas, that I have even suspected that it might be the same. His figures, however, represent a rather more attenuated beak of the convex valves, and less obliquity, both in the convex and flat valves. A much more important difference, supposing his figures to be

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* I mean that the obliquity is in the same direction, viewing the two forms *both in the same way* either looking at the interior or exterior.

exact in all respects, is to be observed in the muscular impressions, there being only one central impression represented in his Fig. 7 *e*, instead of three; though above this, he shows the same kind of a little transverse cartilage? pit, and small round impression by its side, seen in our shell; only both are placed farther in from the margin. Still, as the larger central scar of his figure shows some slight indications of division, and the three central scars in our shell are sometimes in contact, I should not be surprised if a critical comparison would show that there are no real differences between the muscular impressions of the Texas shell and that under consideration. That our shell is not an oyster, however, is clearly evident, from its muscular impressions, as well as from its want of a marginal cartilage-facet, and never having its beaks quite marginal. From the same submarginal character of the beaks in the form figured by Roemer, and its want of a true marginal cartilage-facet, as well as from its general physiognomy, I do not hesitate to express the opinion that it is not a true oyster. While looking through the California State geological collection, at San Francisco, last summer, I saw specimens of a shell either identical with that here described, or very closely allied to it, marked "San Diego, Cretaceous, Mr. Morse, collector."

Locality and position.—Two miles below Point of Rocks, Wyoming. Bitter Creek series.

CORBICULA (VELORITINA) CYTHERIFORMIS, M. and H.?

Cyrena (Corbicula?) *cytheriformis*, M. and H., 1860. Proceed. Acad., May, p. 176.

The shell I here refer with doubt to the above species is certainly a very closely allied form, if not the same. About the only external difference I have been able to see, on comparison with the types of the *C. cytheriformis*, is that specimens here under consideration usually have the beaks rather more elevated, a little more pointed, and slightly less oblique. Their posterior dorsal slope is also a little straighter in most specimens. On examining a considerable number of individuals, however, they are found to vary more or less in most of these characters, so that if there are no differences in the hinge and interior, the slight external differences may be only such as might be produced by local conditions.

Of the form under consideration, we have specimens showing perfectly the hinge, and muscular and pallial impressions, as well as all of the external characters. These show that the cardinal teeth have the backward obliquity of the type of the group *Veloritina*, and that the laterals are elongated nearly as in *Corbicula*, though not quite so long, nor so distinctly striated; and that the posterior lateral is separated, by nearly its own length, from the posterior cardinal. The hinge characters are, therefore, almost exactly intermediate between *Corbicula* and *Veloritina*, the chief difference from the latter group being the slender elongated character of the anterior lateral tooth, as in *Corbicula*. Unfortunately we have no specimens of the typical *C. cytheriformis* showing the hinge clearly enough for minute comparisons. I suspect, however, that specific differences will be found between the hinge of that form and the specimens under consideration. Both have the pallial impression provided with a shallow rounded sinus.

Locality and position.—Point of Rocks, on Bitter Creek, Wyoming, near the bottom of section seen there; as well as at a much higher horizon, at Black Butte Station, on the Union Pacific Railroad, Wyoming. Bitter Creek series.

CORBICULA? FRACTA, *var.* CRASSIUSCULA, Meek.

Corbicula? fracta, Meek, 1870. Hayden's Annual Report for that year, page 314.

This shell agrees so very closely in form and size, as well as in its hinge and pallial and muscular impressions, surface, characters, &c., with the species I have described in the report above cited, from the shale over one of the Hallville beds, under the name *Corbicula fracta*, that it hardly seems proper to separate it specifically. Yet, in the thickness of the substance of these shells from the two localities and horizons, there is a very marked difference; those from Hallville being extremely thin, even in the largest specimens, the thickness not measuring more than from 0.02 to 0.03 inch, while in examples of corresponding size of those here under consideration, it measures from 0.10 to 0.12 inch in thickness. The latter also seem to be more convex, but the Hallville specimens being generally more or less flattened between the laminæ of the shale, it is difficult to know exactly how far this want of convexity may be due to accidental pressure.

I am aware that shells found in argillaceous shales are usually thinner than examples of the same species from more calcareous deposits; but I have never seen a difference of this kind so strongly marked in specimens certainly known to belong to the same species. This thicker shell is, therefore, placed here provisionally as a variety of *C. fracta*, under the name *crassiuscula*, which it can retain if further comparisons should show it to be specifically distinct.

In describing the species *C. fracta*, I noticed several points of difference between it and the characteristic forms of *Corbicula* and *Cyrena*, and suggested for the group of which it may be regarded as the type the subgeneric name *Leptesthes*. The peculiarities *mentioned* were the extreme thinness of the shell, and its very elongated depressed form. The specimens here under consideration show that the thinness of the shell is not a constant character, though they at the same time show that this type presents other more important differences, of which I had seen indications before, but which I did not mention especially, because the specimens then seen were not sufficiently well preserved to permit these characters to be clearly defined. They are differences in the hinge. For instance, although the primary teeth do not differ materially from those of *Corbicula* and *Cyrena*, the anterior lateral tooth differs from that of *Cyrena* in being linear and elongated parallel to the hinge-margin, as well as slightly striated, thus agreeing with the corresponding tooth of *Corbicula*. Its posterior lateral tooth, however, on the other hand, is more nearly as in *Cyrena*, being shorter than in *Corbicula*, and placed very remote from the cardinal teeth, while the intervening cardinal margins are wide, flat, and, when the valves are united, close fitting. Yet this tooth is also striated as in *Corbicula*, though less distinctly. Again, the ligament is also decidedly longer than in *Corbicula*, or than is usual in *Cyrena*, and also less prominent, there being apparently no elevated fulcrum for its attachment. The pallial line shows a shallow subsemicircular sinus.

It will thus be seen that these shells combine some of the characters of both *Cyrena* and *Corbicula*, without agreeing exactly with either. It is well known to paleontologists, however, who have studied fossil-shells of these groups, that there are many species that show intermediate characters between these genera, so that some eminent authorities do not admit the genus *Corbicula*, but place the whole under *Cyrena*. Should this view prevail, the forms here under consideration might be so disposed of. Still, even in that case, it would seem desirable and convenient to separate them subgenerically, by writing the name *Cyrena* (*Leptesthes*) *fracta*. If the two groups *Cyrena* and *Corbicula*, however, are to be regarded as distinct genera, there would be nearly or quite as good reasons for so regarding *Leptesthes* as a genus.

Locality and position.—Black Butte Station, Wyoming, upper beds. Bitter Creek series.

CORBICULA (VELORITINA) BANNISTERI, Meek.

Shell of about medium size, subglobose, the valves being very convex and subcircular in outline; ventral margin forming a regular semicircular curve; anterior and posterior margins nearly equally, and more narrowly, rounded; dorsal outline declining distinctly from the beaks, the anterior slope being more abrupt and concave in outline, and the posterior very convex, with the posterior dorsal margins of the valves inflected so as to form a deep, rather broad sulcus when the valves are united; beaks prominent, ventricose, incurved, contiguous, and placed about one-third the length of the shell from the anterior margin; lunular region impressed; surface ornamented with fine lines and small but rather distinct, somewhat regularly arranged, concentric ridges and furrows. (Hinges and interior unknown.)

Length, 0.87 inch; height, 0.83 inch; convexity, 0.66 inch.

This is a very neat, symmetrical shell, readily distinguished from the other species yet known from the rocks of this region, by its short, very convex form, and rather distinct, regular, concentric ridges and furrows. In one character it agrees with *C. Durkeei*, from the brackish-water beds at Bear River City, more nearly than any other species I have yet seen. That is, in having the posterior dorsal region of its valves strongly inflected, so as to form a deep, broad sulcus or escutcheon along this slope when the valves are united. Its rounded, ventricose form and stronger concentric markings, however, readily separate it from that shell, from which it also differs in being much smaller, while its gibbous form shows it to be an adult shell. It is also related to *C. occidentalis*, M. & H., from the estuary beds near the mouth of Judith River, but it is more rounded in outline, more gibbous, and differs in the inflected character of its posterior dorsal region, its stronger surface-markings, and more impressed lunule. I have not yet seen its hinge or interior, but from its general external characters, I have little doubt that it belongs to the section *Veloritina*.

The specific name is given in honor of Dr. Henry M. Bannister, who discovered the only specimen of the species I have seen.

Locality and position.—Bitter Creek series, Black Butte Station, Wyoming at the same horizon as the large saurian found there.

CORBULA UNDIFERA, Meek.

Shell of moderate size, trigonal-subovate, rather convex, the inequality of the valves not being very strongly marked, though always obvious; beaks moderately prominent, (that of the right valve being only a little more elevated than the other,) located in advance of the middle, contiguous, and incurved, with a scarcely perceptible forward inclination; posterior extremity subangular at the connection of its margin with the base; posterior dorsal slope more or less convex in outline; anterior margin rather short and rounded; base semi-ovate in outline, being most prominent anteriorly, and somewhat straightened behind; left valve about one-fourth less convex than the other, with posterior umbonal slope distinctly angular from the beak to the posterior basal extremity; right valve with posterior umbonal slope less strongly angulated; surface of both valves ornamented with concentric ridges, generally small and regular on the umbonal region, but often swelling out into a few very prominent, angular folds with rounded depressions, marked by distinct lines of growth, and some small ridges between, on the lower half of the valves; all the ridges and folds generally becoming obsolete behind the angular, posterior, umbonal slopes, but continued forward to the front.

Length of a well-developed specimen, 0.76 inch; height to top of umbo of left valve, 0.56; height to top of same of right valve, 0.58 inch; convexity of the two valves united, 0.41 inch.

The most marked feature of this species is its very strongly elevated, sharp, irregular, concentric ridges that rise into larger angular folds below the middle of the valves, thus giving an equally rugose appearance to both valves. *C. perundata*, of M. and H., has nearly as strong concentric ridges, but they are much more regular, and instead of being sharply angular, with rounded, broader spaces between, as in the species here described, they are broadly rounded, with narrow, angular furrows between, on that shell, which also wants the angular, posterior, umbonal slopes of this species.

Locality and position.—Rock Spring Station, Central Pacific Railroad, Wyoming Territory. Upper part of Bitter Creek series.

CORBULA TROPIDOPHORA, Meek.

Shell distinctly trigonal, with height a little more than three-fourths the length, moderately convex; valves subequal, the right one being only a little more convex than the other, and having its beak not much more prominent; both with posterior umbonal slopes angular from the beaks to the posterior basal extremity, that of the left valve especially being very distinctly so, while the sides of the valves, (particularly that of the left valve,) in front of the angular umbonal slope, are flattened; anterior outline truncated with slight obliquity from the beaks to the anterior basal extremity, which is subangular or very abruptly rounded into the base; posterior dorsal margins abruptly inflected toward each other from the umbonal ridge, and forming a nearly straight slope from the beaks to the posterior basal extremity, which is distinctly angular; pallial margin gently convex in outline from the front to the posterior angle; beaks moderately prominent, oblique, incurved, contiguous, and located about half way between the middle and the anterior margin. Surface ornamented by fine lines of growth, and more or less defined ridges and furrows that are usually most distinct on the lower half of the right valve. Cartilage process of the left valve spoon-shaped, rather prominent, and larger than the pit by its side for the reception of the tooth of the other valve. (Hinge of right valve unknown.)

Length of a medium-sized specimen, 0.72 inch; height to top of beak of right valve, 0.52 inch; height to top of same in left valve, 0.49 inch; convexity of the two valves united, 0.33 inch.

This shell is very closely allied to *C. subtrigonalis*, M. and H., with which I have even been inclined to think it might be identical. The typical specimen of that species is a left valve only, so that we have not the means of making a very thorough comparison. Compared with this left valve, however, the corresponding valve of the form under consideration, although agreeing closely in general outline, is seen to be decidedly more compressed, has its umbo less gibbous, and not so strongly incurved, while its posterior umbonal ridge is *much* more angular. Its cartilage-process is also larger and more prominent, and the pit by its side for the reception of the tooth of the other valve is proportionally smaller. As the specimen of *C. subtrigonalis* is evidently water-worn, however, the more rounded character of its posterior umbonal ridge may be in part, at least, due to that cause, though the other difference mentioned could hardly have been so produced.

Along with the typical specimens of the species here described there are separate right valves, apparently of this species, a little larger than the corresponding valve of the perfect specimen from which the description was drawn up. This valve shows a distinct furrow along the inner side of the lower margin for the reception of the edge of the other valve, which furrow doubtless also exists in the typical specimen, but cannot be seen because the two valves are united. There is also another right valve, from the same locality and bed, that is proportionally much higher and shorter, and has its beaks almost exactly central, so as to present more nearly the outline of an equilateral triangle. This may belong to a distinct but allied species; if not, it would indicate a considerable variation in the outline of the species described.

Locality and position.—Point of Rocks, Wyoming. Bitter Creek series.

GONIOBASIS? INSCULPTA, Meek.

Shell terete, or elongate-subconical; volutions apparently about ten, convex, or sometimes flattened-convex, increasing gradually in size; last one not much enlarged, and without an angle around the middle, sometimes slightly concave above in large specimens; suture well defined; aperture unknown. Surface ornamented by distinct, regular, nearly straight, or slightly arched vertical costæ, about sixteen of which may be counted on each volution, while crossing these are smaller regular, deep, revolving furrows that cut each rib into five or six little transverse nodes, which, from the obsolescence of the vertical costæ on the lower part of the last turn, become more or less continuous revolving lines on that part of the shell.

The specimens of this species yet obtained are too imperfect to afford the means of giving accurate measurements. Judging, however, from some of those in the collection, large adult individuals would seem to have attained a length of 1.40 inches, with a breadth of body-volution of near 0.50 inch. Some of these larger specimens, consisting of three or four of the lower volutions, show but a very gradual decrease in breadth upward; while some of those composed of the upper part of the shell indicate a divergence of about 18° for the angle of that portion of the spine.

As none of the specimens show the aperture, it is not possible to determine, from those yet seen, whether this shell really belongs to the fresh-water genus *Goniobasis*, or to some marine genus, although the species will be readily recognized by its sculpturing. Its only known associates are fragments of *Ostrea* and *Modiola*, with *Corbula undifera*, an association that would certainly favor the conclusion that it should be referred to a marine genus, in which case it would most probably fall into *Bittium*, and have to be called *B. insculpta*. We have, however, several examples of unquestionable fresh-water shells associated with marine types, in some of the rocks of this region; while the general aspect of this shell seems, as far as known, to associate it with *Goniobasis*. The fact, too, that nearly all the specimens yet seen are fragmentary, seems to indicate that the species did not live in the same waters with the other forms found associated with it, but that the specimens may have been washed into the sea from streams on the neighboring shores.

In several respects this species resembles *Cerithium mexicanum*, Gabb, figured and described in the California geological report, from the Cretaceous rocks of Mexico. It differs, however, in showing, so far as yet known, no traces of the varices seen on that shell; while the little nodes formed by the crossing of its revolving lines and vertical costæ are transversely elongated, instead of rounded, as on the Mexican species, which is probably a *Cerithium*.

Locality and position.—Rock Spring, Wyoming, from a little above the main ten-foot bed of coal at that locality. Bitter Creek series.

Melania Goniobasis (?) wyomingensis, Meek.

Shell attaining a rather large size, subterete, or very elongate-conical; volutions about nine or ten, the upper ones flattened-convex, and the lower two or three more prominent; suture well defined but not deep. Surface of upper volutions ornamented by small, regular, rather crowded, and slightly arched vertical costæ, crossed by five or six regular revolving lines, that impart to them a granular or minutely nodular appearance; farther down, the vertical costæ become less and less distinct, so as nearly or quite to disappear on the lower turns, while the revolving lines become proportionally stronger, especially one a little above the middle of each volution, which develops a revolving row of rather distinct nodes that are compressed from above and below, so as to become sharply prominent on the lower two volutions, thus giving them an angular appearance; though the last one is rounded below this angle. (Aperture unknown.)

Length, about 2 inches; breadth, about 0.70 inch.

It is not probable that this shell belongs properly either to the genus *Melania* or *Goniobasis*, as those genera are now restricted by the best authorities in conchology; though I have little doubt that it will fall into *Melania*, as defined and understood by those who give greater latitude to genera. It is probable that when its aperture can be seen, it will be found to present characters that would warrant its separation under a new generic name. I suspect, indeed, that some others of our fossil-shells of this kind, from the fresh and brackish water-beds of the Rocky Mountain region, will be found to belong to several undefined groups; but until better specimens can be obtained, we can only range them provisionally under the established genera to which they *seem* to be most nearly allied. Undoubtedly at some future time specimens will be found sufficiently well preserved to enable the paleontologist to classify them more correctly. It seems desirable, however, in the mean time, to define them, so that they can be used by geologists in identifying strata, as it may be ages before perfect specimens can be found; while those we now have can be readily identified *specifically* by their ornamentation and other well-marked characters.

Locality and position.—Black Butte Station, Union Pacific Railroad, Wyoming Territory. Upper beds Bitter Creek series.

TERTIARY FORMS.

Physa Bridgerensis, Meek.

Shell attaining a large size, subovate in form; spire prominent, conical; volutions four and a half to five, moderately convex, last one large but not very ventricose; suture well defined; aperture narrow-subovate, arcuate, acutely angular above, and about twice as long as the spire; columella twisted into a rather prominent fold. Surface with fine sharp lines of growth.

Length about 1.15 inches; breadth, 0.66 inch.

This is a fine large species, with a more prominent spire than any of our recent species resembling it in other respects. None of the specimens found are perfectly preserved.

Locality and position.—Church Buttes, fourteen miles from Fort Bridger, Wyoming Territory. Tertiary.

LIMNÆA, LIMNOPHYSA (?) COMPACTILIS, Meek.

Shell rather small, slender, subfusiform; spire conical, a little longer than the aperture; volutions about six, very little convex, and (for a Limnæa) compactly wound together; last one not ventricose, but rather produced below; suture distinct though shallow, and but little oblique; aperture narrow subovate, very narrowly rounded below, and acutely angular above; outer lip not dilated; columella a little twisted, and apparently so as to form a small oblique plication. Surface smooth.

Length of a medium-size specimen, 0.50 inch, breadth 0.20 inch; length of aperture 0.22 inch; breadth of aperture 0.10 inch.

I have not seen specimens of this little shell showing the columella clearly enough to be sure that it belongs to the genus *Limnæa.* There is a compactness in the rolling together of the volutions of the spire, and a want of obliquity and deepness, observable in the suture, that are not often seen in that genus, and remind one of some forms referred to sections of the old genus *Bulimus,* such, for instance, as *B.* (*Thaumastus*) *californicus.*

Locality and position.—Upper beds of the series exposed at Separation, on the Union Pacific Railroad, apparently belonging to the Tertiary.

PUPA? LEIDYI, Meek.

Shell clavate-subcylindrical, being about three times as long as wide, a little wider above the middle than below, and very obtuse at the apex; volutions about fifteen, very compactly coiled together, and extremely narrow in their vertical diameter; suture merely linear, and so slightly oblique as to appear to the eye almost at right angles to the longer axis of the shell; aperture unknown, but apparently small. Surface ornamented by small, comparatively distinct, regular, crowded, oblique striæ of growth.

Length about 0.55 inch; greatest breadth, 0.20 inch.

The volutions of this shell are so compactly coiled, so very narrow, and show so little obliquity, as to give it the appearance of the abdomen of some insects, the volutions looking like rings, and the obtuse apex of the spire like the posterior extremity of an insect abdomen. I have seen but two specimens, and neither of these shows the aperture; consequently it is not possible to determine whether or not it is a true *Pupa.* Indeed its subcylindrical form, and numerous volutions, give it much the appearance of *Holospira* of Albers, and it is quite probable that when specimens showing its aperture can be examined the name may have to be changed to *Holospira Leidyi.* Specifically it rather closely resembles *H. Remondi*, an existing species found at Sonora, Mexico. It has a more obtuse apex, however, than that species, and also differs in having more narrow and compactly coiled volutions, and a less oblique suture.

The specific name of this interesting little shell is given in honor of Professor Joseph Leidy, the distinguished comparative anatomist of Philadelphia, who discovered one of the specimens from which the description was drawn up.

Locality and position.—Tertiary rocks twelve miles south of Fort Bridger, Wyoming Territory.

REPORT

OF A

GEOLOGICAL RECONNAISSANCE

ALONG THE

UNION PACIFIC RAILROAD.

BY

H M. BANNISTER, M. D.

REPORT OF A GEOLOGICAL RECONNOISSANCE ALONG THE UNION PACIFIC RAILROAD.

The following pages contain an account of a portion of the geological reconnaissance made by Mr. Meek and myself in the coal-bearing formations along the line of the Union Pacific Railroad in the summer of 1872, in connection with the United States geological survey of the Territories, Dr. F. V. Hayden in charge. The work comprised the collection of fossils from these beds, and taking sections and such other notes as would serve for the correct establishment of the various horizons in which the collections were made, with a view of obtaining fuller data for forming a correct idea of the formations and for the determination of their age. I have, therefore, given a consecutive account of all the localities visited by us, which are not elsewhere reported on by Mr. Meek, with our examinations at each; not, however, entering into questions of economic geology, or of general structure, except in so far as it appeared necessary for the elucidation of the points in view. In making this report, in addition to those taken by myself, I have been kindly allowed the use of the field-notes of Mr. Meek.

CARBON.—The first locality where we made any examinations was Carbon Station, the easternmost point where the coal of this region has been opened and extensively worked. Here we stopped a day and examined carefully for fossils in the natural and artificial exposures near the station. The structure here seemed a little complex, the beds considerably faulted and upturned, but we obtained an approximate section sufficiently accurate as to the relative location of the different beds from which we obtained specimens. The coal appears to lie in a local synclinal, the dip of the rocks immediately west of the station being from 20° to 30° in a general direction from east-southeast to southeast, while on the opposite side of the little basin or trough it was about 15° to 20°, the direction varying from southwest to west or north of west. From the different exposures, and from the testimony of the miners as to the beds passed through in sinking shafts, we made the following approximate section:

Section of the strata at Carbon, Wyoming.

	Feet.	In.
1. Argillaceous shale	8	0
2. Coal	0	6
3. Sandstone and sandy shale	59	0
4. Argillaceous shale	2 to 5	0
5. Coal	9	0
6. Light-colored sandy and argillaceous shales, with impressions of leaves	18 to 20	0
7. Coal	3 to 5	0
8. Light-colored sandy shale	9	0
9. Coal	4 or 5	0
10. Light sandy beds, sandstone, and, perhaps, some coal, (estimated)	40 to 50	0

	Feet.	In.
11. Light-grayish sandstone, weathering yellowish or reddish, and varying much in hardness in different portions, irregularly bedded, (estimated)	300	0
12. Thin-bedded, hard, reddish sandstone	50	0

The upper members of this section, from 1 to 5 inclusive, were given as the beds, in their order, passed through in sinking an air-shaft, and were not seen in place by either of us. From an opening made near the railroad-track, which penetrated a portion of these beds, a quantity of fragments of a laminated, ashy-colored sandstone were thrown out, which were quite full of impressions of leaves. These, with similar remains from beds 6 and 8, were all the fossils we obtained, though it was reported to us that shells had been found in the beds underneath the main coal-seam, No. 5. Number 10 of the section is nowhere well exposed, and the thickness of these beds, as well as of those immediately below, could only be estimated in a very general way. Number 11 forms the high bluff of fantastically-weathered sandstone, which is to be seen on the side of the railroad, a little west of the station, and which forms the extremity of a ridge stretching away to the north and east. This appears to be the eastern edge of an anticlinal valley, as in the opposite ridge, a mile or two distant, the beds seemed to have a reversed dip to the west or west-northwest.

FORT STEELE.—Our next stopping-place west of Carbon was at Fort Steele, where we made some examinations of the strata in the extensive exposures along the Platte River, on the southern side of the railroad at this point. The cliffs on the northern side were not visited, as they were merely the equivalents of the beds examined, and could only present local variations. Owing to a lack of time we also did not visit the interesting localities on the railroad east of the station at the fort.

Passing up the valley of the Platte from Fort Steele, the vicinity of the post for the first mile, or a little more, is occupied by rounded hillocks of whitish clays, which probably form the lowest of the beds which are exposed by the rift of the anticlinal at this point. Beyond that distance, however, there appears a series of ridges of harder sandstone rocks abutting immediately upon the left bank of the river for the distance of a mile or more. The hollows, or parallel valleys between the ridges, are caused by the erosion of the less resistant intermediate beds of shales or clays. The whole constitutes an immense series of heavy-bedded grayish-buff and drab sandstones of various degrees of hardness, alternating to some extent with ashy and dark colored shales, amounting altogether to several thousand feet. The sandstones presented a very well marked jointed structure, perpendicular to the lamination, the sloping faces of some of the ridges, when viewed from a little distance, appearing like the edges of vertical strata. The dip of the ridges along the river was nearly due south-southeast, and the angle in the lowest beds about 35°, then gradually increasing to over 40 or 45 in the middle of the series, and again decreasing to from 15 to 20 at the upper limit of our examinations. Beyond that point, the beds appear nearly or quite horizontal. A little below the middle of the series we found in a bed of light-colored shale a stratum of about 4 feet in thickness, almost entirely made up of imperfect specimens of an *Ostrea*, unidentifiable as to species; the only animal remains found in the whole thickness of sandstones and shales. In the upper part of the series we observed various seams of dark carbonaceous shale approaching lignite, and at least one small seam of coal, but without associated fossils, other than indistinct vegetable remains. In the heavy sandstone-beds we observed in several places a curious branched fucoidal impression, (*Halymenites*,) which was afterward noticed by us in sandstone-beds at various localities farther west. As far as is indicated by the fossil remains found by us, there are no grounds for rendering any positive opinion as to the age of this series; the lower clays, however, have been determined, from fossils from that horizon, to belong to the Cretaceous, and it is not impossible that these overlying sandstones may either wholly or in part be properly referred to that period.

RAWLINGS.—Between Fort Steele and Rawlings, the next station west, we made no notes or collections, but stopped several days at the latter place to examine the lower formations there exposed. The mountain immediately north of the village is mainly composed of light-grayish or flesh-colored syenitic granite, above which the sedimentary beds lie tilted at various angles and in different directions on the several sides of the hill. Immediately above the granite is a distinctly stratified deposit of siliceous conglomerate, passing in places into a coarse pebbly sandstone, but mainly made up of rounded pebbles of whitish quartz, rarely over one inch in diameter, in a siliceous matrix. This passes gradually into the beds above; it may be put down, however, as about 75 or 80 feet at its greatest thickness. Above this we have between 300 and 400 feet of hard grayish sandstone, approaching quartzite, regularly bedded, the layers seldom exceeding a foot in thickness. Its color on weathered surfaces varies from a light gray to a reddish brown, a tinge of the latter color predominating throughout the whole; on freshly fractured surfaces, however, it is generally light gray, or is nearly white. The lower and heavier beds are almost a true quartzite; this character is less apparent toward the top, and some layers appear to be full of rough fucoidal casts, which, however, were too imperfect to be of value as specimens. No other fossils whatever were found, in spite of a very careful search; but while there was nothing absolutely characteristic, Mr. Meek was inclined from their general resemblance to undoubted Silurian beds in the western country, as well as their position and the character of the contained fucoidal traces, to refer these beds to the Lower Silurian, and possibly to its lowest member. Above the sandstone is from 10 to 15 feet of dark colored ferruginous sandstone, in places containing a few pebbles, and even approaching the character of a conglomerate. The bed of iron-ore worked on the northeastern side of the mountain represents, I think, a portion of this stratum. The sandstone with its ferruginous capping is well seen in the two hills between which the railroad passes about a half mile west of the station, and also in its upper portion at the base of the hill at Cherokee Spring, three or four miles northwest of the village. On the southwestern corner of the mountain, the sandstone-beds which form the summit of an isolated spur extending in that direction are beautifully polished and finely striated from the action of sand carried by the wind, the angles of the rock still being preserved.

Immediately above the ferruginous upper layer of the sandstone is a heavy limestone formation, the total thickness of which can hardly be less than 300 feet, and is probably much more. It is a hard, splintering rock, in places cherty, generally of a whitish or light-grayish color, but with some layers dark bluish-gray. In it we found a specimen or two of an *Athyris* closely resembling, if not identical with, *A. subtilita* of the coal measures; indeed, there seems to be no doubt as to the carboniferous age of this rock. This limestone appears on the northeastern slope of the mountain for about 100 feet of its lower portion, and can be seen in ridges on the plain at its base. It also caps the hills, between which the railroad-track passes just west of the station, and is also shown in its full thickness in the hills near Cherokee Spring. Above the limestone is a light buff or yellowish sandstone weathering into thin laminæ in the exposures which outcrop in several places in the hills south of the railroad near the station, but we did not measure its thickness nor see its point of junction with the beds below. The vertical distance between the highest outcrop of this rock visited by us and the base of the limestone we estimated at from 600 to 800 feet.

The rocks above the granite dip to all points of the compass, from nearly north on the northeastern face of the mountain, around by east and southeast, to southwest in the hills near Cherokee Spring. In the hills near the station it is about 10° southeast, and is continuous on both sides of the curious gap through which the railroad passes. It increases in angle in the higher sandstone-beds, above the limestone, which I have mentioned as outcropping in the hills south of the railroad, being there not less than 20° or 30°, still preserving, however, the same direction. At Cherokee Spring the beds are also tilted at a high angle, varying from 20° to 30°, apparently greatest in the lower sandstones. In the northeastern exposures on the long slope of the mountain it was slight, not averaging over 10° or 12°; in direction, ranging from south of east to nearly north.

SEPARATION.—We did not attempt to make thorough examinations at Rawlings, or to work out the connection between these lower formations and the Cretaceous, as more time would have been required for this than we could have well given. We therefore passed on to Separation, the next stopping-place to the westward, where we spent one day. The station is situated in a level country with no very prominent exposures of rock in place nearer than a mile and a half or more. At that distance, however, in a direction a little south of east, we reached the first of a series of low ridges extending across the country in a general north and south direction, composed of thin-bedded sandstones dipping at an angle of from 10° to 15° to the west, or a little north of west. These ridges are caused by the harder sandstone-beds standing out prominently from the softer shales and clays which form the great mass of the beds here. Walking directly across the dip we passed over eleven of these ridges in the estimated distance of somewhat less than two miles, the valleys between, as a general rule, affording no exposures. At that distance the series of low ridges ended in a high sloping bluff of heavy-bedded, grayish-buff sandstone, faced in part with a largely eroded bluish-white bed. We noticed ten different seams of Carbonaceous shale or coal in the ridges, some of which doubtless represent workable beds. In the upper part of the first ridge, in the highest beds of the series, we collected specimens of leaves of deciduous trees, which were very abundant in some of the thin layers of sandstone. The only other fossils we obtained were found in a six-inch bed in the second ridge, from which we obtained specimens of fresh-water shells, *Lymnæa*, *Viviparus*, *Goniobasis*, and *Unio*, nearly all fragmentary or in a poor state of preservation. The more eastern ridges, the beds of which are lower in geological position, afforded no remains whatever, either animal or vegetable, to such search as we were able to give.

At one point on the plain between the first ridge and the station, sandstone-beds appear at the surface, but with a very much reduced angle of dip, apparently scarcely over 3° or 4°, the direction still toward the west. The strata appear to assume a horizontal position very rapidly in that direction. Taking the average of the angle of the dip at any point from 10° up to 15°, between which it probably ranges, perhaps even exceeding the latter figure, it will readily be seen that an immense thickness is included in these ridges, not less than 1,800 or 2,000 feet.

Adding to this several hundred feet of beds not well exposed, but which must intervene between the westernmost ridge and the point where the dip ceases and the strata become horizontal, we have, at a moderate calculation, from 2,100 to 2,500 feet of these whitish clays and darker shales and sandstones above the heavy-bedded sandstone in the bluff which formed the lowest geological horizon in our hurried examination at this point. We have no positive evidence as to the character of the intermediate beds between the more widely separated ridges, as the wash from the elevations and surface-soil covered all the evidences of stratification. An artesian boring at the station gives a record of alternations of clays, shales, and soft arenaceous beds for some 540 feet, which is probably the usual character of the softer beds generally. The greater part of this thickness is probably of Tertiary age; the lower portion, however, may belong to the upper part of the Cretaceous. There are no positive evidences of any unconformability, notwithstanding the sudden lessening of the angle of the dip, and no recognizable horizon of separation of the two formations in the whole series above the heavy sandstone.

BITTER CREEK.—From Separation we passed on by railroad to Bitter Creek, making no stoppage at intermediate stations. For the whole distance there appeared to be only exposures of higher Tertiary beds, mostly horizontal, or nearly so, which fill the trough between these stations. At Bitter Creek we stopped over one day and examined these upper beds, as they are to be seen in the immediate vicinity of the station and in the hill known under the name of Table Rock, some four miles or more distant.

Table Rock is a spur of the range of Tertiary hills which appear for a long distance on the southern side of the railroad, and also to some extent in conical outlines to the northward. In its upper portion it is itself an outlier, the strata of which this part of the hill is composed having been washed away in its immediate vicinity. The section it afforded is as follows, the beds numbered from above downward:

Section of the beds exposed in Table Rock.

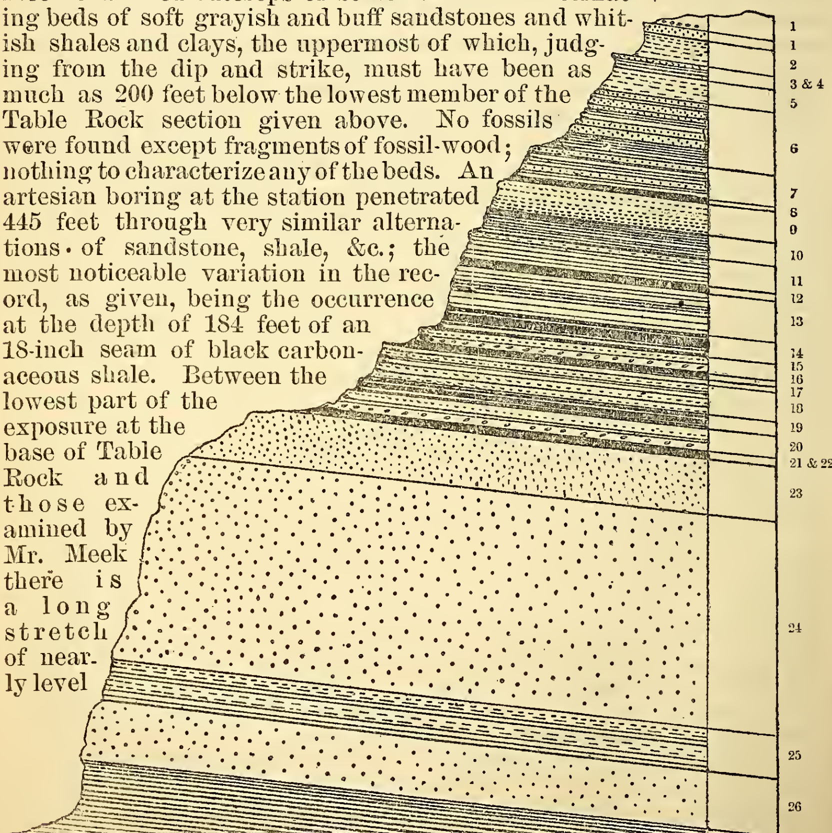
	Ft.	In.	
1. Hard brownish sandstone, largely made up of imperfect casts of *Unio*, &c	15	0	A.
2. Shale, partly carbonaceous	0	6	A.
3. Light-brownish sandstone, massive and incoherent	20	0	A.
4. Sandy shales, light-colored	3	0	A.
5. Same as No. 3	12	0	A.
6. Shaly sandstone, light-brown or buff	20	0	A.
7. Sandstone, same as No. 3	12	0	A.
8. Light-colored shaly sandstone, with intercalated beds of clay and shale	240	0	A.
9. Harder and slightly darker colored sandstone, with a great abundance of fossils, &c., *Melania*, *Viviparus*, &c., top of first bench	12	0	B.
10. Shaly beds	25	0	B.
11. Sandstone beds, containing *Melania*, *Unio*, &c	10	0	B.
12. Shaly beds, with a few intercalated thin layers of harder sandstone, and a four-foot seam of dark shale, about midway from top to bottom	134	0	B.

From the summit of the rock we observed, five or six miles away to the eastward, benches composed of beds superior in position to any in the above section, the thickness of which I roughly estimated at 200 feet. The thicknesses of the different members of the section itself are in a great measure only estimates, as the circumstances were not altogether favorable to the making of accurate measurements. The dip of the strata is about east-southeast, from 3° to 5°, apparently diminishing to the eastward.

The bed No. 9 of the section, in some of its thinner layers, appears to be almost entirely made up of fossil remains, mostly of a species of Melanian, but also a lesser proportion of a species of Viviparus. In places where the rock was decomposed the whole upper surface is covered to the depth of an inch or more with the loose casts of these fossils, which can here be gathered in any quantity, by simply scraping them off the ledges. Other layers below, No. 11, also contain numerous fossils, but in very much less abundance, and casts of Unio are found in large numbers, while they are very scarce in the upper strata. Scarcely any fossils were found in the beds other than those specified.

In the vicinity of Bitter Creek Station, some four or five miles distant in a general westerly or southwesterly direction, Mr. Meek examined outcrops of some 275 feet of alternating beds of soft grayish and buff sandstones and whitish shales and clays, the uppermost of which, judging from the dip and strike, must have been as much as 200 feet below the lowest member of the Table Rock section given above. No fossils were found except fragments of fossil-wood; nothing to characterize any of the beds. An artesian boring at the station penetrated 445 feet through very similar alternations of sandstone, shale, &c.; the most noticeable variation in the record, as given, being the occurrence at the depth of 184 feet of an 18-inch seam of black carbonaceous shale. Between the lowest part of the exposure at the base of Table Rock and those examined by Mr. Meek there is a long stretch of nearly level country, affording no prominent outcrops by which the character of the intermediate beds could be ascertained.

Fig. 54.



SECTION AT BLACK BUTTES.

BLACK BUTTES.—Between the station of Bitter Creek and that of Black Buttes, the next to the westward, is a distance of about nine miles by railroad, but in a direct line it is much less, probably not over seven miles, if, indeed, it is that. A straight line between the two points would run almost directly across the dip, which will average, in the whole distance, not over 5° or 6°, thus giving a probable thickness of the tilted strata, between the stations, of over 2,000 feet. We were unable to make a detailed examination for the whole distance; the 275 feet of sandstones, &c., examined by Mr. Meek, would be included in its upper portion, and at Black Buttes a detailed section of some hundreds of feet of the beds was made by Mr. Meek and myself. Above this section, looking away to the eastward, we could see near at hand, from a little eminence, several hundred feet of alternations of reddish, purple, and bluish-ashy shales and sandstones, with a few streaks of black carbonaceous shales, and beyond them, in the distance, a great development of whitish beds, extending as far as anything could be satisfactorily distinguished by the eye. The whole landscape was about as desolate as could well be imagined, a series of steep rocky ridges, formed by the upturned edges of the harder sandstones, with irregular shallow valleys between. Some of the reddish beds suggested, by their appearance, the supposition that their color was due to the combustion of lignite beds below, a hypothesis which was suffcently verified in numerous other instances in our examination. The succession of the strata will be seen on page 526, Fig. 54.

Section at Black Buttes Station.

	Feet.	
1. Yellowish gray sandstone, with leaves of palm, (Sabal,) &c	2	
2. Bluish-ashy laminated clays	6	
3. Thin-bedded grayish and brownish sandstone	1	
4. Dark shale	1	
5. Bluish laminated clays	6	
6. Red laminated sandstone and shale	20	
7. Thin laminated sandstone (6 or 8 inches) and yellowish shales	10	
8. Coal	1½	
9. Light-colored laminated sandstone, becoming darker below	9	
10. Shale, dark colored below, and lighter and more sandy above	7	
11. Light gray laminated, shale, capped with a thin sandstone	8	
12. Coal	3	E.
13. Arenaceous shales, with a darker seam near middle	12	
14. Coal 4½ feet, with dark shale above and below	6	
15. Shale, darker above, with thin laminated sandstone, *Oysters*	5½	
16. Coal and carbonaceous shale	3	
17. Dark grayish buff sandstone, containing numerous leaves and bones of saurian	2	
18. Shaly beds with thin sandstone laminæ	8	
19. Coal 2 feet, with carbonaceous shale above and below	4	
20. Thin laminated dark gray and light shales, containing numerous fossil shells (brackish water) in lower portion; some thin laminæ of sandstone	6	
21. Coal	1½ to 2	
22. Shale	6 in. to 1	

		Feet.	
23.	Soft bluish white sandstone, mostly massive, but in places thin bedded	15	F.
24.	Massive light gray or grayish buff sandstone, in places almost dark brown, also becoming laminated in parts	70	
25.	Soft light grayish sandy shales and clays	12	
26.	Grayish buff, massive sandstone	20	
27.	Thin sandstones alternating with grayish shaly clays, the sandstones almost entirely disappearing in the lower portion	130	G.
		370 to 371 feet.	

The above section was mostly made up from Mr. Meek's notes, which were more minute than my own, though they agreed together in the main. It is serviceable in pointing out the exact horizon of the fossils procured here, which were mostly from the thin layers of Nos. 15, 17, and 20, with some vegetable remains in some of the higher sandstone layers. Apart from the fossils, the beds in most instances failed to afford well-marked horizons, and sections taken on different lines over the exposures would show numerous differences in the alternations of sandstone, shale, &c., from the one above given. The broken character of the ridges caused by the superior hardness of certain strata or portions of strata over others, sufficiently indicated this variability. The coal-beds themselves, I have reason to believe, partake somewhat of this character; in the section they appeared to be of the thickness given, while in some of the openings it was stated that a very much greater thickness was found. One or two exceptions, however, may be mentioned to the general rule: the reddish sandstone, No. 6, appeared, as far as our examinations extended, to be a pretty constant stratum, and the heavy sandstones, Nos. 23 to 26 inclusive, with their underlying thin laminated grayish sandstones and shales, No. 27, formed a very well marked horizon. It seems quite probable, indeed, that the series of buff and whitish massive sandstone here, Nos. 23 to 26, is the same as that which appears on the other side of the synclinal, at Separation, in the heavy face of grayish buff sandstone covered in places with a thin stratum of whitish rock, which formed the lowest member of the series observed there. The two agree very closely in lithological characters, and apparently also in being the first rocks of this character met with in passing downwards from the soft fresh-water Tertiary beds which fill the synclinal fold. If this supposition is correct we have one pretty definite horizon which will materially aid in determining approximately the age of these beds. It is to be regretted that our examinations near Separation afforded no fossils from the strata nearest the heavy sandstone.

The fossils found here, besides the vertebrate remains, were mostly from No. 20, and consisted of shells of the genera *Ostrea, Anomia, Corbicula, Corbula, Cyrena, Goniobasis?* and *Viviparus*, indicating a brackish water fauna, and one decidedly different from that of the sandstones farther east. The point where the fresh-water deposits begin, and the estuary or brackish-water life ceased, could not be determined, but I am inclined to think that it is not very far above these beds, perhaps a little beyond the scope of the section given above. Mr. Meek was disposed to give the separation as very near this point, considering the brackish-water deposits most probably Cretaceous, and those above them Tertiary. It is possible that there is no very definite horizon of separation, but that the two shade into each other through perhaps several hundred feet of non-fossiliferous sandstones and shales, and without fossils it is not possible to decide the question. In the other beds only a few oyster-shells were obtained, but fossil leaves were abundant in some, and in No. 17 we obtained some huge reptilian bones. The remaining portions of the skeleton were exhumed by Professor Cope a little after our visit, and found to belong to a large Dinosaurian, for which he has proposed the name *Agathaumus sylvestris*, and which he considers as affording conclusive proof of the Cretaceous age of these strata.

The thin sandstones and clays, No. 27, forming the lowest member of the section last given, appear at the base of the bluffs on the northern edge of the bottom-lands of Bitter Creek for a distance of two or three miles northwest of Black Buttes Station, where there appears below them, and apparently dipping unconformably beneath them, a massive, bluish-white soft sandstone, with some intercalated clays and harder laminæ of grayish sandstone. This apparent unconformability is best noticed by viewing it from a little distance to the westward, but is sufficiently prominent at the point where the two beds appear nearest together, only a little valley intervening. At this point the dip of the underlying beds is nearly southeast about 18°, while that of the overlying rocks is only from 5° to 7°, and nearly due east. This unconformability also makes the thickness of these lowest beds of the Black Buttes section less at this point than elsewhere; here it appears not over 130 feet, while a range of bluffs stretching away to the southward, and to all appearance capped with the heavy sandstone which is seen at the station, show a long slope of not less than two or three hundred feet of these beds.

The following section was taken by Mr. Meek and myself in a winding walk over the hills from a point some six miles northwest of the station, to the place where the two apparently unconformable series come together, already mentioned as some two or three miles from the station at Black Buttes. It was made by walking across the dip, estimating or measuring the thickness of each bed. In this manner the lowest beds were first met with, but for the sake of uniformity with the other local sections given in this report, and for convenience of reference, I number the different strata in the descending order, commencing with the uppermost member already described as underlying No. 27 of the previous section:

Section taken between Black Buttes and a point six miles east of Point of Rocks.

	Feet.	
1. Soft bluish-white sandstone, with intercalated clays and harder grayish laminæ	90	H.
2. Whitish clays and shales with some laminated sandstone	48	H.
3. Coarse grayish and buff sandstone	6	H.
4. Whitish sandy clays and dark carbonaceous shale with thin seam of coal	20	H.
5. Massive light gray and whitish sandstone	33	H.
6. Whitish sandy clays with some carbonaceous shale; traces of coal	23	H.
7. Grayish buff sandstone, mostly heavy bedded	37	H.
8. Grayish and dark carbonacous shales with appearance of coal; fused and burnt red in parts	20	I.
9. Soft grayish sandstone with *Ostrea*	5	I.

	Feet.	
10. Dark laminated clays, burnt reddish in places......	5	I.
11. Light-colored sandy clays, passing into bluish-white sandstone....................................	25	I.
12. Heavy bedded reddish and gray sandstone, *Ostrea*..	30 to 50	I.
13. Light grayish and sandy clays and shales with seams of brownish sandstone, (estimated)	350	J.
14. Valley, perhaps 30 to 50 feet; strata unseen.		J.
15. Light and dark-colored shales, with probably some thin seams of coal................................	80	K.
16. Light drab-colored shales with some carbonaceous seams, and some thin-bedded, ripple-marked grayish sandstone	64	K.
17. Bluish and grayish laminated clays with some carbonaceous seams, and some thin-bedded sandstone layers in uppermost part	75	K.
18. Reddish brown and grayish sandstone..............	8	K.
19. Bluish and grayish laminated clays with some carbonaceous layers	26	K.
20. Grayish sandstone, weathering brownish	4	K.
21. Ash-colored sandy clays and shales	12	K.
22. Brownish sandstone..............................	3	K.
23. Light sandy shale	2	K.
24. Impure coal or dark carbonaceous shale	2	K.
25. Carbonaceous and grayish shales or clays..........	24	K.
26. Bluish gray concretionary sandstone	4	K.
27. Arenaceous shales or clays	14	K.
28. Grayish and carbonaceous shales; appearance of coal	8	K.
29. Bluish arenaceous shales or clays	13	K.
30. Laminated bluish white sandstone and sandy shale.	20	K.
31. Gray sandy shale..................................	3	K.
32. Heavy bedded coarse sandstone, whitish in upper portion, and brownish buff below................	130	K.

No. 1 of this section shows signs of having been much disturbed locally. In one or two places I noticed a local dip to the south or southwest. This may, perhaps, be due to a slipping of the beds on each other. This disturbance, in connection with that observed at Hallville, hereafter to be mentioned, suggested the possibility that the apparent unconformability between these beds and those of the previous section might in reality be due to a faulting of the strata, with lateral twisting, although the appearance as far as our examination extended, seemed to favor the contrary view. I am inclined to accept this as the true explanation of the appearance as nothing in the character of the rocks themselves, and in the contained fossils, shows any such decided change, as might be expected with such an evidence of difference of epoch. Apparently the same oyster and a peculiar vegetable impression (already noted as seen in the rocks at Carbon and Fort Steele) were found in several of the sandstone layers above and below the disturbance.

The dip of the heavy sandstone No. 32, at the base, and also at the western end of the series, was nearly due east, and not over 6°, while, owing to the local disturbance, that of the uppermost bed, at the eastern extremity, was southeast, and nearly 20°. In the intermediate beds it would scarcely average over 5° or 6°, with a direction a little south of east. There appeared throughout to be numerous local changes as to degree in the dip, and the total average thickness, though greater, perhaps, than that we have given in our estimates in the detailed section, is hardly as much as would be indicated by the angle of the dip at numerous points where it was taken.

HALLVILLE.—The horizon of the Hallville coal is included in this section, though the mines themselves are at least one and a half miles distant from any part of the line, and are separated from it by the bottom-lands of Bitter Creek. The coal itself could not be recognized, and perhaps is only represented by some of the carbonaceous seams noticed between Nos. 8 and 20. The surface indications, however, are possibly deceptive, and excavations would, perhaps, discover the coal as fully developed as at that place. We visited Hallville, and made a rapid examination of the surroundings. The mines had not been worked for a considerable period, and the place was entirely abandoned at the time of our visit. The drifts had partially fallen in, and we were unable to procure any fossils from the roof-shales, &c., of the coal; for the same reasons, we could not get a very good section of the mines. We noticed, however, a considerable local disturbance, including an apparent southwesterly dip, at one of the points visited. I have already mentioned this disturbance in speaking of that noticed at the junction of sections 2 and 3; it seems to be altogether local, and certainly does not extend to the corresponding beds on the other side of Bitter Creek. That noticed in No. 1 of the foregoing section, although in a higher geological position, may, as has been suggested, be due to the same cause, and simultaneous. In passing eastward from Hallville toward Black Buttes Station, we observed at a point considerably higher in the series a development of some 40 feet or more of whitish sandstone and sandy shale, which could be continued by the eye in the direction of the strike across the line of the section, in which it is represented mainly by No. 5, and perhaps partially by the beds immediately below. This band of whitish sandstone and shale, though varying in width as it was traced by the eye, formed about the best and most continuous horizon in the section. In several cases one of the lignite seams had taken fire along its outcrop, and could be traced for a considerable distance by the baked and reddened clays immediately above it; but these were not generally so continuous over so long a distance, nor were they so valuable in determining the relative position of the Hallville beds in the series. For the most part, the remarks as to the variability of the characters of the rocks which were made in reference to the Black Buttes section will apply equally well here. The fossils found, with the exception of some leaves of dicotyledonous plants in some of the upper sandstones, and apparently the same as those noticed in the beds of the Black Buttes section, were all from beds Nos. 9 and 12, and consisted of only one or two species of oyster. The soft, sandy shale of No. 9 was in places almost displaced by these shells, which made up, I should judge, nearly or quite one-half of the mass of the stratum.

Passing west from Hallville, the heavy sandstone No. 32 forms high, nearly perpendicular bluffs on the right of the railroad, which here seems to run nearly along the strike of the great fold across which these sections are taken. The cliffs continue to border the railroad to Point of Rocks Station, where they open somewhat, and a higher series of beds come in view; beyond this place they again close in and continue near the track for the distance of a mile and a half or more. The whole thickness of the beds is much greater than is given in the section, in which only their upper portion is included; I have roughly estimated it as much as 500 feet. For the most part the bluffs consist of a coarse, heavy-bedded sandstone, generally light bluish-gray or whitish in color, but in places turning to yellowish or even reddish brown. It includes numerous local bands or seams of shale, grayish drab in color, and in parts dark carbonaceous with indications of coal. The rock itself in places passes into a coarse sandy shale, and this unequal hardness causes its exposures to assume a peculiarly rugged and rough appearance in many places, huge bastions standing out from the cliffs, and occasionally presenting rude resemblances to architectural forms. We found no traces of fossils anywhere in this sandstone, but from the appearances I should judge that a more extended examination might discover them in some of the intercalated carbonaceous shales.

Point of Rocks.—In the bluffs near Point of Rocks Station, and above the heavy sandstone, are four or five different seams of coal, the uppermost one of which must be at least 150 to 200 feet above it. Still above this, near the top of the hill, we found a bed containing a great abundance of a large species of oyster, different from those found in the beds Nos. 9 and 12 of the preceding section. We did not make a close examination of the beds here, as their horizon is included in the section just described, though they do not correspond exactly in lithological characters. The better development of the coal here may be merely local; it did not appear so near the top of the sandstone on the line of our examinations, and it seems almost too low in geological position to be referred to the horizon of the Hallville beds, although it may occupy the same.

Commencing at the base of the great sandstone at a point about two and a half miles west of Point of Rocks, and proceeding westward near the railroad track, Mr. Meek and I observed the following succession of beds in the descending order:

Section near the railroad between Point of Rocks and Salt Wells.

	Feet.	
1. Gray and drab sandy shales, with some harder bands of brownish sandstone	25	
2. Massive drab sandstone	27	M.
3. Bluish and dark colored sandy shale	3	
4. Gray sandstone with fossils	1½	
5. Yellowish and brownish-gray sandstone and shales	55	
6. Shaly and massive brownish and buff sandstone	36	
7. Shale, partly dark colored; appearance of coal	2	
8. Soft bluish-white sandstone, mostly in heavy beds, some of its upper portion laminated with a little dark shale, and appearance of coal	30	N.
9. Grayish sandstone, weathering brown, shaly in places, with some whitish beds above	45	
10. Heavy-bedded whitish sandstone	14	
11. Brown or buff sandstone, with some sandy shale	22	
12. Arenaceous shales and clays, yellowish or drab in color, with thin laminæ of harder brownish sandstone	155	O.
13. Heavy-bedded buff and bluish-white sandstone and sandy shales	86	
14. Dark carbonaceous shale or coal	2½	
15. Soft grayish-buff and bluish-white sandstones, with yellowish-drab sandy clays and shales; some thin carbonaceous seams	90	
16. Black carbonaceous shale or coal	2½	
17. Brownish and dark-colored shales	18	

	Feet.	
18. Grayish-drab massive sandstones	20	
19. Ash-colored clays and sandy shales	13	
20. Whitish-buff sandstone	3	P.
21. Light-colored sandy shales, with thin carbonaceous seams.	7	
22. Massive grayish-buff and whitish sandstone, with intercalated light-colored sandy shales	132	
23. Carbonaceous shale; trace of coal	2	
24. Grayish and bluish white sandstone and sandy shale	25	
25. Carbonaceous shale	4	
26. Massive sandstone, bluish white above, grayish buff below	60	
27. Light-gray shale and shaly sandstone	18	
28. Black shale and coal	3–5	
29. Grayish-buff and bluish-white massive sandstones, some portions even weathering brown, with frequent intercalations of soft sandy shales	200–300	Q.

The thicknesses of the different beds given above are, as in the other sections, for the most part merely estimates, such as could be made by walking over the upturned edges of the strata. I am of the opinion that, taken as a whole, the thickness is rather under than over estimated. The angle of the dip varied in different parts of the section: in the uppermost beds, which were at the eastern extremity of the line and farthest from the axis of the fold, the dip was from 5° to 8°, and from there it decreased toward the westernmost and lowest exposures to from 2° or 3° to 5°. The direction was throughout about the same, nearly northeast. The line followed commenced, as has been already stated, near the railroad-track, two and one-half miles from Point of Rocks, and ended at a point some distance to the right of the railroad, and nearly four miles, in a nearly due northeast direction, from Salt Wells Station.

A few leaves were found in one or two of the sandstone layers, but were not in any way characteristic, and the bed No. 4 was almost entirely made up of fossils and their casts, chiefly of a species of *Anomia*, together with oysters, *Corbicula*, *Corbula*, and a few specimens of *Modiola* and *Goniobasis*.

With this last section is completed the whole series of variegated sandstones and shales on the eastern side of this great fold or anticlinal, which continues in the vicinity of the railroad from between Bitter Creek and Black Buttes Stations nearly to Salt Wells. The total thickness of this series, reckoning from a point east of Black Buttes to this place, cannot be much less than 4,000 feet, though in our estimates in the detailed sections we have rather fallen short of this total. This is mainly due to our caution against making an overestimate, and the nature of the exposures, which in many places only consisted of a very gradual slope or shallow valley, showing by its *débris* and on the surface the general character of the beds. The sections show the peculiarity of the series, its alternations of light gray, grayish buff, and whitish and brown sandstones, with drab and ash-colored shales and clays. As regards, however, the alternations themselves, these sections are for the most part correct only for the particular line on which they were taken, the great majority of the sandstone beds changing in respect to color, hardness, and stratification even within the distance of a few feet. I am of the opinion, moreover, that the coal-seams also share this general character of variability, but our examinations could not be sufficiently minute to determine to what extent this is the case.

The accompanying wood-cut is intended as a general section of the eries as observed by us. The general divisions correspond to those given, included in brackets, in the detailed sections, and are indicated by the same letters.

Fig. 55.
SECTION ALONG BITTER CREEK FROM TABLE ROCK TO SALT WELLS.

It is worthy of remark that, of the invertebrate fossils obtained by us as far down as to the base of the series, not one is of a characteristic Cretaceous genus, but all have rather the aspect of a collection obtained from beds of Tertiary age. It is true that Mr. Meek, and I believe Mr. Emmons also, had considered that these beds might be most properly referred to the Cretaceous, but this was rather on account of the change in the general character of the fossil fauna from purely fresh-water, as in the characteristic Tertiary of this region, to brackish-water marine, and the specific affinities of a few of the fossils to California Cretaceous species, than from any very positive evidence. As far as I know, the only evidence of this kind is in the identification, by Professor Cope, of the saurian remains found by us at Black Buttes. It seems to me highly probable, and indeed almost certain, that the workable coal-seams of Wyoming and Utah range from well-characterized Cretaceous strata, as at Coalville and Bear River City, through these beds, which may, perhaps, be best regarded as a gigantic transition series, into the purely fresh-water beds, usually consideed as of Tertiary age, as observed by us near Separation and elsewhere.

SALT WELLS.—Near Salt Wells a very different series comes to the surface and occupies the axis of the anticlinal at this place. The rocks are first seen along the railroad, about four or five miles east of the station, and consist of grayish drab, thin-bedded sandstones and shales, with an entire absence of the heavy-bedded buff and whitish sandstones which form so prominent a feature of the overlying rocks farther east. It forms the high bluffs some two or three miles south of Salt Wells Station, but is wanting in the immediate vicinity of the railroad at that point, and for some distance to the westward, as the station itself is situated in the valley along the anticlinal axis. Two or three miles to the eastward, one or two cuts show sections of the beds close to the track, in which it is pretty uniformly a thinly laminated, dark grayish drab sandstone or sandy shale, and, is as far as we could see, entirely destitute of fossil remains. Mr. Meek examined the bluffs about two or two and a half miles southeast of the station, and found them to consist of very much the same general character of beds, with some intercalated clays, the whole, however, showing no very abrupt variations such as are to be seen in the rocks of the overlying series. No fossils were found, except indistinct traces of fucoids (?) and tracks of annelids. The thickness of the beds exposed in the bluff was about 480 feet, the uppermost of which, by estimate, was 250 to 300 feet below the base of the preceding section, making a total from the base of the bluff to the lowest member of the variegated sandstone series, of over 700 feet. Add to this the probable thickness of beds between the bluffs and the center of the anticlinal valley, hardly under 300 or 400 feet, and we have over 1,000 feet for the thickness of this formation. It seems probable that in its upper portion it contains some coal-seams, as at one point on the railroad, about four or five miles east of Salt Wells, I observed an isolated outcrop of coal in the bottom of a ditch alongside the track, which, from its position, I judged to be below the heavy sandstone series. No seams were seen in any of the other outcrops near the track or in the bluffs.

ROCK SPRINGS.—Passing westward from Salt Wells we find on the other side of the valley the great series of variegated sandstones and clays re-appearing, but with a reversed dip to the northwest of some 10° or 12°. Below it we have a considerable exposure of the thin sandstone, which here appears to stand in more perpendicular faces than on the opposite side of the valley, and has a more reddish cast. The sandstones and clays immediately above, which on the eastern slope of the fold showed no very numerous or valuable seams of coal, here appear to be the great repository of that material; the lowest seam worked, that at the Vandyke mine, is apparently only a short distance, perhaps a few hundred feet, above the base of the series, and other veins occur within short vertical distances of each other immediately above it. We made no detailed section on this side of the anticlinal, but from our examinations we judged that no very close parallelism existed between the beds of the two slopes, although the series preserved the same general characters on both. The principal coal-seam worked at Rock Springs, from 9 to 11 feet in thickness, overlies a heavy bed of bluish-white sandstone very similar to many of those noticed farther east. The record of an artesian boring made at the mines gives, as it was reported to me, some sixteen seams of coal, varying from 18 inches to 8 feet in thickness, passed through in a depth of not more than 730 feet. Some of these may, perhaps, be only beds of carbonaceous shale, but it seems to be beyond question that the coal-seams are better developed here than farther east. Still other veins occur in a higher horizon than was met with in the boring, but they are of less importance. Opposite the station at Rock Springs, on the opposite side of Bitter Creek, a heavy bedded sandstone of perhaps several hundred feet in thickness appears in the rocky face of a bluff and occupies a considerably higher geological position. This may possibly be the equivalent of the heavy sandstone near Point of Rocks, to which it bears a resemblance, but I am not inclined to positively identify disconnected beds in this formation. It seems, however, to be not far from the same relative position to the base of the series.

Some distance below the principal coal-seam at Rock Springs, 50 to 100 feet, or even more, we found a thin seam of hard sandstone, containing a great abundance of certain species of fossils, a strongly ribbed species of *Corbula*, a *Modiola*, and a *Goniobasis*, similar to those found near Point of Rocks, and a few imperfect specimens of *Ostrea*. There are other fossil-bearing beds in the vicinity, of which we heard accounts, but our specimens were all gathered in this stratum.

West of Rock Springs the ledges of this formation may be seen on either side of the railroad for a distance of five or six miles, dipping to the northwest or west-northwest at very much the same angle as near the station. There is not, however, a good continuous exposure, but the upturned edges of the harder beds form slight ridges above the general level of the valley which intervenes between the station and the range of hills to the westward. At the base of these hills we leave the series entirely, it passing underneath the Tertiary beds of which the range is composed. We did not examine the junction of the two series, but there seems, from a passing view, to be an unconformability here, the upper beds having a very slight dip to the west of not over 2° or 3° altogether. These Tertiary beds, where they are cut through by the gorge of Bitter Creek, which the railroad follows, appear as thinly laminated, whitish, or light-grayish arenaceous shales, showing in recent railroad-cuts a slightly bluish tinge. In places there appear bands of darker shale, and capping the hills as the road nears Green River is seen a heavier brownish or reddish sandstone bed, which forms the perpendicular mural escarpments and isolated castle-like knobs which form so prominent a feature near Green River Station. In some layers the shales are dark-colored on freshly fractured surfaces and seem impregnated with petroleum, but they all appear to weather uniformly light yellow or whitish.

GREEN RIVER.—A hill about two miles east of the station, at Green River crossing, on the southern side of Bitter Creek, gave the following section from a rough measurement with a pocket-level:

Section near Green River Station.

1.	Heavy reddish-brown sandstone	100 feet or more.
2.	Whitish arenaceous clays or shales	500 feet.
3.	Reddish or brownish arenaceous shales	50 feet.
4.	Whitish arenaceous clays	130 feet.

The dip was very slight, but one or two degrees to the westward, and is indeed scarcely perceptible. It is best seen on the bluffs, on the immediate bank of the river, above the station, where the beds are seen to dip, with some slight local undulations, to the westward; and the well-known petrified-fish bed which, at its exposure on the railroad about two miles or a little more from the station, is only 40 or 50 feet above the river, at Green River City, is said to be found near the summit of the bluffs some hundreds of feet higher in actual level. The reddish sandstone which caps the hills at the station to the eastward does not appear very prominently to the westward, and perhaps passes into arenaceous shale in that direction. It appears probable that there are some local variations in this formation, but as a whole it presents in this respect a striking contrast to the series below.

BRYAN.—West of Green River City the beds seen at the river disappear, and still higher ones of the same group come in view. These we examined in the vicinity of Bryan, where we visited one or two conical buttes lying to the south of Black's Fork and three or four miles from the station. We found these to consist of thinly laminated grayish sandstone or sandy shale, with, near the summit, some bluish, more argillaceous layers, and on the extreme summit a stratum of harder grayish sandstone filled with rough casts of *Melanians*, *Unio*, &c., and on one a great abundance of bivalve crustaceous remains, (*Cypris*,) all more or less silicified. The height of the buttes was not over 150 to 200 feet, the strata perfectly horizontal. Beside these buttes the country in the vicinity afforded no good exposures, the surface being rather level and uniformly covered with a gravelly superficies completely hiding the underlying rocks.

BRIDGER STATION.—West of Bryan we made no stop till we reached Bridger Station, where we examined to some extent the underlying greenish-gray sandstones and reddish clays, &c., of the Wasatch group.

As far west as Carter the flat table-topped hills, composed of the whitish beds of the superior Bridger group, characterize the scenery, but between that station and Bridger the underlying greenish and reddish gray sandstones appear, and near the latter station predominate. About a mile or more southwest of the station, in a hill on the right bank of Muddy Creek, and near the railroad track, the following section was taken which I copy from Mr. Meek's note-book. It shows the general character and variations of the lower formation, which is characterized by more massive sandstones and clayey beds, differing in color and other respects from the shales above:

Section near Bridger Station.

	Feet.
1. Alternations of gray, rather coarse sandstones, and reddish and ash-colored arenaceous clays, some layers of the sandstone fossiliferous	165
2. Massive gray sandstone, stained reddish above	13
3. Ash-colored and reddish sandy clays	23
4. Gray sandstone	3
5. Reddish and yellowish-gray sandy clays	16
6. Massive grayish sandstone, stained reddish above	23
7. Reddish and ash-colored sandy clays	20
8. Gray sandstone	4
9. Whitish sandy clays	3
10. Gray sandstone	2
11. Reddish sandy clays with some soft sandstone	15
12. Gray massive sandstone	8
13. Reddish and yellowish clays	10
14. Grayish sandstone	5
15. Reddish and ash-colored arenaceous clays, with perhaps some layers of sandstone	42

The upper member of this section closely resembles, and is probably identical with, the beds forming a hill on the southeast side of the railroad-track three-fourths of a mile or more northeast of the station. The same fossils (chiefly rough casts of a *Melanian* and a *Unio*) occur in a thin layer near the top of the hill. The dip in both cases was the same, nearly east, from 4° to 6°. From the summit we could see the reddish layers in ledges to the eastward, thus indicating that we were far, perhaps many hundred feet, below the top of the series. The beds seemed to dip unconformably below the more horizontal whitish strata of the Bridger group, and at one point, at least, I saw a patch of the upper formation lying between the ridges of reddish sandstone. It would thus appear that there had been considerable denudation here, and that portions of the upper group had been washed away, leaving only these outlines to indicate their greater extension in former times.

PIEDMONT.—Beyond Bridger the railroad, following the valley of Muddy Creek, turns to the south, and then bends slightly to the eastward, carrying the traveler again into the area of the higher group, but still showing at the base of the hills the heavy grayish sandstones and reddish clays of the Wasatch formation. The junction was well observed in some high hills about a mile, or little more, east of Piedmont Station, in which the lower, 210 or 211 feet, was made up of the heavy-bedded, grayish sandstone, weathering reddish, with intercalated beds of softer sandy clays, the whole without, as far as we could detect, any trace of fossils, either animal or vegetable. Above this we roughly measured with a pocket-level some 229 feet of whitish beds, mostly argillaceous, but with three or four ledges of white fossiliferous limestone. The slope between each of the limestone-beds was thickly strewn with chips derived from the ledges, and the true character of the intermediate beds was largely concealed from this cause. They appeared, however, to be mainly whitish clays, with, in places, a slightly bluish tinge. The fossils were mostly fish-remains, impressions of scales, spines, and bones, but in the upper ledge we found casts of a small *Planorbis*, and in the lowermost one a *Helix*, closely resembling *H. Leidyi*, from the Tertiary of the Upper Missouri. The upper beds here apparently dipped a little to the north of east, but scarcely more than two or three degrees altogether. The unconformability between them and the underlying rocks was not, as far as we could see, very noticeable at this point, though I thought that I saw in the lower beds a slightly increased dip to the eastward. These lower reddish beds are seen along the railroad to the west of this station in various places, and apparently lie unconformably upon the whitish Cretaceous strata which come into view in that direction.

ASPEN.—The Cretaceous strata which appear near Aspen Station apparently belong to a lower member of the formation than any of the beds examined by us either to the east or west of this point. Immediately at the station they form rounded hills, or ridges, rising to the height of 200 feet or more, and composed of hard, splintering, whitish and bluish slates, the former color predominating toward the summit, and the latter appearing near the base. These slates are full of fish-scales, with occasional impressions of bones and teeth, and near the top of the hills we found a fragment of an Ammonite. The lower bluish beds are also well exposed in several cuts along the railroad for a short distance west of the station, and here also contain numerous fish remains; their color in places is nearly black. In one of these cuts, under the snow-shed just west of the station, we saw one or two thin layers of grayish limestone, full of unrecognizable fragments of fossils. The total thickness of these slates, from their lowest to their highest exposures, cannot be less than 300 or 400 feet; they pass beneath the level of the valley to the westward with an estimated dip of ten or fifteen degrees in a general west-southwest direction. To the westward, within a distance of about two miles, there appear one or two parallel ridges, which, with the valleys between, must represent some 1,500 feet or more of overlying strata, consisting, as far as could be seen in the exposures of light gray and whitish sandstones, and light-colored clays, or shales. The railroad cuts through the westernmost one of these ridges at a point some three miles from Aspen, where we made the following rough section:

Section at Rock Cut.

1. Light-colored shales and shaly sandstone	50 feet or more.
2. Whitish sandstone containing *Ostrea*	3 feet.
3. Light-colored shaly bed	10 feet.
4. Heavy-bedded whitish sandstone	40 to 50 feet.
5. Alternating shales and thin sandstone-beds	40 feet or more.

The heavy sandstone-bed No. 4 forms the crest of the ridge, the upper beds appearing on the slope in the artificial cut. The oyster in bed No. 2 was identified by Mr. Meek as *Ostrea soleniscus*, Meek, a species which we found farther west in Cretaceous beds at Coalville and elsewhere. The dip of the main sandstone was about 30° in a direction nearly southwest.

A little west of this point is the interesting locality at old Bear River

City, where we stopped and made some examinations, the results of which are given elsewhere by Mr. Meek.

EVANSTON.—After leaving Bear River City and Aspen, we spent a day or two at Evanston, and made sections of the rocks about the coal-mines at Almy, on the north side of Bear River, some three miles to the northwest of the station. The section given below was taken in the hill back of the mines, and though not altogether a continuous one, it nevertheless represents pretty fairly the general character of the beds and their alternations. Nos. 1 to 24 inclusive were taken from near the summit of the hill down to the bottom in a ravine, which enters the bottom-lands of Bear River a mile and a half or more east of Almy; of the rest, Nos. 25 to 39 inclusive were taken from exposures in a ravine immediately back of the village, and the remainder chiefly from artificial exposures at the mines. The thicknesses as here given of the different beds, except in the case of the last-named ones, are, as in most of our other sections, estimates made by the eye, more accurate measurements being impracticable with the attention we were able to give:

Section of hill back of the Almy coal-mines.

	Feet.
1. Coarse, pebbly, conglomerate with some intercalated sandstones and clays	50
2. Yellowish and gray sandy clays, or soft, decomposing sandstone	70
3. Massive gray sandstone	6
4. Yellowish and gray sandy shales or soft sandstone	8
5. Coarse grayish sandstone weathering brown	25
6. Reddish and yellowish sandy clays or shales	100
7. Coarse grayish-brown sandstone and conglomerate	15
8. Reddish and ash-colored sandy clays or shales	100
9. Massive light-grayish sandstone	12
10. Yellowish sandy clays	15
11. Coarse, pebbly, reddish-gray sandstone	15
12. Soft grayish sandstone passing downward into decomposing reddish conglomerate	52
13. Yellowish sandy clays, some sandstone at base	50
14. Sandstone and conglomerate	25
15. Gray and yellowish-gray sandstones and sandy shales	45
16. Coarse sandstone and conglomerate	8
17. Sandy clays or shales, some parts reddish	50
18. Conglomerate passing into coarse sandstone	16
19. Yellowish sandy clays or soft sandstone	32
20. Conglomerate	22
21. Yellowish or reddish sandy shales or clays	50
22. Conglomerate	13
23. Yellowish sandstone and sandy clays	50
24. Coarse conglomerate	140
25. Yellowish and whitish sandstone with some sandy clays	170
26. Dark-grayish sandstone and shales	22
27. Light-colored sandy clays or shales	12
28. Grayish-buff sandstone	10
29. Grayish sandy shales with apparently some carbonaceous seams near base	150
30. Reddish and gray sandstone	12
31. Grayish shales or sandy clays	150
32. Reddish and gray sandstone	4

	Feet.
33. Light-colored sandy shales, perhaps some sandstone	45
34. Light-gray or whitish sandstone	14
35. Dark and light-colored sandy shales	60
36. Dark grayish-brown sandstone	20
37. Dark-grayish shale with some carbonaceous layers and perhaps some thin seams of coal near base	100
38. Hard reddish sandstone	5
39. Soft argillaceous sandstone, some harder layers	20
40. Coal	4½
41. Dark clay	4
42. Hard, impure coal—"rock coal"	2
43. Coal	9½
44. Hard, impure coal—"rock coal"	4½
45. Coal	10
46. Shale and clay	10
47. Coal	5½
48. Shaly clay, *about*	20
49. Iron ore, (ferruginous sandstone)	3
50. Clay	15
51. Coal	1

Still above the highest member of this section we could see from 500 to 700 feet of sandstones and sandy clays or shales, which we did not examine closely. In fact, the whole of the upper part of the section is only valuable to give an idea of the alternations and the general character of the whole series. The sandstones afforded in no instance any trace of animal or vegetable remains, and the exposures of the softer beds were such as to give no evidences of any fossil contents, being generally slopes more or less covered with *débris*. The dip was throughout nearly northeast, varying perhaps a little to the eastward; its angle averaged from 17° to 20°.

The first fossils found in place were seen in No. 32, which contained impressions of large leaves of dicotyledonous trees. About this horizon also we picked up a fragment of sandstone containing the cast of a *Helix*, which however might, judging from its appearance, have come from bed No. 30. Farther down bed No. 34 also contained leaf-impressions, and in No. 35 we found imperfect casts of bivalve shells resembling *Unio*. In No. 37, below its middle, we found a two-foot band exposed in a prospecting trench, almost entirely made up of small fresh-water-shells, *Cyclas*, *Physa*, &c., all crushed together and almost unrecognizable, except as to genus.

Nos. 42 to 45 inclusive comprise the 26-foot seam worked at this point. The beds below were not seen by us, that portion of the section having been furnished by Mr. Deuel, superintendent at the mines of the Rocky Mountain Coal and Iron Company at this point.

We also visited the hills on the north side of Bear River, northeast of Evanston, which we found to be composed of very similar strata to those in the upper part of the Almy section, viz, alternations of coarse sandstones, conglomerates, and sandy clays. There seems to have been a considerable disturbance here besides the mere tilting of the beds, and from the altered direction of the strike, which is here nearly north and south, we were led to suspect a considerable lateral displacement with faulting, which might very possibly cause the appearance of the same beds in both these hills, and those about Almy, although at first sight these would appear much higher in geological position. We did not attempt, however, to work out the geological structure to any great extent, as it would have required more time and labor than we were well able to give for that purpose.

We did not discover any evidences of unconformability in the Almy section; the whole formation seemed one continuous series. The fresh-water beds containing shells are, I think, certainly conformable to the coal; indeed, we observed thin carbonaceous seams in its immediate proximity. In the main section I have given the larger divisions, as exposed, on a line terminating at the mines, but the prospecting trench already mentioned, which was opened by Mr. Deuel some two miles below Almy, afforded the following section, which in the larger one is included in the lower part of No. 37:

Section taken two miles below Almy in trench.

	Ft.	In.
1. Coal, or carbonaceous shale	3	0
2. Clay shale	2	0
3. Impure coal	3	0
4. Hard argillaceous sandstone, containing and almost entirely made up of minute crushed fresh-water shells	2	0
5. Coal, or carbonaceous shale	1	0
6. Sandy shale	12	0
7. Coal, or carbonaceous shale, with clay parting	4	6
8. Shale or clay	20	0

Under this, according to Mr. Deuel, is the heavy stratum of argillaceous sandstone, No. 39 of the section, which is seen at the mines above the main coal, and which contains numerous leaf-impressions.

The fossils found, both in this two-foot band and in the sandstones above, would indicate that the age of these beds was Tertiary, rather than Cretaceous, and that they might possibly be even more recent than Eocene. I do not know the grounds of Professor Cope's reference of the coal at this point to the Cretaceous, while he admits the Tertiary age of some, at least, of the overlying sandstones;* but as we found no break or line of demarkation in the whole 2,000 feet or more which we examined, and found our fossils in coal-bearing beds immediately above and conformable to the main coal, the facts, so far as they are known to me, do not seem sufficient for such identification.

From Evanston we went west to Echo and Coalville, which are reported on by Mr. Meek.

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* Pr. Acad. Nat. Sci. Philadelphia, 1872, p. 279

ON THE

EXTINCT VERTEBRATA OF THE EOCENE OF WYOMING

OBSERVED BY THE

EXPEDITION OF 1872,

WITH

NOTES ON THE GEOLOGY.

BY

EDWARD D. COPE, A. M.

ON THE EXTINCT VERTEBRATA OF THE EOCENE OF WYOMING, OBSERVED BY THE EXPEDITION OF 1872, WITH NOTES ON THE GEOLOGY.

PHILADELPHIA, *April* 29, 1873.

I send herewith a detailed report of the results of the paleontological survey of the Green River Tertiary basin, undertaken last summer by myself, under your direction. The report is not complete, but includes the general determination of the vertebrata, with special monographs on some of the mammalia.

The expedition left Fort Bridger July 19, 1872, and followed the road to Cottonwood Creek, southeast eighteen miles, whence we made our first excursions into the bad lands. After this, our route lay along Cottonwood Creek to Smith's Fork of Green River, thence along Black's Fork, and thence to Green River City. We then followed Bitter Creek to Black Buttes, and, leaving the line of the Union Pacific Railroad, traveled south towards the headwaters of the Vermillion. Before reaching this point we explored the Mammoth Buttes, which form the water-shed between South Bitter Creek and Vermillion, and examined the bad lands carefully. In reaching this point we crossed a portion of the Cretaceous formation, and I took especial pains to determine the relations of the strata at these points.

We returned from this region, and struck Green River seventeen miles above Green River City. We proceeded northwards to the mouth of Labarge Creek, and, returning a short distance, ascended Fontanelle Creek to near its source in the outlying ranges of the Ham's Fork Mountains. The relation between the lake-deposits and the older strata here claimed special attention. We then descended Ham's Fork to the Union Pacific Railroad and returned to Fort Bridger.

Special expeditions were made to the region round Evanston, and to Elko, Nevada, with gratifying success.

I leave discussion of the general results until the close of the report. I may premise that we obtained in round numbers one hundred species of vertebrated animals of the Eocene period, of which about sixty were new to science. We added two orders of mammals to those previously represented in this fauna in the United States, viz, the *Quadrumana*, (monkeys,) and *Proboscidia*, the latter in several types of remarkable interest.

The present synopsis includes only the species of vertebrata collected by the expedition, with one or two exceptions, which is respectfully submitted.

EDWARD D. COPE,
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Dr. F. V. HAYDEN,
In charge of Geological Survey of the Territories.

MAMMALIA.

QUADRUMANA.

In the Proceedings of the American Philosophical Society, 1872, p. 554,* the writer described a species of Quadrumanous Mammal under the name of *Anaptomorphus æmulus*, comparing its dental and other characters with those of *Simia*. In the American Journal of Science and Arts, for November,† 1872, Professor O. C. Marsh announced that he believed that three genera previously described by him, viz, *Thinolestes*, *Limnotherium*, and *Telmatolestes*,‡ were referable to the Quadrumana, saying that they "have the principal parts of the skeleton much as in some of the lemurs." Prior to either of these determinations, the author described a new genus and species as allied to *Notharctus*, Leidy, under the name of *Tomitherium*,‖ but made no suggestion as to its ordinal position.

On a re-examination of the last-named genus, I am satisfied that it also should be referred to the Quadrumana, and describe it as follows:

TOMITHERIUM, Cope.

Dental formula $\frac{?}{2}\frac{?}{1}\frac{?}{4}\frac{?}{3}$, in an uninterrupted series. Last molars with five tubercles, others with four; all low and slightly alternating, the outer wearing into crescents. Canines quite small. Incisors very prominent, the median pair with transverse cutting-edges. Symphysis coossified, projecting in front. In the molars, the adjacent horns of the two outer crescents unite with the anterior outer turbercle; the posterior outer is insignificant. There is a projection but no tubercle in front of the outer anterior turbercle. The premolars present but a single compressed conic crown; the posterior, however, widened behind, and with a low turbercle. The first and second premolars are one-rooted, (not entirely a generic character.)

I base the distinction between this genus and *Notharctus* on the small canine, and the sub-horizontal position of the incisors; believing that when other portions of the skeleton are studied, other differences will appear.

The portions of the skeleton of the type species preserved are: the entire dentition of the lower jaw minus the crowns of the outer incisor, canine, and first premolar; the left ramus nearly complete, the extreme angle being wanting; the right humerus complete, with right ulna and radius, the latter lacking the distal extremity; a large part of the left ilium; the right femur nearly entire; part of the left humerus, metatarsals, &c.

The mandibular rami are quite stout, but not very deep; the symphyseal portion long and oblique, and the coronoid and condylar portions elevated, with axis at right angles to that of the horizontal portion. The condyle is well elevated, and the coronoid process small; the dental foramen is half way between the margins of the ascending ramus, and opposite the bases of the crowns of the molars. The inferior margin of the jaw shows no tendency to inflection at a point immediately below this foramen, where it is broken off. The mental foramen is divided, the exits being at points opposite those between the premolars 1–2 and 2–3.

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* Published October 12, 1872.
† Published October 8, 1872.
‡ Published August 7, 1872.
‖ Published August 7, 1872.

The *humerus* has a round head, directed backwards and a little outwards. The tuberosities are rather small, of about equal size, and obtuse; they inclose a short bicipital groove. The bicipital crests are very largely developed, and extend to the middle of the shaft, inclosing an open groove between them. The external is narrow and most elevated, the internal more obtuse and directed inward. The shaft is thus subtriangular in section. The distal extremity is nearly at right angles to the axis of the proximal, and is much expanded transversely. A large part of this expansion is caused by the truncate internal tuberosity, and by the less prominent external one. The latter is continued in a thin ala, which only sinks into the shaft at its middle. The condyles are small, the external the most prominent. There is a shallow olecranar fossa, and no coronoid, and hence no supracondylar foramen. There is an arterial foramen above the internal tuberosity.

The *ulna* is compressed, and contracts rapidly to the extremity. The olecranon is broad and obtuse, and the humeral cotylus oblique to the long axis. The coronoid process is low. The shaft is remarkably curved from right to left, inward. The *radius* has a discoidal head, with central depression, and it was evidently capable of complete rotation. It exhibits a tuberosity and slight flexure below the head. The distal extremity has a horizontal triangular section, with the apex internal and truncate; the shaft near it is quite flat.

The left *ilium* is obspatulate and flat, widest at the convex crest, and slightly concave on the outer side. It is rather thin, and the impression for the sacral diapophyses is elongated. The inferior border thickens gradually to the acetabulum; the superior is excised so as to form an open concavity.

The right *femur* is remarkable for its length. Its shaft is flattened from before backward, and without flexure. The great trochanter is large, and embraces a deep inlooking fossa. There is a flat tuberosity looking outward just below, and the little trochanter is a little below opposite to it. The condyles are sub-similar in size, the trochlear surface wide, but not flat, and the inner border thickened and considerably elevated. The femur is 1.75 times as long as the humerus; it was scarcely longer, though a small piece is wanting from the shaft of our specimen.

Remarks.—Having described the more important parts of the skeleton preserved, I now proceed to consider its systematic position, and the order to which it should be referred.

The first impression derived from the appearance of the lower jaw and dentition, and from the humerus, is that of an ally of the coati, *Nasua.* The humerus, indeed, is almost a *fac simile* of that of *Nasua*, the only difference being a slight outward direction of the axis of the head. The some bone resembles also that of many marsupials, but the flat ilium, elevated position of dental foramen, and absence of much inflection of the angle of the lower jaw, &c., render affinity with that group highly improbable, The length of the femur indicates that the knee was entirely free from the body, as in the quadrumana, constituting a marked distinction from anything known in the *Carnivora*, including *Nasua.* The round head of the radius indicates a complete power of supination of the fore foot, and is different in form from that of *Carnivora*, including *Nasua;* and, finally, the distal end of the radius is still more different from that of *Nasua*, and resembles closely that of *Semnopithecus.*

We have, then, an animal with a long thigh free from the body, a forefoot capable of complete pronation and supination, and a form of lower jaw and teeth quite similar to that of the lower monkeys. The form of the humerus and its relative length to the femur, are quite as in some of the lemurs. The most marked difference is seen in the increased number of teeth; but in this point it relates itself to the other *Quadrumana*, as the most ancient types of *Carnivora* and *Ungulates* do to the more modern; *e. g.*, *Hyænodom* to the former, and *Palæosyops* to the latter. In its special dental characters it shows a close resemblance to small types of the Eocene, which have been regarded as low Perissodactyles, as *Hyopsodus*, &c.

TOMITHERIUM ROSTRATUM, Cope.

Proceedings of the American Philosophical Society, 1872, p. 470, (published by the author, August 7,) l. c., 1873, (read April 18.)

This species was about the size of the prehensile-tailed monkey, so frequently seen in shows. The first and second premolar have but one root, the base of the second being about the size of the base of the canine. The latter are cylindric at base. The incisors form a parabolic outline, and have entire edges, the middle pair transverse ones. Enamel generally smooth, premolars somewhat striate; an indistinct inner cingulum.

Measurements.

	M.
Length of entire dental series, (straight)	.044
Length of symphysis mandibuli	.020
Depth ramus at second molar	.010
Length crown of second molar	.006
Width crown of second molar	.0045
Width between two second molars	.014
Width between two canines	.005
Width of ascending ramus above dental foramen	.016
Length of humerus	.083
Diameter of head	.013
Diameter of shaft at middle	.0085
Diameter of distal end, transverse	.023
Diameter of distal end, antero-posterior	.0078
Depth of olecranon	.009
Depth of ulna at coronoid	.010
Diameter extremity of radius, proximally	.009
Diameter extremity of radius, distally	.010
Length of ilium from acetabulum	.042
Width near crest	.017
Length of femur preserved	.137
Width just below neck	.017
Width at middle	.011
Width at extremity	.019
Width of trochlea	.009
Longest chord of condyles and trochlea	.019

The specimens on which this species was founded were found together by the writer near to Church Buttes, Wyoming.

NOTHARCTUS, Leidy.

Geological Survey, Montana, 1871, p. 364.

This genus is but little known, but is probably one of those which associates characters of lower quadrumana with *Cereoleptes* and other types

NOTHARCTUS LONGICAUDUS, Cope.

Pantolestes longicaudus, Cope. Proceed. Amer. Philos. Soc., 1872, p. 467, (August 3.)

This form is one of those mixed types which are so abundant in the Bridger Group. Its dental formula is M. 3, P. M. 4, c. 1, incisors unknown. The molars in the only specimen known are so worn as to preclude exact description. They evidently possessed anterior and posterior lobes, separated by a valley, which was most expanded on the inner side. The last molar exhibits a short heel posteriorly, which probably supported a small tubercle. The three premolars are all two-rooted and compressed in form. The last presents a crown composed of one large anterior compressed cusp, and a much lower posterior one. There is a slight cingulum in front. The canine is lost, but its alveolus indicates that it was a stout tooth.

So far as the known dental structure goes, this species resembles nearly the *Notharctus* of Leidy, but possesses a more carnassial fourth premolar.

The mandibular ramus is quite slender, and there is a large foramen below the first true molar. The masseteric fossa is pronounced.

I originally assigned but 3 P. M. to this species, but now find that it possesses four, thus resembling *Notharctus*. It differs from all the species described by Marsh, in having the second premolar two-rooted, and from Leidy's two species in its slender proportions.

The remains of this species were found together by the writer in the Bridger beds on Black's Fork, Wyoming.

ANAPTOMORPHUS, Cope.

Proceedings of the American Philosophical Society, 1872, p. 554, published by the author October 12.

This genus is represented by the left ramus mandibuli of a single species. The posterior portion is broken away, and the teeth remaining perfect are the P. M. 2, and M. 1 and 2. The ramus, though small, is stout, and deeper at the symphysis than at the last molar. What appears to be the dental foramen is nearly opposite the bases of the crowns of the molars. The mental foramen issues beneath the first premolar.

Dentition of the *ramus* mandibuli, In. 2, C. 1, P. M. 2, M. 3, total, 16. It differs from monkeys in some respects; there is no interruption in the series near the canine, and the symphysis, though massive, is not coossified. Further details are, the last molar is three-lobed and elongated behind. The composition of the crowns of the preceding molars consists of four opposed lobes, which are very stout, and connected transversely by a thin ridge behind, or in close contact in front. The premolar tooth which is best preserved, is a perfect second, which, while having two roots, possesses a crown which stands almost entirely on the anterior, presenting a curved sectorial crest forward and upward.

The dentition is more typically quadrumanous in this genus than in the last, and it might be referred decidedly to *Lemuridæ* were it not for the unossified symphysis. It no doubt represents a distinct group or family from *Tomitherium*, and one more nearly related to the existing types of Madagascar and South Africa.

ANAPTOMORPHUS ÆMULUS, Cope, loc. cit.

This species was about as large as a marmoset or a red squirrel. The enamel of the teeth is entirely smooth.

Measurements.

	M.
Length dental line	0.0148
Length of last molar	.0030
Length of ante-penult	.0025
Width of ante-penult	.0020
Length of three molars preserved	.0070

From the Bridger Beds of the upper valley of Green River.

CARNIVORA.

MESONYX, Cope.

This genus was described by the writer in the Proceedings of the American Philosophical Society for 1872, p. 460, and published in an advance edition of the same paper on July 29, 1872. It was there referred to the *Carnivora*, and stated to resemble *Hyænodon* in some respects. I propose on the present occasion to attempt a more exact determination of its structure and relationships. The only species yet certainly referable to it is *Mesonyx obtusidens*, Cope, l. c., which is represented by a fragmentary skeleton. There are preserved portions of the skull with the teeth, chiefly mandibular; numerous vertebræ from all parts of the column; parts of scapula, ulna and fore feet; portions of pelvis, femora, tibiæ, tarsals, metatarsals, and phalanges.

The numerous unguiculate digits, the sectorial character of the molar teeth, and the characteristic form of the astragalus demonstrate this genus to belong to the *Carnivora fissipedia*. It becomes interesting, then, to determine the relations of an Eocene type of the order to the families now living.

The cervical *vertebræ* are damaged. The dorsals are strikingly smaller than the lumbars, being less than half their bulk. They are opisthocœlian with shallow cups, and the centra are quite concave laterally and inferiorly. The centra of the lumbars are more truncate, with a trace of the opisthœlian structure, and are quite depressed in form. The median part of the series is more elongate than in the corresponding vertebræ of the genus *Canis*. They exhibit an obtuse median longitudinal angle, on each side of which, at a little distance, a nutritious artery entered by a foramen. The zygapophyses of the posterior lumbars have interlocking articulations, the posterior with a convex exterior articular face, the anterior with a concave anterior one. The sacrum is not completely preserved; three co-ossified centra remain. These are more elongate and the diapophyses have less expansion than in *Felis*, *Hyæna*, *Canis*, or *Ursus*. They are much flattened, and the middle one has two slight median longitudinal angles. The caudal vertebræ indicate a long tail, with stout base. Its proximal vertebræ are depressed, and with broad anteriorly-directed diapophyses. The more distal vertebræ have sub-cylindric centra; the terminal ones are very small.

The glenoid cavity of the *scapula* is shallow; the coracoid process is a short hook separated by a strong groove from the edge of the former. The spine is well developed. In the character of the coracoid, this genus resembles *Felis* more than *Canis* or *Ursus*. The ulna exhibits little trace of articular face for the radius, less than in *Felis* or *Canis*. Its humeral glenoid face is more convex transversely in its anterior or vertical portion than in those genera, and a little more than in *Ursus*. In the hind limb the *femur* resembles that of other *Carnivora* in all essentials. The rotular groove is narrow and elevated, the inner margin a little higher. The condyles are rather narrow, the inner with less transverse and antero-posterior extent, and separated by a wide and deep fossa. The patella is narrow, thick, and truncate at one end. The proximal end of the *tibia* exhibits a very prominent and well elevated crest or spine, which bounds a deeply excavated fossa. The articular faces are separated by a deep notch behind; the external is a little the larger and is produced into a point outwards and backwards; it lacks the notch of the antero-exterior margin so distinct in *Canis*, but possesses an emargination at the outer base of the crest homologous with it. The general form is, however, more like that of *Canis* than of *Felis*, and least like that of *Ursus*. The distal extremity of the tibia presents Carnivorous characters. The two trochlear fossæ are deeply impressed, the outer wall of the external one being formed by the fibula only. The anterior marginal crest is more elevated than the posterior, and presents an overlapping articular face between the fossæ for a corresponding tuberosity of the neck of the astragalus. The inner malleolus is entirely without the groove for the tendon of the *tibialis posticus* muscle, and therefore different from many of the digitigrade *Carnivora*. It has an ovate truncate surface. On the anterior face opposite the inner trochlear groove is a rather small but deep fossa.

The *astragalus* has an elongate oblique neck and a navicular extremity slightly expanded inwards. The trochlear ridges are well elevated, and not very oblique to the true vertical plane, being much as in the dog. The distal extremity is quite different from *Felis*, *Hyæna*, *Canis*, and *Ursus* in having a rather narrow convex facet next the cuboid bone extending from front to rear, and in having the navicular facet pulley-like or slightly concave in tranverse section, while it is strongly convex antero-posteriorly. This is part of the peculiarity presented by the hind foot in this genus. Behind the navicular facet, on the superior face, is a tuberosity which stops the flexure of the foot by contact with the tibia; a trace of it is seen in the dog. The calcaneum has the compressed form of the digitigrades, but the broader interval, and convex external astragaline facets resemble much more those in the bears. The cuboid facet is a frustum of a triangle with the apex directed inwards and downwards.

The *metapodial* bones are rather elongate, and flattened so as to be transverse in position. A second metatarsal is more flattened than corresponding bones of *Canis* and *Felis*. Its cuneiform facet is somewhat concave transversely. The phalangeal condyles are furnished with an anterior and inferior carina, which is wanting above; the articular face is wide above as in *Canis*, and is bounded by a transverse fossa as in digitigrade genera. The phalanges of the first series are elongate and curved as in *Felis*, being relatively longer than in *Ursus*. Phalanges of the others series are quite short. The ungues are short and flattened, their inferior surface is nearly plane, and the superior but little convex. A shallow groove divides the upper face longitudinally to the extremity. The margin below is acute to a slightly contracted neck. There is no indication of collar for reception of the horny sheath, except perhaps a slight area of fracture on each side, and there is no projecting tuberosity below for insertion of flexor tendon. The middle of the proximal part of the unguis is a raised plane, and on each side of it, at the neck, two arterial foramina enter. There is a small foramen in the groove, and several smaller ones near the margin. These ungues resemble somewhat those of some tortoises. They were found with the other phalanges, with which they agree in size and articulation, and no doubt belong to the same animal. It is evident that they differ in character from those of most existing *Carnivora*. The penultimate phalanges agree with them in the depressed form of their proximal articular faces, wanting entirely the triangular form so characteristic of *Carnivora*, especially of the cats and dogs. The short, flat shaft of the same is almost equally peculiar.

The *cranium* is fragmentary. The malar bone of the right side is similar in position and form to that of the *Canidæ*, especially in the presence of a weak angle only, to mark the posterior border of the orbit. It has a much less expanded union with the maxillary than in these animals, and is proximally shallower, thicker, and more prominent. Its posterior portion is more plate-like.

There are numerous *teeth* preserved, but separate from the skull, and mostly mandibular. The inferior canine is stout especially in the root, which is a flat oval in section. The crown is but little curved, slightly compressed, and without edge or groove. The premolars graduate into the molars, so that the line of distinction is not easily drawn. The first premolar has a single root; the crown is slightly conic, with a small tubercle at the base behind. This tubercle increases in size on the premolars 2 and 3, and becomes on the true molars a longitudinal cutting edge extending along the axis of the crown, not much elevated above a wide base. It occupies half the length of the crown in the larger molars, and is preceded by an elevated conic cusp. In front of the base of this, a small conic tubercle projects forwards, which appeared as a rudiment on the third premolar. The number of mandibular teeth would appear to be, P. M. 3, M. 4. No portions certainly referable to the superior molars were found.

Conclusion. In summing up, it may be accepted as a result of the above analysis that the genus *Mesonyx* represents a family of *Carnivora digitigrada*, distinct from any now living on the globe. The form of the astragalus renders it probable that the inner toe is wanting or rudimental, and that there were four digits on the hind foot. The foot was also short, and the claws flat, and altogether without prehensile use, but rather adapted for aquatic life. The number of molars exceeds that in any recent terrestrial family of *Carnivora* except the *Protelidæ*, and their sectorial form allies it at once to the extinct *Hyænodontidæ*. To this family the genus *Mesonyx* may possibly be at present referred. Among recent families it approaches nearest the *Canidæ*, but has structures borrowed from others, while its numerous molars constitute a point of greater generalization than any. Although sectorials, this character is not nearly so marked as in the existing *Carnivora*, the cutting edge being obtuse and occupying half the crown only, while the elevated cone occupying the remainder distinguishes the genus from these and from *Hyænodon* also. The lobe corresponding to this cone is preceded in *Hyænodon* by a cutting edge, in *Mesonyx* by a tubercle.

MESONYX OBTUSIDENS. Cope.

Proceedings American Philosophical Soc., 1872, 460, (July 29.)

This species was as large as our largest wolves. While the proportions of the limbs were not very different, the body was rather more slender behind. The orbit was smaller, and the cheek bone more prominent than in those animals. The long tail added to the general resemblance to the dogs. The measurements are as follows:

Measurements.

	M.
Length malar bone	0.073
Depth malar bone in front	.016
Depth malar bone at postorbital angle	.023
Depth malar bone at middle of orbit	.015
Thickness malar bone at middle of orbit	.013
Transverse diameter glenoid cavity of scapula	.025
Transverse diameter ulnar cavity for humerus	.014
Length centrum dorsal vertebræ	.019
Diameter centrum do., transverse	.018
Diameter centrum do., vertical	.014
Length centrum of a median lumbar	.030
Diameter centrum do., transverse	.025
Diameter centrum do., vertical	.016
Diameter centrum, first sacral vertical	.014
Diameter centrum, first sacral transverse	.026
Expanse of do	.046
Length of two sacral vertebræ	.049
Length of proximal caudal	.022
Expanse diapophyses caudal	.036
Diameter centrum do., vertical	.009
Diameter centrum do., transverse	.015
Diameter centrum distal caudal, vertical	.007
Diameter centrum do., transverse	.007
Chord of femoral trochlea and condyles	.038
Width trochlear groove	.013
Width condyles	.029
Width tibia proximally	.038
Diameter do. antero-posteriorly	.039
Diameter shaft, .050 M. from end	.017
Diameter distal extremity transversely	.026
Diameter distal extremity antero-posteriorly	.018
Length patella	.025
Width patella	.015
Length astragalus	.030
Width astragalus above	.016
Width astragalus distally	.017
Width astragalus neck	.012
Width cuboid facet of calcaneum	.016
Depth cuboid facet of calcaneum	.011
Width of a second metacarpal (shaft)	.012
Depth of a second metacarpal (head)	.014
Width of a second metacarpal, distal end	.010
Length proximal phalange	.0290
Width proximally	.0100
Width proximally of a penultimate do	.0085
Length of a penultimate do	.0110
Length ungueal phalange	.0150
Width medially	.0065
Width proximally	.0070
Length crown of canine tooth, (worn)	.0200
Diameter of base fore and aft	.013
Diameter premolar, (1)	.006
Length crown do	.006
Length base premolar, (2)	.011
Height crown premolar, (2)	.009
Length crown true molar	.018
Width crown true molar	.008
Height of cutting edge	.005

There are no cingula on the teeth, and the enamel is perfectly smooth. The appearance of the crowns as well as the bones indicates an adult animal.

The bones of this animal were found together on a bluff of Cottonwood Creek, Wyoming, by myself, while attached to Hayden's geological survey of the Territories for 1872.

SYNOPLOTHERIUM. Cope.

Proceedings American Philosophical Society, 1872, 483, (published August 20.)

Represented as yet by a single species, which is known from fragmentary remains of a single individual. The portions preserved are: a large part of the skull with nearly complete dentition, the superior molars loose; lumbar and caudal vertebræ; large portions of both fore limbs, including the bones of the feet; smaller portions of the hind limbs and feet.

The bones of the *fore limbs* are stout in their proportions. The *humerus* has a well-marked rugose line for muscular insertion on its posterior face, but no prominent angle. Distally the inner and outer condylar tuberosities are almost wanting, and there is neither external aliform ridge, nor internal arterial foramen. The olecranar and coronoid fossæ are confluent, forming a very large supracondylar foramen. The condyles are moderately constricted medially, and there is a well-marked submedian rib separated from the outer condyle by a constriction. The latter is continued as an acute ridge on the outer side of the olecranar fossa. The inner condyle is the more prominent, and its outer margin is a sharp, elevated crest. The *ulna* has a very prominent superior process, continuing the cotylus upward. The coronoid process, on the other hand, is rather low. The radial cotylus is flat and broad. The distal end is not preserved. The *radius* has a more transverse head than *Canis* or *Felis*, and has three articular planes, the inner being a wide, oblique truncation of the edge. The shaft is angulate below, and becomes a litttle deeper than wide near the distal end. The extremity is lost. The *carpal* bones are probably all present. The fore foot was found in place so that the relations of the bones are known with certainty. The scaphoid and lunar appear to be distinct. The former exhibits proximally the inner tuberosity, then a slight concavity, and then the convexity, where it is obliquely truncated so as to give a general rhomboid outline. Beneath there are but two facets, the inner the deepest, and divided lengthwise by the truncation of the bone. The larger facet fits correctly the O. O. trapezium and trapezoides. The lunar was not found in its place, but two fragments taken from the matrix just behind it, adhering to the pisiforme probably belong to it. The upper face is concave. The cuneiform is large and concave lengthwise above for the narrow extremity of the ulna. Below it has a large concave facet for the unciform. The pisiforme is of unusual size, and is as stout as the largest metacarpus, and nearly half as long as the outer (5th) metacarpal. It articulates with a thick V-shaped facet of the cuneiform. Its extremity is obtuse and expanded. The trapezium is large and attached to its metacarpus laterally, sending a process downwards posteriorly. If supports a narrow articular surface for the metacarpus of a small pollex or inner digit, which is not preserved. The trapezoid is smaller and of a triangular outline, with the base forwards. The magnum is a rather small bone articulating as usual with the metatarsals 2 and 3. It is depressed in front. The unciform is a large bone with a considerable external anterior surface. Two-thirds of its upper surface are in contact with the cuneiform, the remaining part projecting upwards with convex face to unite with the lunare. Below it supports metatarsals 4 and 5.

There were probably five digits of the fore foot, the inner small or rudimental. The proportions are stouter than in the dogs, but not so much so as in the bears. The *phalanges* have a length similar to that seen in some bears, but the metatarsals are more elongate. The lengths of the latter are, 5th shortest, then 2d, 3d, and 4th. Their condyles are broad, with median keel behind, and shallow supracondylar fossa in front. The first phalanges are about one-third the length of the metacarpals; the second of digit No. 2, broad and stout, and half as long as the phalange of the first row. An ungueal phalange has a singular form, so that the claw might be supposed to have a subungulate character. It is flat, considerably broader than high, and with expanded and obtuse extremity. The articular extremity is depressed and transverse, concave in vertical, convex in transverse section. The anterior three-fifths of the superior middle line are occupied by a deep gaping fissure, which separates the extremity into two points. The inferior face is entirely flat, there being no tendinous tuberosity. The sides are grooved, and give entrance each to a large arterial foramen proximally. These claws resemble those of *Mesonyx*, and differ remarkably from those of existing terrestrial *Carnivora*.

Of *hinder limb* the only characteristic pieces remaining are the navicular, cuboid, and an external cuneiform bone. The cuboid is rather stout, with a slight concave facet at one extremity and two at the other, one of them smaller and sublateral. The navicular is wide and flat, and with a strongly concave astragaline facet. Below, it presents two deep oblique concave facets for the cuneiforms, with a small sublateral one on the outer side. The facets of the cuboid and astragalus indicate four well developed digits and another perhaps smaller one. Thus in this genus they were on both limbs probably 5–5, with the inner small.

The *cranium* is fractured above. There remain the squamosal and periotic bones, occipital condyles, malar and part of maxillary, both premaxillaries and the greater part of both mandibular rami. The postglenoid process of the squamosal is produced inferiorly far below the auditory meatus, even further than in the bears. Its proximal portion includes, on the lower face, a strong groove at right angles to the axis of the cranium, with its defining margins acute and prominent. This is the transverse glenoid cavity of the carnivorous type. The zygoma has a wide curvature indicating a powerful temporal muscle. The posterior angle of the malar extends well posteriorly. Its anterior portion projects, forming a longitudinal rib; there is no produced postorbital process. The tympanic bone is produced upwards and outwards and forms a tube with everted lips. The opisthotic (mastoid) separates it entirely from the exoccipital, and overlaps the posterior half of the tube by a laminar expansion. A pit in this bone near the *meatus externus* represents the insertion of the stylohyal ligament. There is no bulla, the tympanic chamber being small and with thick walls. The character of this region forbids the idea of any tapiroid affinities on the part of this genus, and resembles that seen in the bears more than that of any other carnivorous type.

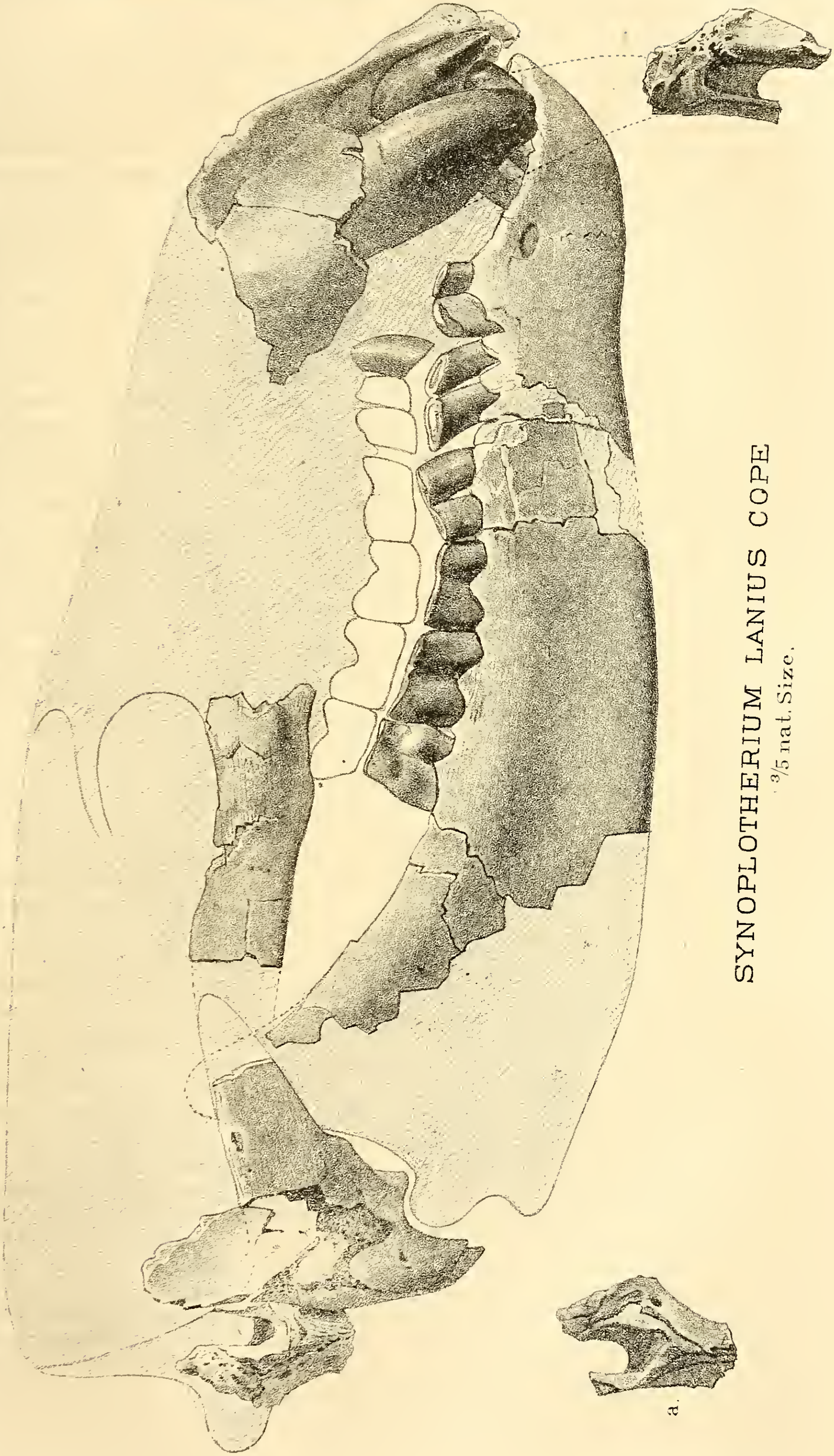
The *premaxillaries* are vertico-oblique in position, presenting the nareal opening directly forwards as in cats, but with a still less prominent alveolar border. The horizontal part of this border is indeed very short, including but two small incisors. It then rises vertically, and turns obliquely backwards to the maxillary, inclosing a deep sinus with the canine tooth. From the anterior side of this sinus the larger external incisor issues, with its root extensively exposed externally. A rib ascends from the front of its alveolus to the anterior or nareal margin of the bone. The triturating surfaces of the incisors are directed backwards, and the alveolar edge is thickened in front of them with a tuberosity. The teeth are much worn so that the forms of the crowns cannot be determined, but projecting .25 inch beyond the alveoli they are compressed, the large outer tooth with a longitudinal angle in front.

The *mandibular rami* are quite elongate, and indicate a cranium near the size of that of the brown bear, (*Ursus arctos.*) Their form is slender, and they have a long, rather narrow, symphysis, which projects obliquely forwards. The angle is not preserved. The mental foramen is large and issues just behind the canine teeth.

The *dentition* is I. $\frac{3}{?0}$; C. $\frac{1}{1}$; M. $\frac{?7}{7}$. The canine is of very large size, especially the part protruded beyond the alveolus. The crown is stout at the base, but is soon compressed and obliquely truncated by the attrition of the inferior canine on its inner face. Two superior molars preserved are three-rooted, and the section of the crown is more or less equally trilobate. The number in the maxillary bone is estimated at seven, the number found in the ramus of the mandible. There are six two-rooted molars below and probably one single-rooted premolar, though this is indicated by an alveolus only. The molars are rather narrow antero-posteriorly, and are not very different in size, except that the penultimate is a little longer, and the last a little shorter than the others. There was evidently a longitudinal cutting edge behind, and some other shorter process on the front of the crown; the edge is preserved on the last tooth and resembles that of *Mesonyx*, so that I have little doubt that the remainder of the tooth was, as in that genus, a conic tubercle. The most remarkable feature of the genus is seen in the inferior canines. These are very large teeth, and are directed immediately forwards, as in the case of the cutting teeth of rodents. They work with their extremities against the retrorse crowns of the two external incisors above, and laterally against the superior canine. They are separated by a space about equal to the diameter of one of them. In this space I find no alveoli nor roots of teeth; the outer alveolar wall extends far beyond the inner. The latter terminates opposite the middle of the superior canine. It may be that there are no inferior incisors.

Some of the vertebræ display stout triangular neural spines; on the lumbars the posterior zygapophyses are embraced laterally by the grooved correspondents of the succeeding vertebra. Some of the caudal vertebræ are long, slender, and without neural arch, indicating that this genus, like *Mesonyx*, had a long, slender tail.

Affinities. Having described the available parts of this form, it remains to consider its place in the zoological system. The structure of the dentition of the upper jaw, with the mode of articulation of the mandible, removes it from such orders as *Rodentia* and *Edentata*. The only remaining ones with which it is necessary to compare it are the *Perissodactyla*, *Proboscidia*, and *Carnivora*. As many of the diagnostic bones are wanting, it is necessary to rely on collateral and empirical indications of relationship. From tapiroid types the development of the tympanic region distinguishes it. From Proboscidians the slender feet and reduced ulna, as well as the longitudinal crests of the teeth separate it. It then remains to compare it with *Perissodactyles* of the types which possess strong canine teeth. In points of resemblance to these we have the flat claws and separate scaphoid and lunar bones; nevertheless the greater number indicate truer affinity to the *Carnivora*. Such are the external transverse glenoid cavity, the teeth with longitudinal crests, the slender digits, the well-developed tympanic bone; confirmatory are the large canine teeth, the incomplete orbit, and the projecting inner condyle of the humerus. The form of the claws is not absolutely incompatible with the same order, as it is approximated by some of the Seals.



SYNOPLOTHERIUM LANIUS COPE

3/5 nat. Size.

Thos Sinclair & Son lith. Phila.

Among *Carnivora*, the feet are like both dogs and bears. The very prominent postglenoid ridge, and the narrow tympanic chamber* are decided points of resemblance to the bears, but the *cavum tympani* is even less expanded than in those animals. The characters of dentition are more like those of the *Hyænodontidæ* and *Mesonyx* than any other group, and even the remarkable incisor-like inferior canines are approximated by the anteriorly directed canines of *Hyænodon leptorhynchus*, Laiz. et Par.

As a summary, it may then be concluded that the genus *Synoplotherium* is a Carnivore, presenting a number of points of resemblance to the bears, and to the extinct *Hyænodons;* but that its distinct scaphoid and lunar bones, and flat claws ally it to other forms of *Mammalia*, showing it to be a more generalized type of the order than either of the above. The peculiar approach of the lower canines is a special modification for peculiar habits, which I suspect to have been the devouring of the turtles which so abounded on land and in the waters of the same period. The slender symphysis could most readily be introduced into the shell, while the lateral pressure of the upper canines with the lower, would be well adapted for breaking the bony covering of those reptiles.† It is not unlikely that this genus, *Mesonyx*, and possibly *Hyænodon* form port of the lost series which terminated in the Seals of the present.

SYNOPLOTHERIUM LANIUS. Cope.

Proceed. Amer. Philos. Soc., 1872, p. 483.

The cranium of this species is rather less than that of the grizzly bear, while the other bones do not indicate so large an animal.

Measurements.

	M.
Length glenoid cavity	0.045
Width glenoid cavity	.025
Diameter zygomatic fossa	.058
Width opisthotic inside for. stylohyoideum	.014
Diameter meatus auditorius externus	.012
Diameter cavum tympani	.009
Length ramus mandibuli preserved	.228
Length of series of seven molar teeth	.131
Length of last molar crown	.0155
Width of last molar crown	.0080
Length of penultimate crown	.0215
Width of penultimate crown	.0100
Length exposed part of inferior canine	.024
Length exposed part of superior canine	.032
Length exposed part of outer upper incisor	.023
Diameter triturating-surface inferior canine	.028
Diameter triturating-surface do., transverse	.0166
Diameter superior canine, (antero-posterior)	.024
Diameter of the two inner incisors	.010
Diameter of exterior incisor, (oblique)	.010
Diameter symphysis mandibuli	.044
Diameter nareal orifice	.040
Depth nareal orifice	.031
Depth mandibular ramus at M. 6	.049
Thickness below of ramus at M. 6	.014
Length of a superior molar crown	.020

* See Professor Flower's Osteology of Mammalia on this point.
† See Proceed. Amer. Philos. Soc., 1872, p. 484.

	M.
Diameter condyle of humerus	.047
Diameter shaft of humerus (compressed)	.0410
Diameter condyles of humerus	.0415
Diameter condyles of humerus, (antero-posterior)	.032
Diameter head radius, (transverse)	.0282
Diameter head radius, (vertical)	.0162
Diameter shaft radius	.016
Diameter cotylus of ulna, (long)	.030
Depth ulna at coronoid process	.034
Length carpus and digit 2 without unguis	.112
Length two phalanges do	.037
Length metacarpal do	.061
Length metacarpal No. 3	.074
Length metacarpal No. 4	.070
Length metacarpal No. 5	.053
Length scaphoid, transversely	.023
Length cuneiform, transversely	.027
Length pisiform	.027
Width pisiform distally	.016
Length unciform, transversely	.020
Width unciform, antero-posteriorly	.013
Width trapezoid, antero-posteriorly	.0155
Width trapezium, antero-posteriorly	.0114
Length trapezium, vertically	.016
Width scaphoid, antero-posteriorly	.015
Width navicular, antero-posteriorly	.0155
Length navicular, transversely	.0255
Length ungueal phalange	.016
Width ungueal phalange	.010
Diameter centrum of lumbar vertebra	.029
Diameter centrum of caudal vertebra	.009

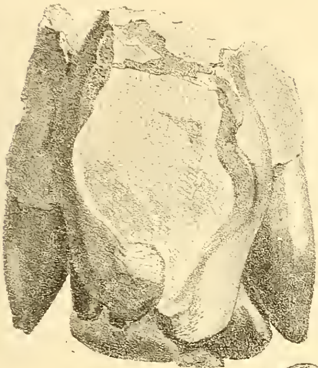
The dental series is uninterrupted from the canine, if, as I believe, there is an alveolus for a simple premolar behind it. This I overlooked when first describing the species, and hence gave the molars as 6 instead of 7. The superior canine is smooth, but the inferior one of the left side has a longitudinal groove on its extero-inferior face.

Restoration.—This carnivore had a large head, with a long, rather narrow, and truncate muzzle. The limbs were relatively smaller, not exceeding those of the black bear (*Ursus americanus*) in length and thickness. The tail was long and slender as in the cats, while the claws were broad and flat.

History, locality, &c.—The teeth are very much worn, indicating the hard food on which the animal had subsisted, as well as its mature age. I originally described this species as resembling the remarkable genus *Anchippodus** of Leidy, and subsequently (on the Short-footed Ungulata of Wyoming, &c., p. 5,) have alluded to the large rodent incisor-like teeth as though they were homologous in the two genera. I there identified those teeth in *Synoplotherium* as canines, adding that they were probably the same in *Anchippodus*. Having determined the carnivorous affinities of the former genus, the homology of these apparently similar teeth in the latter becomes problematical. With our present knowledge, the type of molar teeth in *Anchippodus* resembles that of many ungulates, and it is not therefore probably allied to *Synoplotherium*. Nevertheless, it is not yet certain that the teeth in question are incisors, and that the genera are in nowise related, though a similar modification of a remarkable character in distinct but co-existent types is by no means an unprecedented circumstance.

The remains on which the above identification is based, were found by the writer on a terrace of the Mammoth Buttes, near South Bitter

* See in Hayden's Geol. Surv. Montana, 1871, (as *Trogosus*.)



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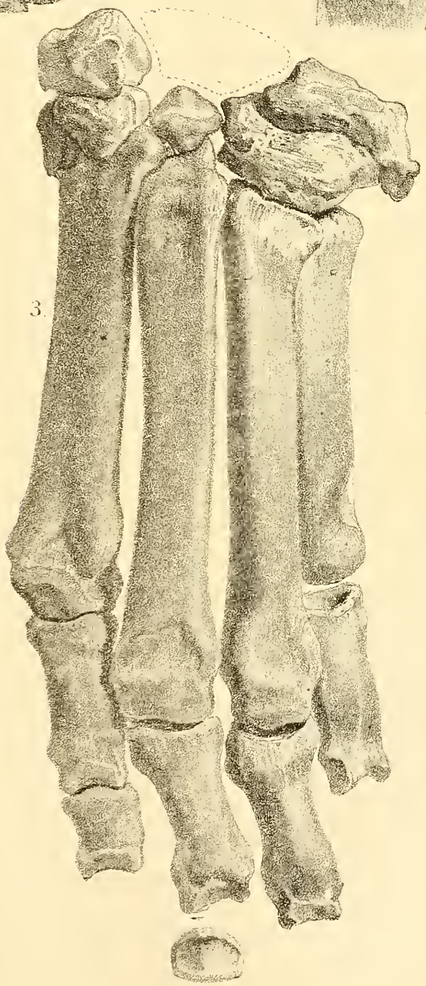

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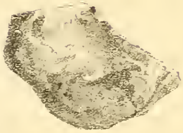
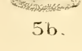


4a.

4b.

5a.

5c.



5b.

SYNOPLOTHERIUM LANIUS COPE

Fig. 1 and 2, 3/5 nat. Size. — 3, 4, 5, nat. Size.

Thos Sinclair & Son lith Phila.

Creek, in Wyoming. The cranium and fore foot and leg were excavated from the deposit.

Formation, the Bridger Group of the Eocene of Hayden.

Professor Marsh has described two genera of *Carnivora* from the same formation, embracing species approaching this one in size. They are both distinguished by the broader forms of the crowns of the inferior molar teeth, and other points.

STYPOLOPHUS, Cope.

Proceed. American Philos. Soc. 1872, p. 466; published August 3, 1872.

This genus embraces small species of carnivorous animals found by the writer in the Eocene formation of the Bridger Group. It is represented by portions of mandibular rami of three species, with molar and premolar teeth.

The generic characters are seen in the composition of these molars, which have but two roots, and a posterior table, as is seen in tubercular molars of some *Viverridæ*. The anterior two-thirds of the crown is composed of conic cusps. On the last molars these are in two series, two lower, of the inner, and one more elevated, of the outer, opposite the interval between the inner. Its outer face is regularly convex, but its posterior forms, with that of the outer series, a single flat vertical plane, which forms a sharp angle with the inner and outer faces of the cusps.

The structure is, in general, somewhat like that of *Mesonyx*, Cope, but the lack of cutting edge on the posterior lobe, and the two rows of tubercles separate it widely. Dr. Leidy describes *Sinopa* as having a sectorial tooth as in ordinary *Carnivora*, with an interior cusp; hence it is not probably the present form, although one species was about the size of the *S. rapax*.

STYPOLOPHUS INSECTIVORUS, Cope.

Proceed. Amer. Philos. Soc. 1872, p. 469; published August 7, 1872.

Represented by a posterior molar and a premolar of the right side of an animal less than half the size of the *S. pungens*, Cope. The molar presents three anterior trihedral acute tubercles, of which one is exterior and more elevated than the others. Its posterior plane forms one transverse face with that of the inner posterior. The posterior tubercular heel is low, and supports an oblique ridge which bounds a deep groove behind the outer cusp, no doubt to receive that of the upper jaw. This arrangement is not seen in *S. pungens*. The premolar is a flat cone with faint traces of a tubercle behind and cingulum on inner side.

Measurements.

	M.
Length crown molar	0.0050
Height inner cusp	.0040
Length heel	.0025
Width crown	.0030
Height crown premolar	.0040
Length crown premolar	.0040

Found in the Eocene Bad Lands of Black's Fork, by the writer.

STYPOLOPHUS PUNGENS, Cope.

Loc. cit., 1872, p. 466; published August 3.

This is the type of the genus, and is partially described in the generic paragraph.

The enamel is smooth.

Measurements.

	M.
Depth ramus at last molar	0.011
Length last molar	.0072
Width last molar, posteriorly	.0040
Height inner tubercle	.0062
Height external tubercle, (anterior)	.0040

This species was about the size of the gray fox.
From the bluffs of Cottonwood Creek, Wyoming.

STYPOLOPHUS BREVICALCARATUS, Cope.

Loc. cit., p. 469; published August 7, 1872.

Established on a portion of the left mandibular ramus, containing the penultimate and ante-penultimate molars, of an animal of larger size than the type of the genus, *S. pungens*. The molars have the general characters of the corresponding ones of that species, but differ in their greater elevation in comparison with their length, and the greater convexity of the outer side. The shortness is occasioned by the abbreviation of the heel, which, in the last molar present, is very small and flat, without keel or tubercle on its surface. That of the molar preceding it is larger, and presents in its elevated outer margin a trace of the keel seen in the smallest species. Enamel smooth.

Measurements.

	M.
Length of two molars	0.016
Length of penultimate crown	.008
Width of penultimate crown	.0047
Length of penultimate heel	.002

There is some similarity between *Stypolophus* and *Triacodon*, Marsh. If the heel of the molars of the former were wanting, they would be those of the latter. The premolars might be supposed to have this structure, but the form seen in *S. insectivorus* disproves this view. In fact, I have seen both molars and premolars of *Triacodon aculeatus*, Cope, and the former lack the heel of the *Stypolophi* entirely.

VIVERRAVUS, Marsh.

Amer. Journ. Sci. Arts, 1872, p. 127.

VIVERRAVUS PARVIVORUS, Cope.

Miacis parvivorus, Cope. Proceed. Amer. Philos. Soc. 1872, p. 470, August 7.

Established on a portion of the right ramus mandibuli, containing portions of three molars, the penultimate being perfect. As in *Canidæ*, the molars diminish in size posteriorly, the last being single-rooted, the penultimate being two-rooted. The structure of that tooth is approximately that of *Stypolophus*, *i. e.*, with three trihedral cusps in front and a heel behind; but the cusps are of equal height, and their point of union not raised above the surface of the heel. This is a valley bounded by a sharp margin which is incurved to the outer cusp, leaving a vertical groove on the outer side, as in *Stypolophus* sp. This genus further differs from that one in the single-rooted, small, tubercular posterior molar, which is wanting in that one. The ante-penultimate molar is much larger than the penultimate. The crown of the latter is laterally expanded, and bears a cingulum at the base antero-externally. Enamel smooth.

Measurements.

	M.
Depth ramus at penultimate molar	0.0080
Length crown of penultimate molar	.0040
Elevation crown of penultimate molar	.0025
Width crown of penultimate molar	.0033

Found on Black's Fork of Green River. An ally of *Stypolophus* and *Triacodon*.

This species appears to belong to the genus *Viverravus* of Marsh, which bears date July 22, 1872, consequently sixteen days earlier than *Miacis*, which thus becomes a synonym. The species is different from those described by that author.

UNGULATA.

In no group of *Mammalia* have the determinations of paleontology been more significant than in the *Ungulata*. Here, in an especial manner, the anticipations of science have been realized, in the filling up of the numerous gaps in the series of living forms. Here especially is it evident, that the existing fauna is but a fragment, and that the faunæ of the past, as we know them to-day, are but the precursors of what we may bring to light to-morrow.

The primary range of variation in the structure of the *Ungulata* has been generally admitted by zoölogists to be found in the structure of the limbs and feet. Three most prominent types have been distinguished on this basis, viz: the *Artiodactyla*, *Perissodactyla*, and the *Proboscidia;* with some of lesser importance, those of the *Toxodontia* and *Hyracoidea*.* If we direct our attention to the detailed structure of the feet, or of the teeth, each division offers its own range of variation; witness in the *Artiodactyles* the differences between the *Ruminantia* and *Omnivora*, and in *Perissodactyla*, between *Equus* and *Rhinoceros*. In either order canines and incisors may be present or absent, and molars assume a great variety of patterns of enamel plication. The toes in the latter order may vary from four to one. Nevertheless, the most diverse genera are bound together by intermediate forms, often extinct. Connecting *Omnivora* and *Ruminantia* come *Oreodon*, *Merycopotamus*, *Tragulus*, &c. In *Perissodactyla*, *Anchitherium*, *Palæosyops*, &c., connect the extremes.

The Proboscidians have, on the other hand, remained until recently an isolated group with but few representatives, hence its definition as an order has been more or less obscured by characters of a special nature, drawn from the dentition, trunk, &c., which it has been found necessary to omit in characterizing the two orders above mentioned. These characters are so striking in their appearance as to suggest greater systematic importance than belongs to them. Thus the trunk is not more important as a character of the *Proboscidia*, than it is of the *Perissodactyla*, where the tapir alone possesses it. Nor are the complex molars and large tusks to be regarded as a definition, for in the *Phacochœrus* we have molars as compound as in some mastodons, huge canine teeth, and no incisors below; characters very different from many Artiodactyles. Nor can we regard the exclusive union of the astragalus with the navicular as a final test, for in Perissodactyles the facet for union with the cuboid may be considerable (*Rhinocerus*) to almost nothing, (*Equus*.)

The occasion for this discussion is presented by the discovery by the paleontologists of Hayden's geological surveys of 1871-'72, of the remark-

* *Vide* Gill, Arrangement of the Families of Mammals, Smithson. Misc. Coll., 1872, No. 230; the best analysis of the *Mammalia* yet published.

able types *Bathmodon*, *Uintatherium*, and *Eobasileus*. These genera contradict in several particulars the characters usually assigned to the *Proboscidia*, while they agree with them in others, and they thus present the problem of classification, which will ever recur so long as additions to our knowledge of the life of the past continue to be made. This problem is simply the question as to what characters shall be retained as definitive of natural divisions, on the discovery of intermediate forms. As our system is an expression of the possession of structural characters, our higher groups or orders are naturally expressions of the existence of the more comprehensive characters, or those present through the most extended series of species. Hence we believe them to be also those assumed earliest in time.

In the case of the *Ungulata*, the structure of the feet seems to define the greatest range of the species. Thus the *Artiodactyla* and *Perissodactyla* are digitigrade or unguligrade, while the *Proboscidia* are plantigrade. The first order exhibits the equal development of the third and fourth toes; the second of the third toe, while in the *Proboscidia* the structure is like the last, with more numerous digits. But this order differs from both the preceding in the relations of the ulna and radius. In *Artiodactyla* and *Perissodactyla* the ulna diminishes greatly distally and presents but a small carpal articular surface obliquely behind that of the much larger radius. In *Proboscidia* the ulna expanding presents the larger articulation with the carpus, and the radius crosses it obliquely, and presents its articular face alongside of the ulnar.

The characters of the three orders may be thus stated:

PROBOSCIDIA.*

Feet plantigrade but elevated behind by a plantar pad. Toes numerous, short, the middle (3d) largest. Hind limb with knee free from the body; tibia without spine; astragalus flat, not produced anteriorly. Fore limb with well-developed ulna articulating extensively with the carpus alongside of the smaller radius, which crosses it obliquely.

PERISSODACTYLA.

Feet digitigrade, with a hock-joint. Toes reduced in number, the third largest. Hind limb with knee inclosed in integument of body; femur with third trochanter; tibia with spine. Astragalus with pulley-shaped articular face for tibia and anterior prolongation. Fore limb with ulna reduced; its carpal surface smaller than that of the radius, which supports the foot in front of the ulna.

ARTIODACTYLA.

Feet digitigrade or unguligrade. Toes reduced, the third and fourth principally and equally developed. Hind limb with knee applied to the side of the body, and elevated hock; femur without third trochanter; tibia with large spine. Astragalus with both inferior and anterior pulley-shaped surfaces. Ulna much reduced distally, behind the radius, which includes almost the whole of the carpal articulation.

This arrangement violates previous views less than any other that would recognize the primary characters of the *Eobasileus*. The difficulty of determining the limits of the two first-named orders is partially

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* These characters have been mostly given by Prof. Gill, l. c.

caused by the fact that the *Hyracoidea* present the radius of the *Proboscidia* with the hind foot of the *Perissodactyla*. These animals are, however, well regarded as a distinct order. Whether all the animals to be included in the *Proboscidia* possessed a proboscis or not, is of secondary importance. It is nevertheless highly probable that *Loxolophodon* and *Eobasileus* possessed one, and not unlikely that such forms that approach still nearer the tapirs were not without an organ such as they possess, and which Cuvier ascribed to the *Palæotheria* and other allies.

PROBOSCIDIA.

One incisor or canine on each side; molars compound, with postero-anterior replacement; nasal bones abbreviated; astragalus articulating with navicular only; no third trochanter .... *Elephantidæ*.

Neither incisors nor canines; molars simple, with vertical replacement; nasal bones shortened; (?) foot; no third trochanter...... *Dinotheriidæ*.

No incisors; nasal bones elongate; astragalus articulating with both navicular and cuboid; no third trochanter................ *Eobasiliidæ*.

Dentition complete, *i. e.*, incisors present; ? nasal bones. Astragalus articulating with both navicular and cuboid; a rudimental third trochanter .... *Bathmodontidæ*.

These suborders present a series of approaches to the *Perissodactyla*. Thus the *Eobasiliidæ* agree with the typical *Proboscidia* in addition to the above points, in the posterior expansion of the scapula, and its apical acumination; in the very short cervical vertebræ; in the flat carpal bones; in the absence of pit for round ligament of the femur; in the flattened great trochanter, contracted condyles, and fissure-like intercondylar fossa of the same bone. In the longitudinal crest of the tibia separating glenoid articular faces which are on a transverse line. In the short calcaneum, which is wider than long, and tubercular on the inferior face. In the five digits; the acetabulum not separated by a peduncle from the iliac plates, and the lack of angular production of the latter beyond the sacrum. Also in the three distinguished sacral vertebræ, as contrasted with the five closely co-ossified ones of the *Rhinocerotidæ*. These characters are, some of them, of subordinate value only.

The chief differences are seen in the cranium, though here also there are important resemblances. Thus, the palate is not excavated be-the molars posteriorly, as is *Perissodactyla*, nor are the palatine bones produced posteriorly and separated from the maxillaries, as in *Artiodactyla* generally. They have a shallow excavation and accompany the maxillaries posteriorly without interruption, as in *Elephas*. In *Loxolophodon* the malar bone forms the middle element of the zygomatic arch, sending a narrow strip only forward to the neighborhood of the lachrymal. In *Uintatherium*, according to Marsh, its extention toward the side of the face is rather greater, much as in some Perissodactyla. The dentition is not far removed from that of *Dinotherium*, and the mode of succession of the teeth was in all probability similar. The premaxillaries and nasals are excavated and exostosed for the attachment of a trunk in *Loxolophodon*. The lateral and occipital crests of the cranium, though different from the enlarged sinuses of the diploe of Elephants, represent the external walls of this structure, and furnish a hint as to its mode of origin, and serve to ease the transition to Perissodactyles.

The differences in the cranium are consequent upon its anterior elongation, the nasal bones and premaxillaries becoming thus much extended. The lachrymal is perforated by a small lachrymal canal in *Uintatherium*, according to Marsh, but excavated on the margin only in *Loxolophodon.* It is neither in *Elephas.* There is a post-glenoid process much more largely developed than in *Elephantidæ.* Other differences of still less importance are to be seen in the anterior position of the exterior nares, and the presence of horns.

The *Bathmodontidæ* are represented by *Bathmodon.* With a structure of the hinder limb nearly resembling *Eobasileus*, we have more pronounced relationships to the Perissodactyles. The scapula has the massive apical acumination of the *Elephantidæ*, and there is no round ligament of the femur in some of them. The astragalus has the same flattened form seen in *Uintatherium*, and is even less like that of the *Perissodactyla.* The type of molars and the long compressed canines are similar to those of *Loxolophodon.* On the other hand, the cervical vertebræ are rather longer, and there is a rudimental third trochanter of the femur.

History, &c. I originally referred the *Eobasileidæ* to the *Proboscidia*, on account of the structure of the limbs, and subsequently stated a number of reasons for this conclusion at a meeting of the Academy of Natural Sciences of Philadelphia, held January 14th, 1873, (published January 16th.) In the present paper, numerous confirmatory characters are added. The *Bathmodontidæ* I have heretofore referred to the *Perissodactyla.*

Professor Marsh, in describing a species of this group, *Titanotherium* (?) *anceps*, (July, 1871,) compares it with perissodactyle species, and in describing the tibia says that it, " at its proximal end, has the femoral surfaces contiguous, with no prominent elevation between them, resembling in this respect some of the *Proboscidia.*" A few days before the publication of my conclusions, in a foot-note, (July 22d, 1872,) he altered the name *Titanotherium* to *Mastodon*, indicating that he had reached the same opinion. Shortly after, (American Journal of Science and Arts, September 27th,) he altered his view, constructing a supposed new order "*Dinocerata*," for their reception.

As regards the name of the order here defined as including the four families above mentioned, I have preferred using one already employed to coining a new one. This is the better course also, if, as is not unlikely, the distinctions on which it, as well as the other two orders, repose, shall be broken down by new discoveries in paleontology.

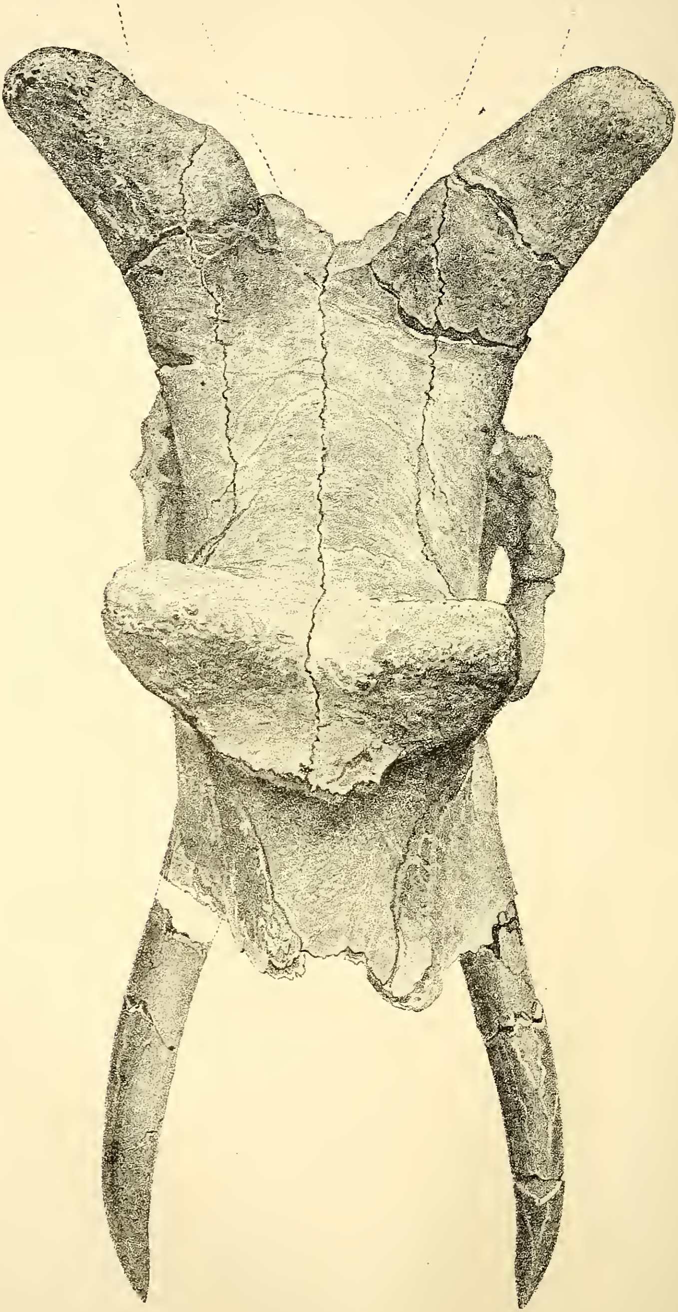
EOBASILEIDÆ.

The genera of this group known to the writer are four, which differ as follows:

1. Nasal bones with flat horizontal horn-cores overhanging their apex.
Cervical vetebræ short; malar bone much reduced in front.. *Loxolophodon.*
2. Nasal bones with small tuberosities.
Cervical vertebræ short .... *Eobasileus.*
Cervical vertebræ longer; the malar bone reaching maxillary face.. *Uintatherium.*
3. Nasal bones without the anterior horn-cores.
Cervicals (?).. *Megaceratops.*

The above is the closest approximation to nature which my present material allows. It is not at all unlikely that the difference in development of the anterior nasal tuberosities seen in *Loxolophodon cornutus* and *Eobasileus pressicornis* will turn out to be only specific.

The dentition of this group requires special notice. Judging from the



LOXOLOPHODON CORNUTUS COPE

1/6 nat. Size.

Thos Sinclair & Son, lith. Phila.

relative sizes of the teeth, I have written the molar series of *Loxolophodon* 4—2, but judging from the forms of the crowns, it should be 1—5. However this should be, I have no doubt that as in other *Proboscidia* the premolar and not the molar series is deficient, and that there are three or four true molars at least. In a mandible found alone, which agrees in size with some species of *Uintatherium*, six molars are preserved. Of these the posterior two display three sub-transverse crests, of which the anterior two form a chevron with open apex directed to the inside. Anterior to the front crest is a cingular tubercle. The symphyseal part of the jaw is remarkable: it is co-ossified, exceedingly compressed, and curved upwards so as to resemble slightly the narrow prow of a South Sea boat. There are two teeth on each side, which are separated from the molars by a diastema. They are much compressed and curved upwards and forwards, and the anterior pair issue from the jaw in contact. The crowns are lost in the specimen. The determination of these teeth is facilitated by the presence of the mental foramen below the posterior one. This foramen issues, as is well known, posterior to the canines in all *Mammalia*, and either below premolars or the diastema. The two teeth in our fossil will then be premolar and canine respectively, and the incisors must be regarded as wanting. This is in conformity with the structure of the upper jaw, and is rendered probable by the great reduction of the symphysis of the lower jaw in the species. It is also suggested by the almost universal tendency to reduction of the incisors seen in the mammals of the same extinct fauna. In *Bathmodon* and *Palæosyops* the canines are thrown into the incisor series as in *Ruminantia*, and in *Palæosyops* the outer incisors are much reduced. In several genera there are but two incisors. Finally, in *Synoplotherium* the large inferior teeth described by myself as incisors, and which resemble the cutters of *Rodentia*, are immediately in front of the mental foramen, and bear the same relation to it and to the premolar teeth, as do the canines of *Palæosyops* and other *Mammalia*. Hence I believe these to be canines, and that the inferior incisors are wanting in my specimen. The probability of the truth of this determination is increased by the presence of a small interval between them, and by the fact that they oppose the canines of the upper jaw.

LOXOLOPHODON, Cope.

Proceedings American Philosophical Society, 1872, p. 580, extra copies published August 19; and p. 488, (August 22.) *Tinoceras*, Marsh, American Journal of Science and Arts, 1872, (October.) Published (described) September 21.

The cranium in this genus is very elongated and compressed. The muzzle is posteriorly roof-shaped, but is anteriorly concave, and flattened out into a bilobed shovel, which rises above the extremity of the bone. This extremity is subconic, and short and decurved. A second pair of horn-cores stands above the orbits; each one composed externally of the maxillary bone, and internally of an upward extension of the posterior part of the nasal. Behind this horn the superior margin of the temporal fossa sinks, but rises again at its posterior portion, probably above the level of the middle of the parietal bones. This portion of the skull is injured in my only specimen. The occipital rises in a wall upward from the *foramen magnum*, and supports, probably, a little in front of the junction with the superior and inferior ridges bounding the temporal fossa, a third horn-core on each side. The base of this core is as stout as that above the orbit, and subcylindric in section. The temporal fossa has its principal extent posterior to the zygomatic arch, and is in form like a trough, the inferior edge being recurved from the squamosal process to the summit of the occipital crest. It is narrow within the zygomatic arch, which is short, inclosing a space whose length is less than one-fourth that of the cranium.

The *occipital* bone extends but a short distance on each side of the condyles, and is separated from the mastoid by an irregular suture, which is pierced by a large mastoid foramen. On the inferior face, near to each condyle, and one-third the distance from its inner extremity, is a posterior condyloid foramen, isolated by a narrow bar from the extremity of the *foramen lacerum posterius.* The paramastoid process is represented by a small tuberosity, and the mastoid by a rather larger one, some distance anterior to it.

The *meatus auditorius* opens upwards just below the external ridge of the temporal fossa, and at a little distance behind the post-glenoid process. Its canal contracts rapidly, and extends upwards and backwards towards the labyrinth. It is separated from the *foramen lacerum* by but a thin wall, and if there was an expansion of the *cavum tympani*, it must have been exceedingly small, owing to the close approximation of the mastoid to the basi-occipital and sphenoid at this point. The labyrinth is lodged in a petrous mass opposite the occipito-mastoid suture, and the canals are small.

The *basi-occipital* contracts anteriorly, and with the sphenoid forms an uninterrupted boundary of the *foramen laccrum.* This terminates opposite to the posterior boundary of the external meatus, and gives rise to a wide, shallow groove, which extends anteriorly between the pterygoid ala and the post-glenoid process, and turning outwards round the latter, grooves it. Opposite to the post-glenoid process, and just posterior to the end of the pterygoid, a small foramen enters, which is probably the *foramen ovale.* Almost continuous with it is a canal which pierces the base of the pterygoid longitudinally, and issues in an excavation of its external face near the sphenoid.

The *pterygoids* are remarkable for their great length, inclosing, as they do, with the palatine process, a deep, narrow, trench-like fossa, which measures almost the entire length of the zygomatic fossa. Processes of the sphenoid contribute to these walls, (which are thus double,) and the sphenoid roof is strongly concave. The *alisphenoid* is elongate antero-posteriorly, and is principally in contact superiorly with the frontal; anteriorly it has a short suture with the lachrymal. Almost its entire length is traversed by a shallow groove which terminates in a small *foramen opticum*, opposite to a point marking the posterior third of the zygomatic fossa, The *foramen rotundum* issues as usual between the alisphenoid and the pterygoid, but is considerably anterior as well as inferior to the *f. opticum.* I cannot determine whether the orbitosphenoid is distinct.

The *lachrymal* is a large bone, of a triangular outline, the shorter side being inferior. It is entirely on the inner face of the orbit, and, as in the elephant, separates the frontal and maxillary by its superior prolongation. Its inferior border is slightly notched in front by the large *foramen infraorbitale posterius*, and the anterior is deeply emarginate, passing behind the small *f. lachrymale.*

The *palate* is remarkable for its length and narrowness. Its roof is chiefly composed of the maxillaries, but a very short portion is formed by the palatine plates of the *o. o. palatina.* These are produced into a median point behind, between the nares, and exteriorly form the inner wall of the postnareal trough for a considerable distance. The closely united *maxillaries* form the outer wall for a short distance, being pro-

LOXOLOPHODON CORNUTUS COPE
1/6 nat. size.

Thos Sinclair & Son lith Phila.

duced in a contracted form behind the molar teeth. The two bones inclose a small foramen in this prolongation, and a larger one on the anterior suture of the palatine, the *foramen palatinum*. The posterior nares are not excavated anterior to the line of the posterior border of the last molars. The palate is deeply concave anteriorly. There is an elongate foramen close to the alveolus of the first premolar, extending anterior to it. The premaxillaries are longitudinal and separated anteriorly for two-fifths of their length, by a large *foramen incisivum*, which they do not inclose. They extend on the side of the muzzle into an acute angle upwards and backwards, and are prolonged forwards above the exterior nares, which the suture reaches by an abrupt descent. The maxillary supports the malar on a posteriorly directed process which reaches to the end of the anterior third of the arch below, half that distance on the side, and is bordered by a narrow strip of the malar on the inner side, as far as the anterior boundary of the orbit. The *premaxillaries* do not inclose the very large *foramen incisivum* in front, and are therefore deeply furcate.

The *dentition* is I. 0; C, 1; P. M. 4; M. 2. The canine is a tusk of compressed form, with anterior and posterior cutting edges, and a strong posterior curvature. Its fang is embraced one-third by the premaxillary bone, and is inclosed in a rib-like swelling of the sides of the cranium, which extends upward and backward. The premolars are well worn, and have transverse cordate surfaces of attrition. These have probably resulted from the wearing down of a chevron of two crests converging inwards, in some with an inner tubercle. On the molars this crescent is represented by a V, with the apex inwards; on the last, the inner tubercle is at one side (the posterior) of the apex.

Name.—I first applied the name *Loxolophodon* to this genus in a short paper published August 19, 1872, as above cited, with a diagnostic description; the *L. cornutus* was there cited as the first species, and is here retained as the type. I again described it more fully in a paper published August 22d, citing *Eobasileus* (August 20th) as a synonym, perhaps incorrectly, as indicated by the present paper. The same nomenclature was employed in a paper read before the American Association for the Advancement of Science, held at Dubuque, commencing August 23, 1872.

In the paper of August 22d, I regarded this genus as identical with that to which I had previously (February 16, 1872) applied the name *Loxolophodon*, and included in it the species there called *Bathmodon (Loxolophodon) semicinctus*, Cope. With further material this appears not to be correct; the *Bathmodon semicinctus* belongs truly to that genus, and is very near to the *B. radians*, so that the name *Loxolophodon* becomes a synonym in this connection, and may be used again for the present genus without interference. It was, moreover, not described at the former date, and had no proper claim to recognition.

Professor Marsh, in the American Journal of Science and Arts, 1872, (September 21,)* applied the name *Tinoceras* to a species (*T. grandis*) of this genus, and gave a description, in which some of the generic characters may have been mentioned. He had previously applied it without description to the *Titanotherium ? anceps*, August 24th, (and 19th,† in an erratum, where *Mastodon anceps* is altered into *Tinoceras anceps*.) As no characters whatever were assigned to it on either of these occasions, it had no value in zoological nomenclature.

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*I did not receive this, and most of the other papers of Professor Marsh on this fauna, till early in December, 1872.

† These papers were not received by me till early in December, 1872.

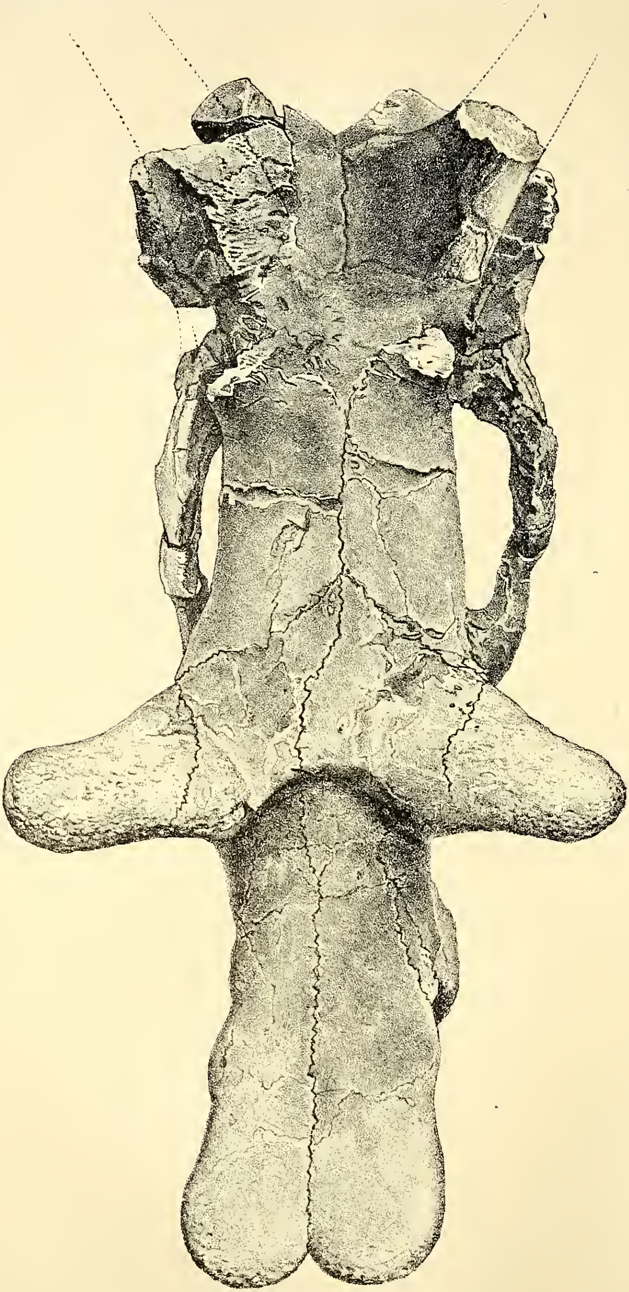
LOXOLOPHODON CORNUTUS, Cope.

Loxolophodon cornutus, Cope, Proceedings American Philosophical Society, 1872, p. 580, (August 19;) *loc. cit.*, 1872, p. 488, (August 22.) The short-footed Ungulata of the Eocene of Wyoming, p. 8, (April 14, 1873.) *Eobasileus cornutus*, Cope, American Naturalist, 1872, p. 774. *Tinoceras grandis*, Marsh, American Journal of Science and Arts, October, 1872, (published September 21,) *fide* Marsh.

Established on the remains of a single individual, which consist of a nearly perfect cranium, the right scapula complete, several vertebræ, including the sacral, the first or second rib, the pelvis complete, and the entire right femur; also probably the proximal end of a radius.

The species is remarkable for the narrow form of the *cranium*, its width at the middle being one-fourth its length. A little in front of the middle are situated the horn-cores. These diverge, the upper portion having an outward curvature. The base of each is triangular with obtuse angles, in section, and the inner angle is the section of a rib-like projection which extends across the front to its fellow and rises half way up the horn-core. Above its rather abrupt termination the core is transversely compressed, with oval obtuse apex. The core measures M. .240 (9.5 inches) from its base in front, M. .108 (4.25 inches) in width at the base behind, and .077 (3 inches) in diameter at the apex. A slight swelling of the sides of the muzzle descends obliquely forward from the base of each horn, which enlarges below into a prominent rib, which incloses the alveolus of the canine tusk. In front of the horns the muzzle is roof-like; anteriorly it flattens out, and swells a little above the posterior end of the nasal meatus. In front of this it expands again, and rises gently to the extremity of the bilobed nasal shovel, which overhangs the premaxillaries, the nasal meatus, and the greater part of the apex of the nasal bones. The latter is short and with a wide base, and resembles two lateral cones flattened together, their extremities obliquely truncate outward and excavated. The composition of the upper surface of the cranium is somewhat difficult to determine, owing to the injured state of the posterior part. If we regard the bone which bounds the lachrymal behind and above, as frontal, as I did in originally describing the species, it gives an extraordinary extent to the nasals, for the common suture of these bones extends V-shaped backward, to a point opposite to the middle of the zygomatic arches. It gives to the nasals an extent equal to that of the frontals and parietals combined. They not only support the anterior lobes, but form the inner half of the median horn cores, rising as high as the tuberosity above described. To regard these bones as frontals would involve the improbable peculiarity of their extending beyond the nareal orifices, and the terminal cone of the nasals is not separated from them by suture, but by a groove only. The question is decided in favor of their being nasals, by those bones as preserved in *Eobasileus pressicornis*, Cope, where the lobe is represented by a tubercle only on the side of a continuous nasal. The immense length of the snout in *Loxolophodon* looks as though the nasal bones had extended themselves forward, so as to ossify the basal portions of an elephantine proboscis.

The frontals descend behind the horns, with a very obtuse or rounded continuation, to the inner side of the fossa, and without any superciliary margin. They form with the posterior part of the nasals a shallow median basin. The suture with the parietals is very indistinct, but if I have truly discovered it, it forms another posteriorly directed chevron, and leaves but a narrow superciliary portion of the frontals. Above the



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postglenoid processes the parietals rise again to the transverse occipital crest, but to what height is uncertain. At the mastoid region, the cranium widens a little, and is excavated at the sides by the temporal fossæ. Near where the lateral and posterior crests join the inferior ridge-like border of the temporal fossa, in front of a position occupied by a knob in *E. pressicornis*, is a strong horn-core with sub-cylindric base. It stands obliquely backwards towards the junction of the inferior squamosal and transverse crests, and is connected to these by an oblique ridge, one side of which is marked with irregular, short, longitudinal rugosities. At the base of these elevations are three sinuses. This portion was found close to the skull, but separated from it, and the precise mode of its attachment has not been discovered by actual fit.

The occiput rises upwards for four inches above the condyles; perhaps it displayed a posteriorly sloping transverse crest as in *E. pressicornis*. The paramastoid and mastoid tuberosities are narrowed and extend obliquely downwards and forwards. The lower part of the exoccipital suture runs along a ridge, and there is a tuberosity in front of the mastoid foramen. An irregular A-shaped crest extends upwards with the apex at the inferior temporal crest, and its anterior limb forming part of the posterior boundary of the *meatus auditorius*. The inferior temporal crest is directed outwards below, but forwards above.

The narrowness of the cranium is readily seen on comparing the postglenoid processes. These are not deep, but have considerable transverse extent, and are separated by a space only a little greater than the transverse diameter of each. The zygomatic arches are compressed posteriorly, with crest-like superior ridge, but rounded above anteriorly. There is not the least trace of posterior boundary of the orbit. The squamosal process overlaps the malar bone extensively, terminating in a point, the latter ending obtusely. The malar is supported in front by a maxillary process, which is united with it by a zigzag suture on the outer face and a squamosal one within and below. The *foramen infraorbitale exterius* is large, and issues a short distance in front of the orbit, not so near it as in the elephants. From this point to the ridge inclosing the canine alveolus the side of the maxillary bone is deeply concave, and the palatal surface correspondingly contracted. The bone is continued upwards and outwards as the external part and apex of the middle horn-cores. Anteriorly it is bounded by the premaxillary to a point as far anterior to the base of the horn as the width of the latter; behind that point it is in contact with the nasals. The premaxillary is prolonged upwards and backwards into a narrow tongue. Its inferior portion is convex above on each side, concave below, with projecting alveolar borders, which are flat and slightly concave fore and aft. The extremity of each is rugose below, supports a prominent tubercle medially and a smaller one at the superior angle.

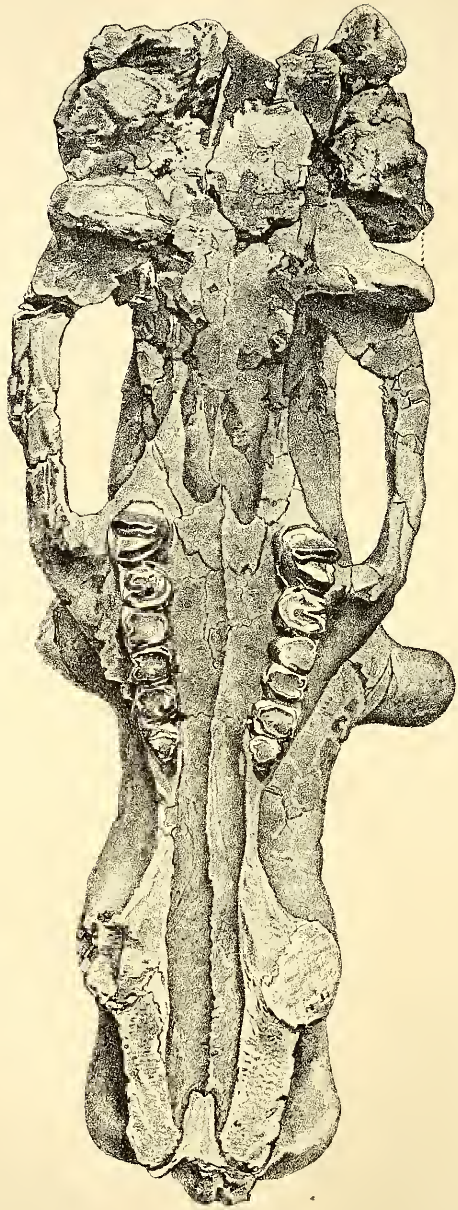
The exterior nares are not separated by osseous septum. Their lateral borders are marked on the inferior surface of the nasal and premaxillary roof by a curved ridge or crest, which converge forwards and bound the interior concavity of the roof. This gave support to muscular or ligamentous attachments. The posterior angle of the nares is abruptly excavated with thickened walls. The palate is remarkably narrow, and is most deeply excavated between the alveoli of the tusks, or at the maxillo-premaxillary suture. From near this point to the palatine suture a low but sharp crest extends along the middle line. The width of the palate at the diastema is one-ninth of its length. The diastema is more than half the length of the molar series. The pterygoid process of the palatine bones has two convergent grooves on its inferior surface.

The *teeth* are remarkable for the extent of the exposure of their slender roots, as well as their very small size as compared with the size of the animal. The tusk is slightly turned outwards at the tip and the inner face is worn by attrition with some opposing tooth for one-third its length on the posterior third. The superior margin of the enamel on this side is chevron-shaped, the apex being only one-third the length from the extremity. It extends further upwards in front and on the outer side, but is worn in an oval patch at the apex of the chevron of this side by contact with the inferior teeth, as above described. The enamel is smooth behind, rugose in front. The apex contracts regularly to a flattened obtuse point. The fang is hollow for about half its length. The enamel of the molars is nearly smooth. Each one has a strong cingulum fore and aft, which is discontinued on the inner and outer faces except in P. M. 1, and M. 2. In the former, it is continued on the outer side at the base of the concavity of the exterior face; on the latter, it is continued round the inner side. The grinding surface of the P. M. 1 is tripodal, and probably composed of a worn crescent and inner tubercle. The others are transverse arrow-shaped; the P. M. 4 is much more worn than the others. M. 2 is larger than M. 1. Its oblique crests have evidently been worn from before. All the molars have three roots, but the posterior pair are united for part of their length in all.

The *vomer* does not unite with the superior crest of the palatine bones. The sphenoid flattens out behind the postnareal trough and is co-ossified with the basioccipital. The latter is marked by two oval surfaces at the place of suture, with a slight prominence between. No lower jaw was found with this specimen, but from the contraction of the parts opposed to it, it was evidently very small.

Cranial measurements.

	M.
Length from end nasals to end occipital condyle, (3 feet 1.5 inches)	0.930
Width just behind end nasal shovels	.192
Width in front of horns	.132
Width at base of horns in front	.205
Width behind horns at apex of frontal suture	.185
Width above posterior edge *meatus auditorius*	.310
Width between apices horn-cores	.370
Width basis supraoccipital horn-core	.100
Width including zygomatic arches, (greatest)	.320
Length of nasal bones to ridge between horn-cores	.410
Length of nasal bones to frontal suture	.540
Length of zygomatic fossa above	.230
Length from angle nares to end shovel	.205
Length from angle nares to end premaxillary	.155
Length from end premaxillary to basis of canine	.120
Length from end premaxillary to basis of P. M. 1	.276
Length of molar series	.185
Length of palate	.450
Length of pterygo-palatine crest	.200
Length of sphenoid axis	.185
Length of basioccipital, (with condyles)	.128
Width between tips premaxillaries	.070
Width at canine alveoli	.185
Width between canine alveoli	.080
Width at diastema	.050
Width between last molars	.070
Width between pterygo-palatine crests	.065
Width of post-glenoid process	.095
Width between post-glenoid processes	.095
Width basioccipital at front	.073
Width basioccipital at condyles	.200
Width of space for tympanic chamber	.034
Length tusk on curve, (12.7 inches)	.320



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	M.
Diameter at middle do. (antero-posterior)	.050
Diameter at base do. (antero-posterior)	.063
Diameter at middle do. (transverse)	.030
Diameter crown P. M. 1 transverse	.022
Diameter crown P. M. antero-posterior	.024
Diameter crown M. 1 antero-posterior	.035
Diameter crown M. 1 transverse	.034
Diameter crown M. 2 transverse	.043
Diameter crown M. 2 antero-posterior	.045
Elevation of shovel above base of apex of nasal	.060

The measurements may require some correction in respect to the supraorbital width, where the cranial walls have suffered from compression. The frontal of one side has been pushed so as to overlap that of the other by about an inch.

The *scapula* is of a sub-triangular form, the front being vertical, the apex directed backwards and an angle upwards. The posterior expansion is considerable, as in the elephants, while the superior angle is acuminate and much produced and massive. The spine is much elevated, bounding a deep supraspinous fossa. It is truncate in front, descending to near the border of the glenoid cavity. Its extremity is dilated in alate fashion, equally fore and aft, and not posteriorly only as in the elephants. The glenoid cavity is flattened so as to be longitudinal, and the coracoid is a rudimental tuberosity.

Measurements of scapula.

	M.
Total length, (25.25 inches)	0.640
Total width	.480
Length apex from spine	.140
Elevation of spine proximally	.125
Length of glenoid cavity	.185
Width of glenoid cavity	.110

The interior side of the scapula is strongly convex by the development of two longitudinal ribs, one corresponding to each fossa, but concave in longitudinal section.

The proximal end of the *radius* exhibits two facets oblique to each other, the larger concave and transverse, the other oblique downwards. Transverse width M. 0.130; vertical .070. The extremity of a humerus not found with this individual, to which the radius applies pretty well, has a very oblique trochlear face, and measures seven inches across the condyles. It, however, belongs to a smaller species.

The *femur* is entire. Like that of other species of the group it is much expanded proximally and deep distally, with the shaft contracted and somewhat flattened in the plane of the great trochanter. The latter is in one plane, with its external margin turned a little backwards. The head is part of a globe, and is a little more elevated than the trochanter, and separated from its apex by a shallow concavity. There is no little trochanter. The trochlear face is not elevated nor wide, and with lateral borders subequally developed. The antero-posterior axis of the condyles is somewhat oblique to a line at right angles to the proximal end. On this account the interior condyle is the longer; its articular face is continuous with the trochlear, with a marginal notch; the outer condyle is continuous, with continuous outer margin. Strong ridges revolve from above the condyles to the posterior face of the shaft, the inner near the condyle. The outer runs parallel to the main axis as a low external ala, and backwards three inches above the condyle. The face between the ridges is concave.

Measurements of femur.

	M.
Total length, (31.75 inches)	0.747
Total proximal width	.255
Diameter of ball	.136
Transverse diameter at middle of shaft	.096
Antero-posterior diameter at middle of shaft	.074
Antero-posterior diameter condyles posteriorly	.150
Transverse diameter condyles posteriorly	.160
Transverse diameter condyles distally	.145

The *pelvis* has a large transverse expansion. The iliac plates are ovoid in outline, with the apex outwards and downwards. The margins are rather thin excepting the internal above the acetabulum. These are massive, and with a longitudinal excavation. They terminate in a deep oblique excavation for the diapophyses of the sacrum. The inferior margin rises compressed from just above the acetabulum. The latter is large for the size of the ilia, and its margins rise to a slight elevation beneath the exterior margins of the latter. The *incisura acetabuli* is obclavate, and nearly symmetrical. The *os ischium* is compressed and deeper than the pubis. It possesses a tuberosity on the posterior inferior margin. The *obturator foramen* is small, and is a vertical oval. The *pubis* is rather slender and short. Its section at base is subtriangular; beyond, it becomes more compressed, and is spirally twisted on itself through a part of a circle. Its anterior margin near the symphysis, is strongly rugose for the origin of the *pectineus* muscle; the rugosity extends into a band on the outside of its proximal portion.

Measurements of pelvis.

	M.
Long diameter of ilium	0.605
Transverse diameter at acetabulum	.430
Length inferior free margin do	.250
Long diameter acetabulum	.150
Shorter diameter acetabulum	.130
Shorter diameter obturator foramen	.070
Width ischium to tuberosity	.140
Length ischium at tuberosity	.110
Diameter pubis at obturator foramen	.062
Expanse of ilia laid on a flat surface and with sacrum in place, (4.2 feet)	1.280

The general character of the pelvis is more like that of the elephant than that of any Perissodactyle. It agrees with the former and differs from that of the rhinocerus in the shortness of the pedestals of the ilias or rather in the sessile position of the latter on the acetabula; also in the absence of production of the iliac crests in advance of and above the sacrum. It is also elephantine in the shortness of the inferior elements of the pelvis.

Of *vertebræ*, there are preserved a dorsal, two lumbar, and some sacral. The first is very short and transverse. It is so injured that I can only give measurements. The base of the transverse neurapophysis is a flat oval; both capitular articular surfaces are deep. The anterior lumbar is longer, but still short; its articular faces are slightly concave. The neural arch is wide, and supports the diapophyses. The sides of the centrum are concave and pierced by foramina, and there is a strong rugose hypapophyseal keel. The section at the middle is subtriangular. I have three sacral vertebræ which are separated by very distinct sutures. They diminish very rapidly in size, and the centra become flattened transverse. It is doubtful whether there was a fourth vertebra, and the tail must have been short and slender. The articular face of the first is a transverse, rather broad ellipse, and twice the diameter of the third distally. The diapophysis of the second is much the stoutest. It unites with the subvertical plate-like diapophysis of the first as well as with that of the third. It is concave above, and terminates distally in a massive L-shaped surface of articulation with the ilium. The foramina inclosed by the diapophyses are quite large. The inferior face of the first sacral centrum is slightly concave with a hypapophysial tuberosity in front; it is strongly concave in the second.

Measurements of vertebræ.

	M.
Antero-posterior diameter of dorsal	0.044
Diameter at bottom neural arch do	.040
Length base of neurapophysis	.041
Diameter centrum lumbar, (vertical)	.090
Diameter centrum lumbar, (transverse)	.110
Diameter centrum lumbar, (antero-posterior)	.080
Length three sacral vertebræ	.225
Transverse extent of sacrum, (15 inches)	.380
Diameter first vertebra at free end, (transverse) (4.6 inches)	.122
Diameter first vertebra at free end, (vertical)	.093
Diameter last vertebra at free end, (vertical)	.021
Diameter last vertebra at free end, (transverse)	.065
Total expanse of heads of rib	.106
Diameter capitular face, (vertical)	.048
Diameter tubercular, (vertical)	.030
Width rib just below head	.050

Restoration.—We may ascribe to the *Loxolophodon cornutus*, form and proportions of body similar to those of the elephant. The limbs, however, were somewhat shorter, as the femur is stouter for its length than in the *E. indicus*. It was similar in this respect to certain species of *mastodon*. The tail was quite small. The neck was a little longer than in the elephants, but much less than in the rhinoceroses; the occipital crest gave attachments to the *ligamentum nuchæ* and muscles of the neck, which must needs have been powerful to support the long muzzle with its osseous prominences, and to handle with effect the terrible laniary tusks. The head must have been supported somewhat obliquely downwards, presenting the horns somewhat forwards as well as upwards. The third or posterior pair of horns towered above the middle ones, extending vertically with a divergence, when the head was at rest. The posterior and middle pair of horns were no doubt covered by integument in some shape, but whether dermal or corneous is uncertain. Their penetrating foramina are smaller than in the *Bovidæ*. The cores have remotely the form of those of the *Antilocapra americana*, whence I suspect that the horns had an inner process, or were palmate as in the prong-horn at present inhabiting the same region. The nasal shovels may have supported a pair of flat divergent dermal horns, but this is uncertain; they are not very rugose.

The elevation of the animal at the rump was about 6 feet, distributed as follows:

Measurements.

	Inches.
Foot	4.50
Tibia	20.50
Femur	31.75
Pelvis	16.00
	72.75

The anterior limb was stouter than the posterior, judging from the proportions in *Eobasileus pressicornis*, and was no doubt more elevated if of the Proboscidian character. This would give us the hypothetical elevation at the withers:

Measurements.

	Inches.
Leg	61.00
Scapula, (actual)	21.00
Neural spines, (extremities)	7.00
Or 7 feet 5 inches	89.00

These measurements are made from the plantar and palmar surfaces, allowance being made for the pads.

The neck, estimating from the dorsal vertebræ and from the cervicals of other species preserved, could not have very much exceeded 1 foot in length. This, added to the length of the cranium, gives a total of near four and a half feet. The obliquity of the antero-posterior axis of the cervical vertebræ indicates that the head was posteriorly elevated above the axis of the dorsal vertebræ. Thus it is entirely clear that the muzzle of this animal could not have reached the ground by several feet, and that, as occurs in the similar cases of the tapirs and elephants, there was a proboscis to supply that necessity. The indications derived from the bones of the muzzle confirm this conclusion, as has been already pointed out.

Further than this, the symphysis madibuli is very short and narrow, and its teeth could have had no adaptation for cutting off vegetation. The mental foramen is small, and the small nutrient artery thus indicated is entirely adverse to belief in a powerful or prehensile under lip to make up for the uselessness of the teeth. The long decurved canine teeth would, moreover, partially prevent the lips from touching the ground. The posterior position of the molar teeth indicates use for a proboscis as well as for a long, slender tongue. The fact that the *foramen infraorbitale* of the *Loxolophodon* is less than in the elephants, in no wise militates against the possession of a proboscis, for it is still smaller in the tapir, which has one, and larger in many rodents which are without it. There could have been no interference from horns near the ends of the nasal bones, for the bases of these project beyond the origin of a proboscis, and were directed outwards, while the latter hung downwards.

This species was probably quite as large as the Indian elephant, for the individual described is not adult, as indicated by the freedom of the epiphyses of the lumbar vertebræ, and fragments of others in my possession indicate very considerably larger size.

Habits.—The very weak dentition indicates soft food, no doubt of a vegetable character, of what particular kind it is not easy to divine. The long canines were no doubt for defense chiefly, and may have been useful in pulling and cutting vines and branches of the forest. The horns furnished formidable weapons of defense. That the anterior nasal pair were not used for rooting in the earth is evident from the elevation of the head, which would render this impossible.

This huge animal must have been of defective vision, for the orbits have no distinctive outline, and the eyes were so overhung by the horns and cranial walls as to have been able to see but little upwards. The muzzle and cranial crests have obstructed the view both forward and backward, so that this beast probably resembled the rhinoceros in the ease with which it might have been avoided when in pursuit.

Synonymy.—According to Marsh, he described this species September 21, 1872, under the name of *Tinoceras grandis*, which thus becomes a synonym of *Loxolophodon cornutus*. As the name *Tinoceras* had never been described prior to that date, although applied to the *Titanotherium* (?) *anceps*, Marsh, previously without description, this name becomes a synonym of *Loxolophodon* or *Eobasileus*, should the two latter ultimately prove to be identical.

Locality.—The remains of the *Loxolophodon cornutus* were found by the writer in August, 1872, in a ravine of the bad lands of Wyoming. The greater part of the cranium, femur, &c., were excavated from the base of a cliff of perhaps 250 feet in height, on the side of a ravine elevated about 1,000 feet, in the Mammoth Buttes, on South Bitter Creek. As the basin of Bitter Creek is 7,500 feet above the sea, the fossil was taken from an elevation of 8,500 feet. The horizon is the Bridger Group of the Eocene of Hayden.

EOBASILEUS, Cope.

Proceedings of the American Philosophical Society, 1872 p. 485, (*separata*, August 20.)

As pointed out above, this genus resembles *Loxolophodon* in the cervical vertebræ, but agrees with *Uintatherium* in the rudimental condition of the nasal horn-cores, which are mere tubercles. The posterior or third pair of horn-cores are also very different, and probably stand on the largely developed lateral crests of the superior surface of the cranium, as in *Uintatherium*. They are apparently preserved in *E. furcatum*, (which is not the type of the genus,) and are compressed from base to summit; in *Loxolophodon* the base is nearly cylindric.

The characters of this genus had not been indicated in any of the descriptions published by paleontologists prior to its establishment as above cited.

The cervical *vertebræ* in *E. pressicornis* are very short. The limbs are much as in *Loxolophodon*, as are the scapula and pelvis. The *symphysis pubis* of *E. pressicornis*, or an ally, is short, and was separated from the ischiadic symphysis; but whether this belongs to the genus is not entirely certain.

The *unciform* bone, of perhaps the same species as the above, displays, as in living proboscidians, three inferior facets. The external facet is deeply concave, and unites with the superior face by an acute angle. It supported the small outer toe by its metatarsus directly. The other two are more nearly on one plane, and are deeper than wide. The unciform is in form a little less than a quarter of a circle, and the external (anterior) depth is one half its transverse length. Its superior surface is slightly convex.

EOBASILEUS PRESSICORNIS, Cope.

Loxolophodon pressicornis, Cope. Proceed. Amer. Philos. Soc., 1872, p. 580, (published August 19.) Loc. cit., p. 488, (August 22.) *Eobasileus cornutus*, Cope, l. c., p. 485, (August 20,) not *Loxolophodon cornutus*, Cope, l. c., August 19.

Represented by numerous portions of the cranium, with fragments of limbs of one individual; of almost all portions of the skeleton, except the cranium, of a second. A humerus, with astragalus of a third, is of uncertain reference, while a single humerus of another specimen may belong here. Fragments of several other individuals of appropriate size may pertain to it.

The *cranium* is represented by nasal, maxillary, malar, occipital bones, &c. The first named has a half-conic apex, and an oblique compressed tuberosity, which forms the lateral border behind it, and is directed obliquely upward. The apex of each nasal is vertically compressed acute, and is deeply pitted and rugose for muscular or ligamentous attachments. The inferior lateral marginal ridge is contracted, and incloses a concave median space. The tuberosity sinks to the level of the median suture. The posterior part of the nasal rises to the *apex* of the middle horn-core, forming its inner face. The postero-superior angle of the premaxillary reaches to near the base of the horn, and is not drawn out to a narrow apex as in *L. cornutus*. The horn is compressed antero-posteriorly at the base; at the apex obliquely inward and forward. The outer face is concave on the lower half; the inner, convex. The posterior face is concave and the anterior convex, when viewed from the side.

Measurements of nasal bone.

	M.
Width of both at tuberosity	0.124
Width of both at base of distal cone	.060
Depth of suture at front of tuberosity	.030
Length of suture, from premaxillary to horn-core	.035
Length of horn-core, (in front,) (6 inches)	.150
Diameter, (externally)	.080
Diameter of apex	.048

The occipital region is furnished with an enormous transverse crest which extends upward and backward. Its margin is gently convex, and its supero-anterior face concave. The posterior is narrowed by the inferior crest-like margins of the temporal fossæ, which extend from the squamosal part of the zygoma and gradually contract, terminating abruptly in a low knob where it joins the transverse crest. The posterior face between the former is divided into two planes by a low vertical ridge, which terminates some distance below the summit. The transverse crest is continued in a curve forwards on each side as the superior margin of the temporal fossa. The specimen does not indicate whether these crests supported horns, but they are very stout.

Measurements of occiput.

	M.
Elevation from *foramen magnum*	0.180
Width between inferior temporal crests	.250
Width of condyles with foramen	.1[illegible]0
Elevation above internal sinuses at angles	.180

The mastoid tuberosity is short and stout; the mastoid foramen is large and not piercing a crest. The ex-occipital suture is obliterated. The ʌ-shaped crest behind the meatus in *Loxolophodon cornutus* is little marked here. The surface of the bone has various muscular impressions. The basi-occipital exhibits a low median crest dividing lateral concavities; transverse width at condyles .077 M. The fragments of teeth are too uncharacteristic for specific description. Numerous cranial fragments accompany the above, but have not yet been properly placed.

The *atlas* is broken; its cotyloid cavities are rather shallow, and the diapophyses small. Its antero-posterior diameter below at the middle line is .070; at base of diapophysis .070. The condyles of the *femur* present the characters of the group. There is a deep vertical groove on the inner side just above the condyle. The latter approach each other closely on each side of the intercondylar fossa and are flattened on the superior posterior margins. Width across extremities M. .150.

At a distance of 100 or 200 feet from the above specimen I found portions of the skeleton of a smaller animal, probably a different but allied species. It is represented by portions of ribs and limbs, of which the ulna is described under *Uintatherium*. Two or three hundred yards from the typical specimen, I obtained remains of almost all parts of the skeleton of what is probably the present species. The femur is identical in character. The specimen embraces cervical, dorsal, and lumbar vertebræ, ulna, both femora and tibiæ, astragalus, navicular, &c., and large parts of the scapulæ and pelvis.

The *scapula*, in its proximal portions, differs little from that of *Loxolophodon cornutus*, beyond its inferior size. The coracoid is a compressed tubercle inclosing a groove with the glenoid cavity.

Measurements.

	M.
Diameter glenoid cavity, (longitudinal)	0.168
Diameter glenoid cavity, (transverse)	.098

The *os pubis* displays a strong pectineal rugosity, commencing near the acetabulum.

Measurements.

	M.
Long diameter of acetabulum	0.143
Length common pubic suture	.108
Diameter pubis, near acetabulum	.052

The *femur* is nearly as long as that of *Loxolophodon cornutus*, but is more slender, and has a relatively smaller head. It is flattened fore and aft, and the great trochanter is much expanded and with a shallow concavity on the posterior face. There is a marked concavity on the posterior face of the shaft above the condyles. There is a rudiment of the little trochanter. The *tibia* is scarcely three-fourths the length of the femur, and has a rather contracted shaft, which is in section rounded triangular, one angle presenting forward. There is no spine except a rudiment in the swollen upper portion of the anterior ridge. The articular surfaces are together rather narrowly transverse. They are separated by a keel which is undivided posteriorly; anteriorly, the contiguous margins of the cotyli separate. The long axis of the inner of these is directed antero-posteriorly outward in front; of the other, similar but much more transverse. It overhangs the shaft outward and backward, and supports beneath, the sub-round down-looking fibular articular surface. The distal articular surface is distinguished from allied species by the downward prominence of the malleolar process, the antero-posterior width, and the greater extent of the fibular articular face. The face is slightly concave antero-posteriorly, and openly sigmoidal transversely.

Measurements of leg.

	M.
Length with astragalus in place	1.200
Femur, length	.750
Femur, diameter ball	.118
Femur, width at great trochanter	.220
Femur, width at middle shaft	.091
Femur, depth at middle shaft	.060
Tibia, length	.470
Tibia, width proximal surfaces, (transverse)	.147
Tibia, width proximal surfaces, (antero-posterior)	.070
Tibia, transverse diameter shaft	.061
Tibia, antero-posterior diameter shaft	.065
Tibia, antero-posterior diameter shaft, distal articulation	.092
Tibia, transverse diameter shaft, distal articulation	.121
Fibula, length	.430

Measurements.

	M.
Fibula, transverse width at middle	.032
Fibula, width proximal articular face	.042
Fibula, width malleolar articular face, (transverse)	.052
Fibula, width malleolar articular face, (longitudinal)	.044

A section of the fibula, near the proximal end, is sub-triangular; a short distance below, sub-circular; on the distal two-thirds it is flat, with the thinner edge convex inward.

The *astragalus* is a flat bone, with its entire superior face occupied by the tibial articular surface. This is as broad as long, and very little convex. It is broader in front than behind; the outer margin is concave, the inner slightly convex. The posterior margin projects most on the outer side, and it is divided by a pit-like cavity, which sends a groove to the inner margin. The outer malleolar surface is an antero-posterior oval; the inner, a concavity, beyond which the inferior portion of the bone projects. The inferior face is divided by a prominent transverse angle, between sub-anterior and sub-posterior faces. The latter receives the calcaneum on two oval surfaces, which are joined behind by a narrow strip. The navicular face is sub-rhomboid, the cuboid one-third as large, and triangular, with a round base outward. The margin of the former scarcely projects beyond the superior face.

Measurements of astragalus.

	M.
Total width	0.128
Total length	.107
Width tibial face in front	.090
Length tibial face, externally	.068
Length internal malleolar face	.045
Length outer calcaneal, malleolar face, antero-posteriorly	.050
Length navicular facet	.085
Width navicular facet, (antero-posterior)	.060
Length cuboid facet	.065
Width cuboid facet, (antero-posterior)	.035

A *cuneiform* belonging to the individual mentioned first, has been already described.

Measurements of cuneiform.

	M.
Depth in front	.047
Width, (transverse)	.095
Width of internal facet	.038
Width of second	.027
Width of third	.043
Width of external	.026

A distal end of a humerus was found with two astragali about 100 yards from the last individual. The articular face is very oblique to the transverse axis, but is about equally developed on opposite sides of the shaft. The condyles are unequal, have parallel axes, and are separated by but a shallow concavity. The fossæ of opposite sides are not very large nor deep.

Measurements of humerus.

	M.
Transverse diameter, distally	.175
Transverse of inner condyle	.104
Transverse of outer condyle	.125
Transverse diameter, olecranon	.110

The portion of *ulna* just measured belongs to the individual of which so many fragments were found, or No. 2.

The dorsal *vertebræ* of the same are somewhat distorted by pressure; I will therefore describe a cervical of natural form. The centrum is very short, and the articular face is a wide, transverse oval. Both are slightly concave, and the axis being slightly oblique, the anterior is the more elevated. The surface of the latter is quite rugose, except on the margins. The cervical canal is wide, and the neurapophyses and parapophyses narrow. Inferior surface regularly convex.

Measurements of cervical vertebra.

	M.
Length centrum	.044
Length basis neurapophysis	.040
Length anterior articular face	.102
Depth anterior articular face	.086
Width neural canal at base	.060

Relations.—Besides the difference in the development of the anterior nasal tuberosities, which might be sexual only, this species differs from *L. cornutus* in the simple naso-maxillary horn-cores, which want the interior tuberosity of that species, and in the fact that they are composed exclusively on their inner sides of the nasal bones to the apex, the maxillaries forming the outer face. *E. pressicornis* has also a much wider and less massive supraoccipital basin, with lighter horn-cores, if present. Minor differences have been already mentioned.

The measurements given by Marsh for his *Titanotherium* (?) *anceps* (later *Tinoceras anceps*) are considerably smaller than those of corresponding parts of *Eobasileus pressicornis*, but represent more nearly a species of the size of *Uintatherium robustum*. When the species is sufficiently described, we shall be able to determine to which of the genera it should properly be referred.

Restoration.—The elevation of this animal was not much less than that of the *Loxolophodon cornutus*, but the proportions were more slender; as in all the species of *Uintatherium* in which the horns are known, these appendages stood in front of the orbits, and nearer the nareal opening than in the type of the former genus. The muzzle, too, is materially shorter and more contracted, and the true apex of the muzzle was not overhung by the great cornices seen in *Loxolophodon*. The horn-sheaths were probably simple, while in *L. cornutus* they were probably palmate. The occipital and parietal crests are much more extended in this species than in the *L. cornutus*, so that in life the snout and muzzle had not such a preponderance of proportion as in that species. All the species of this genus were rather more rhinocerotic in the proportions of the head, although the horns and tusks produced a very different physiognomy. The extremities of the nasal bones, though not excavated as in that species, are strongly pitted and exostosed, and this, taken in connection with the elevation of the head, renders it probable that this species also possessed a proboscis.

History.—This species was originally described by the writer in a short paper, which was published and distributed August 19, 1872, under the generic name *Loxolophodon*. I shortly afterward referred it to the new genus *Eobasileus*, under the name *cornutus*, under the impression that it was the same as the *Loxolophodon cornutus;* but finding this was not the case, I again used the specific name here adopted.

EOBASILEUS FURCATUS, Cope.

Loxolophodon bifurcatus, Cope, in extra copies on Proboscidians of the Eocene of Wyoming, August 19, 1872.* *Loxolophodon furcatus* in the same, Proceedings American Philosophical Society, 1872, p. 580, *separata*, Aug. 20. L. c. 488, August 22.

This species was originally described from a large horn-core whose extremital part resembles strongly the nasal shovel of *Eobasileus cornutus*, on which account I referred it to that position on the skull. Marsh has described somewhat similar horn-cores from the lateral crests of the skull behind in *U. mirabile*, whence it may be that my specimen is referable to that position, although it differs much from those of that species.

The basis is very narrow and lenticular; a short distance above it the outer side is convex. The anterior and posterior extensions of the base differ; the one is thinner, the other more massive and with a shallow groove above its commencement. The latter may be posterior. If so, the compressed apex of the horn-core sends down a rib outwardly to the anterior and one inwardly, which disappears on the convex base. The general form is spatulate with the apex expanded obliquely across the lateral crest, and regularly rounded in superior outline. Its anterior face is flat, the posterior convex; its surface is grooved by very small blood-vessels.

As compared with the posterior horn-core of *Loxolophodon cornutus*, there is every difference. That is continuous with one margin of the crest, this erect above it; that has a round base, this a lenticular one. It is more like that of *U. mirabile*, which I only know from Marsh's figure, but abundantly distinct. It is much more elongate, especially above the (?) posterior part of the crest, and is flattened, and without the triangular section of that species.

Measurements of horn-core.

	M.
The total length above crest, (5.5 inches)	0.135
The total length above base, (7¼ inches)	.180
Width across apex, (in front)	.095
Thickness across apex, (in front)	.028
Thickness at base	.040

It is not certain that this horn may not belong to the *E. pressicornis*, if it be a posterior core, of which, however, I am not yet sure. In that case the name *furcatus*, under which it was first described, becomes a synonym of *E. pressicornis*.

UINTATHERIUM, Leidy.

Proceedings Academy Natural Sciences, Philadelphia, 1872, p. 169, (published August 1st.) *Uintamastix*, Leidy, loc. cit., *Dinoceras*, Marsh, Amer. Journ. Sci. Arts, 1872. October, 1872, (published September 27.)

This genus resembles the last in its general proportions, but differs in its more elongate cervical vertebræ. The centra of these are flat at both extremities, but have not such a marked elephantine abbreviation as seen in the two genera above described. This enabled the head to approach the ground more nearly, and as the limbs were shorter in some of the species, they no doubt modified the length of the proboscis, if present.

Several names have been applied to this genus. Professor Leidy's name, here employed, bears date early in August. Under date of September 27th, Professor Marsh proposed the name *Dinoceras* (American Journal Science Arts, 1872) for the *U. mirabile*, but did not give his

*See Proceedings American Philosophical Society, 1872, p. 515, where this name is recorded.

reasons for separating it from his *Tinoceras*, (the names of the two bear an objectionable resemblance,) or those published by Dr. Leidy or myself. As it is evidently synonymous with *Uintatherium*, I include it here, as is done by Dr. Leidy.

I am acquainted, by autopsy, with two species of this genus. None of them are so large as the *Eobasileus pressicornis*. *U. robustum*, Leidy, is smaller, and the *U. lacustre*, Marsh, smaller still. *U. mirabile*, (*Dinoceras*,) Marsh, is about the size of the *U. robustum*, and nearly allied to it; but it may be distinct, as it wants a tubercle on the last molar. I therefore retain three species, as follows: *Uintatherium robustum*, Leidy; *U. mirabile*, Marsh; *U. lacustre*, Marsh. For convenience I compare these species with those of *Eobasileus*.

The naso-maxillary horn-cores have been seen in *E. pressicornis* and *U. mirabile*, and the nasal tubercles in the same. The posterior horn-cores are known in the *U. mirabile*. The posterior and lateral crests of the cranium inclose a basin-shaped concavity above in all these species; it has been observed in all but *E. furcatus*. The dentition is similar to that in *Loxolophodon*, *i. e.*, I. 0; C. 1; P. M. 4; M. 2. The first premolar in *U. lacustre* has an internal cone and outer concave crest. The worn surfaces of the other teeth in that species, *U. robustum* and *U. mirabile*, are narrow ovate, with a deep exterior emargination. The true molars support two crests, which converge inwards and unite: there is a small tubercle behind the apex in *U. lacustre* and *U. robustum*. The tusk is long, compressed, and double-edged, as in *Loxolophodon*. The last inferior molar in *U. robustum* possesses three transverse crests, the posterior two parallel, and obliquely directed inwards toward the axis of the anterior, which is the highest.

In a specimen of one of the smaller species, the *ulna* widens considerably distally, being nearly as wide as the much expanded olecranon. The latter is large, flattened, and subtransverse, and presents a sharp ridge internally. On the inner side of the distal part of the articular face for the humerus is a tubercle, from which a short, wide groove runs out on the inner face of the bone. The head of the radius is a little exterior to the middle line, and the shaft crosses the ulna in an open, shallow groove, to the inner side.

The *cuboid* is flat, and displays two proximal and two distal articular facets in *U. furcatum*. The astragalus of the same species is subbifurcate posteriorly, and has internally an extensive oblique malleolar fossa. The *calcaneum* is short and massive, with two superior and one small anterior articular facet.

The species may be thus distinguished:

1. Large species, (occipital condyles extending over about 0m.170 :)

Naso-maxillary horns long; tibia with wide articular faces .... *E. pressicornis.*

Horn-cores flat, elevated .... *E. furcatus.*

2. Species of intermediate size :

Molars smaller, with an additional tubercle on the last. *U. robustum.*

Last molar without additional tubercle, (Marsh ;) maxillary horn-cores low, triangular ; posterior horn-cores short, triangular in section .... *U. mirabile.*

3. Smallest species, (occipital condyles extending over about 0m.095 :)

Molar teeth larger, the last with a posterior expansion. *U. lacustre.*

Previous to describing the species I notice a part of the skeleton of a large mammal, second only in bulk to *Loxolophodon* and *Eobasileus* above described.

These remains, which were not found in association with a cranium, consist of several vertebræ, some carpal bones, and the entire hind limb of the left side except the toes and the cuneiform and navicular bones.

The odontoid process is very stout, with a descending trihedral apex. Length M. .078; diameter at base, .048. A dorsal vertebra, with a single (anterior) capitular articular face, is quite concave in front.

Measurements.

	M.
Diameter antero-posteriorly	.057
Diameter vertically	.094

A cervical vertebra has the proportions of the dorsal as to its centrum, thus differing materially from species previously described. The articular surfaces are slightly concave.

Measurements.

	M.
Length (antero-posteriorly)	0.065
Diameter, vertical	.087
Diameter, transverse	.100

The *femur* resembles that of the other species already described, but is remarkable for the relatively small size of the head. While the lengths of the bone are not very different, and the expanse of the great trochanter about the same, the head of *L. cornutus* is large, the present one is very much smaller, and that of *E. pressicornis* intermediate. There is a rudimental third trochanter, and the condyles are as large as, and similar to, those of *E. pressicornis*. The external marginal condylar ridge is quite short. The shaft is broken and some small pieces lost; it is now 26 inches long, but was no doubt longer when complete.

Measurements of femur.

	M.
Expanse of great trochanter	0.230
Diameter of head	.109
Diameter of shaft at middle	.093
Diameter above condyles	.152
Diameter at extremity of condyles	.139
Diameter (vertical) of inner condyle	.125

The *tibia* is perfectly preserved. It is short and stout, and with massive extremities. The outer basal part of the spine remains and is prominent. The cotyli are not oblique; the inner is sub-round, the outer transverse, widening outwardly; their long axes are at right angles to each other. The crest is a low ridge of contact of the cotyli. The superior fibular face is a transverse oval; the inferior much smaller than in *E. pressicornis*. The shaft is contracted, and flattened behind and on the inner side. The distal extremity is transverse, less truncated for the fibula than in *E. pressicornis*, less convex behind, and with a less prominent external malleolus. The point dividing the astragalus behind is more prominent.

Measurements of tibia.

	M.
Total length	0.398
Diameter head longitudinal	.080
Diameter head transverse	.138
Diameter shaft transverse	.063
Diameter do. antero-posterior	.060
Diameter distal articulation antero-posterior	.077
Diameter distal articulation transverse	.113
Diameter distal extremity, fore and aft	.093
Diameter distal extremity, transverse	.125

These measurements show that this bone is considerably shorter than in *E. pressicornis*, though of equal distal diameter. In both species the measurements considerably exceed those given by Marsh for his *Titanotherium* (?) *anceps*. The form of the articular extremities in this animal differs from both in being more narrowed and transverse.

The *fibula* is larger proximally and smaller distally than in *E. pressicornis*. Diameter proximal articular face .039; of the distal .045.

The *astragalus* is similar in size and form to that of *E. pressicornis*, but differs in two points. The posterior margin is deeply incised for the ligamentous insertion, and the outer lobe is clearly cut to this fossa, on the inner side. There is a pit for a ligament on the convexity of the inner part of the middle of the tibial articular face. A third difference is seen on the inferior face. The inner calcaneal facet is longer and narrower, and is margined on the inner side by a large fossa parallel to its axis, which is wanting in the other species. The *calcaneum* is short and wide; its only anterior articulation is with the cuboid and is small. The heel is deeper than long, and is obliquely truncate downwards and inwards.

Measurements of calcaneum.

	M.
Length	0.105
Width	.092
Depth in front	.056
Length heel	.047
Depth heel	.055
Length cuboid facet	.038

The *cuboid* is a flat sub-triangular bone with two unequal articular faces below.

Measurements.

	M.
Length	0.064
Width	.076
Depth	.031
Length cuneiform, (antero-posterior)	.040
Depth cuneiform	.017

The *humerus* of a third specimen may or may not belong to this species. It was found in another locality. Its condyles are much less oblique than in that one described under *E. pressicornis*. The olecranar fossa is shallower. It belonged to a larger animal.

Measurements of humerus.

	M.
Transverse diameter distally, (7.75 inches)	0.195
Transverse diameter, inner condyle	.125

Remarks.—The remains were discovered by the writer in the Bridger Bad Lands, on South Fork of Bitter Creek, Wyoming.

UINTATHERIUM ROBUSTUM, Leidy.

Proceedings Academy Natural Sciences, Philadelphia, 1872, p. 169, August. *Uintamastix atrox*, Leidy, l. c.

I have been able to examine, through the kindness of Professor Leidy, the type of his description, and find it to belong to a smaller species than any of those above described. The lateral parietal and supraoccipital crests are well developed, and the latter extends obliquely backwards. Several peculiarities are to be observed in the dentition.

Thus there is a great inequality in the height of the transverse crests of the posterior upper molar, the anterior, or the arched one, rising to a high cusp at its outer extremity. A small tubercle exists on the side of the inner angle of the grinding surface in the penultimate molar. The same angle is much elevated in an anterior molar. The canine is wider distally than in *L. cornutus*, and less recurved. The mastoid process is quite prominent. The humerus has a prominent internal condyloid ridge and tuberosity, and the condyles are not very oblique. The inner posterior lobe of the tibial face of the astragalus is quite well defined; there is no median ligamentous pit on the trochlear face.

Measurements, (from Leidy.)

	Inches.
Depth lower jaw at last molar	3.25
Length humerus, about	21.00
Diameter at condyles	7.50

Found by Dr. J. V. Carter and Dr. Leidy, near Fort Bridger, Wyoming.

Dr. Leidy has suggested with some reason that this species and the *Dinoceras mirabilis* of Marsh are identical.

UINTATHERIUM MIRABILE, Marsh.

Dinoceras mirabilis, Marsh, Amer. Journ. Sci. Arts, 1872, October, (published Sept. 27.) *Loc. cit.*, Jan. 28, 1873.

The cranium of this species has been partially described as above cited, and figures in the last-named paper largely supply the deficiency. From this it is evident that it differs from *Loxolophodon cornutus* in the generic characters already mentioned, and, further, in the anterior position of the naso-maxillary horns, the perforation of the lachrymal, the anterior development of the malar, the oblique occiput, &c. It differs from the *E. pressicornis*, besides the inferior size, in the shorter nasal bones and greater posterior approach of the premaxillary bones to the base of the horns; in the much shorter horns and greatly smaller part taken in their composition by the nasals.

These differences account for the great number of errors committed by Professor Marsh in his allusions to other species, especially *Loxolophodon cornutus* described by me, (see his second article above quoted.) According to Marsh this species differs from *U. robustum* in the absence of a small tubercle on the last molar, and presence of one on the penultimate molar.

Measurements, (from Marsh.)

	M.
Length of cranium, (28.5 inches)	0.722
Width over orbits	.202
Width between summits naso-maxillary cores	.169
Width between summits nasao-maxillary cores	.038
Height naso-maxillary cores, (3 inches)	.075
Length canine (9.25 inches) below jaw	.232
Diameter fore and aft at base	.064
Diameter transverse at base	.025
Length of molar series	.150
Last superior molar series	.036

UNITATHERIUM LACUSTRE, Marsh.

Dinoceras lacustris, Marsh, l. c. October, 1872, (Published September 27, 1872.)

I have several of the teeth and the occipital, parietal, and other portions of the cranium of this species. It is distinguished from its congeners, apart from its smaller size, by the large size of the teeth. These are nearly as large as those of *Loxolophodon cornutus*, and considerably larger than those of *U. robustum* and *U. mirabile.* The occipital condyles are not larger than those of the elk, *Cervus canadensis.* The mastoid protuberance is prominent, and the post-glenoid process more produced downwards and with less fore and aft diameter than in the other two species. The inferior temporal ridge is strongly marked, and the posterior condyloid foramen is large.

The posterior molar has a wide floor extending from the posterior or straight transverse crest to the cingulum. This crest is low, and has a low tubercle near its apex behind. The other molars have strong fore and aft cingula, but none at ends. The worn surfaces are first V-shaped, ater arrow-shaped. The first premolar has a curved outer crest and inner conic tubercle.

Measurements.

	M.
Diameter of occipital foramen and condyles	0.092
From exterior end condyle to mastoid	.058
From exterior end condyle to post-glenoid process	.080
Transverse diameter last upper molar	.045
Transverse diameter third premolar	.029
Length molar series	.163

Found by the writer in the Bridger formation of South Bitter Creek, Wyoming.

MEGACERATOPS, Leidy.

Proceedings Academy Natural Sciences, 1870, p. 1. Hayden's Geological Survey, Wyoming, 1872, p. 352, ("*Megacerops.*")

This genus is only known from the extremity of the nasal bones bearing the horn-cores. The latter are intermediate in position to the nasal and naso-maxillary horns of *Eobasileus*, &c., and may represent the median pair, in which case the diagnosis of the genus should be nasal horn-cores wanting.

The genus was originally regarded by Dr. Leidy as allied to *Sivatherium*, and therefore ruminant; he also supposed that it possessed a proboscis "as in the tapir." The latter proposition has much in its favor, especially as the affinities of the genus are evidently with the *Proboscidia.*

MEGACERATOPS COLORADOENSIS, Leidy.

Megacerops coloradoensis, Leidy, l. c.

The part of this species preserved indicates an animal of the size of the largest *Unitatheria.* The nasal bones are co-ossified, and the horn-cores are sub-cylindric, obtuse, and about two inches in length. They are situated above a point a little behind the anterior nares.

BATHMODONTIDÆ.

As already pointed out, the structure of the limbs and feet in this suborder is as in the order generally, and the scapula has the same form in general. The symphysis mandibuli is furnished with teeth, and forms a long solid spout. The astragalus has a very peculiar form, being even more exceptional than in *Uintatherium.* The superior articular surface is flat or concave in the middle. It is turned inward in front of the articular face for the inner malleolus, terminating in a long point. The cuboid articular face is quite small and sublateral, and sessile like the navicular. The fibular facet is extensive, and the internal lateral well marked.

On the other hand the coracoid process is produced into a curved hook, and is thus more largely developed than in other Proboscidians or Perissodactyles. The neck is longer than in the other Proboscidians, and the parietal bones appear to be narrowed by the approximation of the temporal fossa, as in the *Rhinoceros*. Almost nothing, however, is known of the structure of the skull.

The genera are two, as follows:

Penultimate molar unlike the last, with external crescent and embracing ledge .... *Bathmodon.*
Three molars alike, with two transverse crests not meeting within .... *Metalophodon.*

BATHMODON, Cope.

Proceedings American Philosophical Society, 1872, p. 417.

This genus was originally chiefly distinguished by the dentition; at present many other important peculiarities are added. First, as regards the molar teeth; the two transverse crests I find to be separated (not united) at their inner extremities, by a narrow fissure. The anterior is much the longer, and is curved; its anterior wall slopes steeply down to the narrow cingulum. The posterior is short and straight, and bears a crest. The numbers are I. 3; C. 1; P. M. 4; M.? 3.

The entire mandible presents the following dentition: I. 3; C. 1; P. M. 4; M. 3. The incisors radiate around the narrow extremity of the trough-like symphysis, and have transversely expanded crowns. The canine is inclined forward, and forms part of the same series. Its crown is triangular in section, the outer face convex. In the males it was enormously enlarged, as indicated by a symphysis in my possession. The anterior premolar approached the canine. The former teeth have an external chevron directed inward, whose extero-superior surface of enamel is acute cordate. Besides this is a little longitudinal ridge, which represents another chevron of the true molars. On the first of the latter, both chevrons are developed, the posterior the least, both with their anterior ridge boundaries lowered; they sink entirely on the last two molars, which become thus two-crested, as in those of some Tapiroids and the premolars of *Dinotherium.*

The sternal segments are cylindric; in one the articulations for the hæmpophyses project laterally, giving the piece a T-shaped form. The atlas has a flat diaparapophysis, presenting its edges fore and aft; the arterial canal traverses it obliquely. The coracoid is double, having a tuberosity on the edge of the glenoid cavity, and a prominent hook just outside of it. The lumbar vertebræ are quite short. The cuneiform bone is narrow pyriform, with two triangular facets on one side, the smaller being sublateral; and one twisted over the other. The ungueal phalanges are very short, somewhat flattened, and with the terminal portion transverse and rugose as in some toes of *Elephas.*

In the remains pertaining to this genus obtained by Dr. Hayden, there are numerous individuals of apparently three species. Two of these are larger and one smaller, the latter in part indicated by an individual without epiphyses on the lumbar vertebræ. It presents marked difference in the form of the astragalus atlas, scapula, &c.

a Larger species:

Astragalus everted in front; nearly as wide as long; lower premolars narrower, more elevated, and rugose.. *B. radians.*

Lower premolar broad, lower, and smooth............... *B. semicinctus.*

aa Smaller species:

Astragalus much wider than long, decurved in front....... *B. latipes.*

BATHMODON RADIANS, Cope.

Proceedings American Philosophical Society, 1872, (February 16,) p. 418. Hayden's Geological Survey of Montana, 1871, p. 350.

In addition to the characters already assigned to these species as above cited, I add the following:

The apex of the *scapula* is a massive flattened acumination with truncate extremity. The spine is elevated and truncate next the glenoid cavity, which is a wide oval, much produced at the coracoid margin. The transverse process of the *atlas* is rounded distally, and is about as long as wide; the surface for the axis is directed obliquely inward. The *fibula* has the inner sharp edge prolonged to the proximal end; the form of the latter is much as in *Eobasileus*. The *astragalus* is slightly concave in both directions on the trochlear face, most so antero-posteriorly. The anterior outline of the same is strongly and obliquely convex, and the surface is produced sideways into a latero-anterior apex. The inner malleolar border is thus very concave; the outer is gently convex with a long fibular facet. The posterior margin concave, the inner tuberosity prominent. The *navicular* facet is as broad as long, and nearly sessile, being probably separated by a groove from the tibial. The cuboid facet is subround, small, and sublateral; the calcaneal situated diagonally opposite each other. The antero-internal is twice as large as the other, is transverse and truncate internally by a facet near the apex, at right angles. The other calcaneal facet is subround.

Measurements.

	M.
Length ramus mandibuli to anterior margin of coronoid process	0.310
Length premolars and molars	.218
Length last molar crown	.040
Width last molar crown	.030
Width last premolar crown	.018
Length last premolar	.025
Width symphysis at canines	.045
Diameter canines ♂	.028
Diameter canines ♀	.023
Length exposed portion incisor 2	.026
Width crown incisor 2	.0245
Length diapophysis atlas	.047
Width diapophysis atlas	.056
Width facet for axis	.053
Width glenoid cavity scapula, (straight)	.086
Length coracoid from inner basis	.045
Length proximal articulation fibula	.027
Length distal articulation fibula	.042
Diameter shaft fibula	.042
Total length astragalus, (fore and aft)	.072
Total width astragalus	.065
Length navicular facet	.045
Width navicular facet	.034
Width cuboid facet	.025
Length cuboid facet	.023
Length anterior calcaneal facet	.040
Width anterior calcaneal ..do	.024
Length posterior calcaneal..do	.021
Length fibular, ...do...(axial)	.043

The teeth are slightly rugose, and the inferior canines show a tendency to imitate the form of the incisors in a slight basal angular expansion of the crown. This forms an approximation to the tapirs. The middle pair of incisors is directed outward, is the smallest, and, like all the others, has the roots much exposed.

This species was originally described from teeth of the upper jaw. I have since obtained the entire mandible (except the angles) taken out at the same place and near the same time. The size, color, &c., would indicate that they belong to the same individual. Accompanying the first specimens were many bones of individuals of different sizes, which I learn from the finder were all taken from within a short distance of each other. Many of them belong to the same species, as the jaws and teeth, and I have described as such those that relate properly to them as to size, mineral appearance, &c.

The smaller specimens belong also to several individuals, and possibly to more than one species. I describe them together, but regard the astragalus as the primarily distinctive bone.

BATHMODON SEMICINCTUS, Cope.

Proceedings American Philosophical Society, 1872, p. 420. *Loxolophodon semicinctus*, Cope l. c.

The tooth on which this species was based shows a near relation to the corresponding one of *B. radians*.

BATHMODON LATIPES, Cope.

Proceedings American Philosophical Society, 1873, March.

Established on atlas axis, dorsal and lumbar vertebræ, scapula, humerus, phalange, femur, astragali, &c., of a specimen found with the *B. radians*.

The transverse process of the atlas is stouter and less flattened at the base than in *B. radians*. The axis is but little oblique, and has a low, obtuse hypapophysis below. Its form is much as in the larger species, being rather elongate, but shorter than in *Rhinocerus* and other Perissodactyles. The dorsals and lumbars are short and plane; the former are obtusely, the latter acutely, keeled below. The head of the femur has no ligamentous fossa. The astragalus is considerably broader than long, the apex turned outward in front of the inner malleolus, being especially produced. The tibial face is concave transversely, and convex anteroposteriorly at the front, plane behind. There is a posterior submarginal foramen, which is not bridged over in one specimen, producing a deep notch. The navicular facet has considerable transverse extent, and the anterior side of the bone is more transverse than in *B. radians*. The calcaneal facets are diagonally opposite to each other; the outer is subround, the inner anterior narrow and transverse. It differs in the two specimens, the perforating foramen not being bridged over in the one (the type) with the similar posterior interruption described above. This may be due to fracture. The only ungueal phalange has the articular face not quite sessile on the transverse rugose free extremity.

Measurements.

	M.
Diameter diapophysis atlas, (fore and aft)	0.036
Diameter axial facet of atlas	.034
Diameter centrum axis, (transverse)	.080
Diameter centrum axis, (vertical)	.037

		M.
Length centrum axis to odontoid		.057
Width neural canal do		.030
Diameter of centrum of dorsal	fore and aft	.040
	vertical, (total)	.043
	transverse	.059
Diameter neural arch of same	vertical	.018
	transverse	.032
Diameter centrum of lumbar	anterior-posterior	.041
	vertical, (total)	.050
	transverse	.063
Diameter head of femur		.060
Length astragalus fore and aft		.050
Width astragalus		.065
Length navicular facet		.049
Width navicular facet		.020
Width cuboid facet		.018
Length cuboid facet		.016
Width (fore and aft) anterior calcaneal		.018
Length posterior calcaneal facet		.022
Length fibular, (axial)		.041
Length terminal phalange		.012
Width do. proximally		.015
Width distally		.030
Diameter glenoid cavity scapula	vertical	.051
	transverse	.080

From the beds of the Green River epoch near Evanston, Utah,.(now Wyoming.)

METALOPHODON, Cope.

Proceedings American Philosophical Society, 1872, p. 542. (Published September 20.)

In distinguishing this genus from *Bathmodon*, I stated that the differences were in the dentition so far as known; *i. e.*, that the crests of the true molars are not united internally and that the premolars are two (not three) crested. I would now add to the characters, that there are three molars on each side, with transverse crests, which do not unite at the apex, except in the case of the anterior, when they are slightly connected. In *Bathmodon* there is but one such tooth, the posterior. The inner or third crest of the posterior premolar of that genus is only a cingulum, and is not probably a generic character.

METALOPHODON ARMATUS, Cope. Loc. cit.

This species is represented by the greater part of the dental series of both jaws, which I took from a decayed cranium myself, and can thus be assured of their mutual relations. One of the true molars, at least, belonged to the milk series, as indicated by the unworn crowns of the successional teeth accompanying. Some of the premolars are but little worn.

The *incisors* are well developed, those of the premaxillary subequal in size. The crown has a convex cutting edge and flat inner face. The outer face is convex. In some the inner face is more concave, and is bounded by a cingulum next the root.

The *premolars* present a single external crescent of acuminate outline, and a smaller, more transverse one, within. A cingulum bounds the crown fore and aft, but is wanting at both base and apex of the triangular base. In the more posterior the crescent is more open, and the crown less transverse.

The *molars* present an increase in transverse extent of the external crescent, and the interior one is wanting. In the posterior two the anterior ridge curves round at the apex of the <, but is separated by a considerable interruption from the posterior. The latter is shortened, and terminates externally in a conic tubercle, which approaches the outer extremity of the anterior ridge. In the last molar the posterior ridge is shorter, nearly straight, terminating at a cone at each extremity.

The *canine* is damaged, but was of large size, amounting in one or the other of the jaws to a tusk. The probably superior is compressed, with acute edges. The inner face gently convex, the outer more strongly so, with an acute ridge on its anterior convexity, inclosing an open groove, with the interior cutting edge. This surface of the dentine, when exposed, has a transversely wrinkled character, but no trace of "engine-turning" in the fractures.

In the *mandible*, premolar and molar teeth are recognizable; the character of the incisors remaining uncertain. As usual in the ungulates they possess a relatively smaller transverse diameter than do the corresponding teeth of the maxillary. They change very materially in form from the front to the terminus of the series, and, in connection with the superior molars, are very instructive as to the generic connection of different types of dentition.

The peculiarity of the *premolars* consists in the fact that, besides the single external crescent exhibited by those of the upper jaw, they have a rudimental second one in the position it should occupy in corresponding teeth of Palæosyops. The inner border of the crown is convex, and extends from apex to apex of the crescents. There are no cingula to these teeth. The rudimental crescent diminishes anteriorly, its angle becoming first obtuse, and then disappearing. Posteriorly the reverse process takes place, and proportions increase. But in the last molars they do not assume the proportions seen in *Palæotherium* and allied forms. They increase in the elevation of corresponding ridges of the crescents and decrease in the others, so that the resultant form is nearly like that of *Dinotherium* or perhaps *Lophiodon*. The outer ridge of one crescent appears as a cingulum, which sinks to the base of the crown from the apex. This is rudimental in the genera just mentioned. The corresponding bounding ridge of the other crescent is reduced to a rudiment extending diagonally across the valley between the remaining crests, as is seen in not a few genera of the Eocene.

Measurements of the teeth.

	M.
Total length of superior incisor	.057
Length crown (inner face) superior incisor	.015
Width crown (oblique) superior incisor	.020
Width crown (oblique) inferior incisor	.023
Length crown (inner face) superior incisor	.018
Width canine .030 from tip	.020
Width posterior molar	.039
Length posterior molar	.028
Elevation posterior crest do	.016
Width anterior true molar	.035
Width premolar	.028
Length premolar	.0215
Length premolar, (first)	.016
Width premolar, (first)	.008
Length premolar, (inferior)	.024
Width premolar, (inferior)	.020
Width penultimate lower molar	.023
Length penultimate lower molar	.037

In comparison with *Bathmodon semicinctus*, Cope, the crowns of the premolars are of similar size, but more elevated.

This large ungulate was found in a stratum below those of the Green River group of Hayden, or in the lower beds of that series, near Black Buttes, Wyoming.

It is not certain that the last-named species of *Bathmodon* does not belong to this genus. All three are distinct from the *M. armatus*, the latter, though young, being considerably larger than *Bathmodon latipes*.

PERISSODACTYLA.

PALÆOSYOPS, Leidy.

Hayden's Geological Survey of Montana, 1871, page 358; (?) Proceedings Academy Natural Sciences, Philadelphia, 1871, p. 118. *Limnohyus* Marsh, American Journal Science and Arts, 1872, p. 124.

This genus has been partially described by Professor Leidy, and much light is thrown on its structure by the materials obtained by the survey of 1872. As pointed out by Leidy, this genus differs from *Palæotherium* in the isolation of the internal cones of the superior molars from the external longitudinal crescentoid crests, and in the presence of but one inner tubercle on the last three premolars instead of two. There is but one internal cone on the last superior molar. Number I. 3, C. 1, P. M. 4, M. 3. Number of inferior molars similar; true molars, with four acute tubercles alternating in pairs and connected by oblique crests, which thus form two V's, with their apices exterior. The last molar adds a fifth posterior tubercle. The last premolar lacks the posterior inner tubercle. The second and third have but one, the outer series of tubercles,—and the first is compressed. The canines are separated by a slight interval from the premolars, and are in continuity with the incisors.

The dental characters are generically identical with those of *Titanotherium*, Leidy, which must be referred to the *Perissodactyla*, and not to the *Artiodactyla*, as left by Leidy in the "Extinct Mammalian Fauna of Dakota and Nebraska," though originally referred by him to this order.

The species originally named by Leidy *Palæosyops paludosus* belongs to the succeeding genus, *Limnohyus*, Leidy. He afterward included species of the present genus in it, and in so doing first characterized the genus. Hence I agree with him in retaining the generic name for the latter, and not the former, as is done by Marsh. The original form was not characterized generically, a brief specific description only being given.

PALÆOSYOPS LÆVIDENS, Cope.

Limnohyus lævidens, Cope; Proceedings American Philosophical Society, 1873; published January 31. *Palæosyops paludosus*, Leidy; Hayden's Survey of Montana, 1871, p. 359, not Proceedings Academy Natural Sciences, Philadelphia, 1870, p. 113.

A species about the size of the *Anoplotherium commune*, Cuv., and intermediate between the *Palæotherium magnum* and *P. medium*. It is considerably larger than the existing tapirs, and was one of the most abundant of the quadrupeds of the Eocene of North America.

It is chiefly represented by a nearly complete cranium with dentition, from Bitter Creek, and a cranium lacking the posterior part of one side and the lower jaw, from Cottonwood Creek. The molars have the general form of those of *L. robustus*, but the second superior premolar has but one outer tubercle. The cingula are much less developed than in that species; those between the inner cones of the molars being entirely absent. These cones are low, and, with the rest of the crowns of all the teeth, covered with smooth and shining enamel. The anterior median small tubercle of the first true molar is wanting. The last true molar has but one interior cone.

The canine tooth is powerful and bear-like; the outer incisor is the largest. The premaxillary bones are short, and the side of the face elevated and plane to the convex nasal bones. The nasal bones are long, narrow, and convex. Zygomatic arch massive.

Measurements.

	M.
Length molar series, (No. 1)	0.140
Length true molars	.085
Length three incisors	.034
Length crown canine	.030
Length crown last molar	.039
Width crown last molar	.036
Length cranium to occipital crest	.345
Length true molars, (No. 2)	.101
Length last molars, (No. 2,) (oblique)	.039
Width last molars, (No. 2,) (transverse)	.038

PALÆOSYOPS MAJOR, Leidy.

Survey of Wyoming, 1871, p. 359. *Limnohyus robustus*, Marsh, Amer. Journ. Science and Arts, 1872, p. 124.

Numerous specimens from Cottonwood Creek, Black's Fork, Bitter Creek, &c.

PALÆOSYOPS VALLIDENS, Cope.

Proceed. Amer. Philos. Society, 1872, p. 487, published August 22, 1872.

Represented by the dentition of one maxillary bone with other bones of one individual; a portion of the same dentition of a second; with both rami of the mandible, with complete dentition, of a third. The species is distinguished by the details of the dental structure, and by the superior size. It exceeds, in this respect, the *Palæosyops major*, Leidy; while the three posterior lower molars measure 4.25 inches in length, the same teeth of the present animal measure 5 inches. The last superior molar of another specimen measures 2 inches in length; in the third the first true molar is 1.5 inch in length, while the last inferior molar is 2.25 inches long. The peculiarity in the structure of the superior molars consists in the existence of two strong transverse ridges, which connect the inner tubercle with the outer crescents, inclosing a pit between them. These are most marked on the premolars, where also is found the peculiarity of the almost entire fusion of the outer crescents into a single ridge. These united crescents are narrower than in *P. major*, and the summits of all the crescents are relatively more elevated. The number of inner tubercles is the same as in that species; all the teeth have very strong basal cingula, which rise up on the inner tubercle. The inferior molars are relatively narrower than in *P. major*, and the posterior tubercle of the last is larger and longer, and is an elevated cone. The inner tubercles in all the lower molars have broader bases and less acumination.

The bones containing the maxillary and mandibular teeth were not found together in any instance, so that it is possible that the different series may represent different species. No other species of the genus was, however, found in the localities to which the respective parts could be referred. Should these prove not to pertain together, the lower jaws may be regarded as typical of the species.

Found in the Mammoth Buttes, on South Bitter Creek.

LIMNOHYUS, Leidy.

Proceedings Academy Natural Sciences, Philadelphia, 1872, p. 242, *Palæosyops*, Marsh, Amer. Journ. Sci. Arts, 1872, p. 122, not of Leidy, 1871.

This genus only differs from the last in possessing two conic tubercles of the inner series on the last superior molar, instead of one, a character first pointed out by Marsh.

LIMNOHYUS PALUDOSUS, Leidy.

Proceedings Academy of Natural Sciences, Phialdelphia, 1870, p. 113, not of later descriptions.

My expedition did not obtain any specimens which I can as yet certainly refer to this species. The measurements given by Professor Marsh for his *Palæosyops laticeps* approach very nearly to this one. Thus the width of the crown of the last superior molar is M. .038; in *P. laticeps* .040; in *L. diaconus*, Cope, it is .047.

LIMNOHYUS DIACONUS, Cope.

Palæosyops diaconus, Cope, on some Eocene Mammals obtained by Hayden's Geological Survey of 1872, 1873, p. 4.

The species is as large as the *Palæosyops major* of Leidy, but differs in the relative proportions of the teeth. Thus the last three molars have the same antero-posterior length, while the space occupied by four premolars is shorter. The anterior and posterior cingula of the true molars are very strong, but it is not well marked on the inner side between the cones. The latter are acutely conic, and the median anterior tubercle is strongly developed. Although the wearing of the teeth indicates maturity, the enamel is coarsely and obtusely rugose. The fourth premolar differs from that of *L. major* in its smaller size relatively and absolutely, and in the presence of a prominent vertical tubercle on the outer face, rising to the angle of the deep notch between the lobes. The third premolar is as wide as the fourth, and about as large as the corresponding tooth in *L. major*, but different from it in the absence of tubercle and ridge that mark its external face. The first premolar has two roots, and the canine is large and stout.

This large Palæotheroid is represented by parts of the two maxillary bones, which present the crowns of the third and fourth premolars, and of the second and third true molars, with the bases of the other molars and premolars.

Measurements.

	M.
Length of entire molar series	0.1710
Length of true molars	.1060
Length of last molar, (crown)	.0420
Width of last molar, (crown)	.0473
Length second molar	.0350
Length fourth premolar	.0260
Width fourth premolar	.0260
Width third premolar	.0200
Length third premolar	.0200
Diameter of basis of canine	.0263

The *L. paludosus*, Leidy, is similar to this species in the rugosity of the enamel of its teeth, but appears by the measurements to be distinctly smaller, so as to relate to it about as to *P. major*.

In comparison with Marsh's description of his *P. laticeps*, the measurements are all larger, and the enamel is as rugose as in *L. major*, instead of smooth. The shortening of the premolar series is greater in *P. diaconus;* thus in *P. laticeps* the two sets of molars are related as 49 mm. to 61; in the present one, as 106: 65; were the proportions similar, the length of the premolar series should be 69 mm.

From Henry's Fork of Green River.

LIMNOHYUS FONTINALIS, Cope.

Palæosyops fontinalis, Cope; Proceedings of American Philosophical Society, 1873, January 31.

The smallest of the tapiroids of this series, being about the size of a dog. It is represented especially by a considerable part of the cranium of an individual in which the last superior molar is not quite protruded, but with the other molars and last premolar of the permanent dentition in place. The enamel of these teeth is in accordance with the age, delicately rugose, and while the cingulum is present fore and aft, it is wanting internally and externally. The anterior median tubercle is present on all the true molars, and the bases of the acute inner cones are in contact. The sagittal crest is truncate, and the squamosal portion of the zygoma very stout. The nasal bones are together very convex in transverse section.

Measurements.

	M.
Length of true molar series, (2.75 inches)	0.067
Length of last molar	.025
Width of last molar	.026
Length of penultimate molar	.026
Length of penultimate molar	.026
Depth squamosal process	.025

Found by the writer on a bluff on Green River, near the mouth of the Big Sandy, Wyoming.

HYRACHYUS, Leidy.

Geological Survey of Montana, 1871, p. 360.

This genus was originally described by Leidy from portions of skeletons of individuals from the Eocene Tertiary of Wyoming. He recognized it as related to the *Lophiodon* of Cuvier in dentition, and as sharing with characters of that Eocene genus peculiarities which belong to the existing genus *Tapirus.*

Having obtained a large series of remains of this genus, including more or less numerous portions of six species with nearly complete skeleton of *H. eximius*, Leidy, I propose to give such an account of its osteology as will place its relations on a certain basis.

The characters which distinguish its dentition from those of the allied genera are as follows:

Tapirus, Briss. *Lower jaw:* Third molar two-crested; three premolars, the third and fourth with two transverse crests. *Upper jaw:* Seven molars, first with an inner heel tubercle; other premolars with two transverse crests.

Hyrachyus, Leidy. *Lower jaw:* Third molar with two crests; four premolars, third and fourth with one transverse and one longitudinal crest. *Upper jaw:* Seven molars, first without interior heel; premolars with two transverse crests.

Lophiodon, Cuvier. *Lower jaw :* Third molar with three cross-crests; premolars three, Nos. 2 and 3 with longitudinal crests. *Upper jaw :* Premolars with longitudinal crest only, No. 4 with two transverse crests. *Upper jaw :* Premolars with only one transverse crest.

In *Hyrachyus* the nasal bones are elongate, and unite with the maxillaries anterior to the orbit; in *H. eximius* above the *foramen infra-orbitale exterius ;* in *Tapirus* those bones are much shortened, and either do not unite with the maxillaries or join them and the frontals above the orbit at different points from the anterior to the posterior borders. The temporal fossæ are so extended as to produce an elevated sagittal crest, which is bifurcate behind, each projection continuing along the outer margin of the occipital region as a lateral crest. The tympanic bone is unossified beneath the *meatus auditorius externus*, which is bounded in front by a strong postglenoid process. Posteriorly it is bounded by a long descending mastoid process of the squamosal bone, nearly closing it below. This is bounded posteriorly by a long and stout paramastoid process, which is compressed from before backward and curves backward and inward. The foramen magnum has prominent supero-lateral margins which are nearly straight, and unite at a right angle above.

The dentition is thus: I. $\frac{3}{3}$; C. $\frac{1}{1}$; P. M. $\frac{4}{4}$; M. $\frac{3}{3}$; a considerable diastema separates the premolars and the canine.

In the species studied, the vertebræ are divided as follows: C. 7; D. 18; L. 7; S. 5; C. (?). Of the cervicals the seventh only is not pierced by the arterial canal. The atlas has a broad flat "tranverse" process.

The digits are 4—3; the third with a symmetrical hoof, those of the exterior digits halved; the former have two reverted proximal processes, the latter one. The astragalus exhibits a deeply grooved and extensive trochlear arc, with rather long neck, which has a greater facet for the astragalus, a lesser for the cuboid bone.

From the above it is evident that this genus is nearly allied to *Tapirus* and cannot be removed to another family. Professor Leidy states that the premolars differ from those of *Tapirus* in having "but one inner lobe connected with the exteral crest by two transverse crests." The appearance of one lobe is produced by the posterior curvature of the anterior transverse crest round the inner extremity of the posterior crest.

I now proceed to describe the skeleton more exactly.

HYRACHYUS PRINCEPS, Marsh.

Amer. Jour. Sci. and Arts, 1872, p. 125.

From South Bitter Creek.

HYRACHYUS EXIMIUS, Leidy.

Hayden's Geol. Survey Montana, 1871, p. 361.

Cranium.—In the specimen to be described, the anterior portion from the glenoid cavities is wanting. The sagittal crest is quite elevated, and the lateral occipital quite prominent, and continuous below with the superior margin of the squamosal portion of the zygoma. Four nutritious foramina pierce the parietal bone near its middle and above the paramastoid process, and two enter the squamosal above the postglenoid process. The paramastoid process approaches near the occipital condyle by its posterior border. I cannot discover the sutural boundaries of the mastoid bone, but that separating the paramastoid process from the process in front of it is distinct. The condyle of the mandible is massive, and the posterior border of the latter extends backward with a slight obliquity.

Measurements.

	M.
Elevation of sagittal crest above foramen magnum	0.045
Width of bifurcation of crest behind	.033
Width of occiput behind meatus auditorius	.070
Width between and inclusive of occipital condyles	.046
Width temporal fossa at meatus	.050
Width meatus auditorius	.012
Width condyle of mandible	.032
Depth of ramus behind	.095

In further illustration of the species I add measurements of teeth, &c., from another specimen:

Measurements.

	M.
Length of last two superior molars	0.041
Length of last	.019
Width of last	.022
Length of inferior molar series	.095
Length of premolars	.040
Length of last molar	.021
Width of last molar	.013
Depth ramus at first true molar	.040

Vertebræ.—The atlas is deeply incised anteriorly above. It is rather short, and its traverse processes are flat, thin, about as long as broad, and with regular convex distal margin. The arterial foramen issues some distance above and within the notch which marks the anterior base of the transverse process. It enters at the notch at the posterior base. The neural arch is quite convex, and its anterior margin is obtusely rounded. The axis is near the same length, and bears a prominent and elongate laminate neural spine. Its diaparapophysis is narrow and overlaps the parapophysis behind it three-quarters of an inch; it is pierced for the cervical artery. The centra of the third and fourth cervicals are about equal in length to that of the axis, but the remaining ones shorten successively to the seventh, which maintains a length somewhat greater than its width. The parapophyses of these, except the seventh, are flattened, and have considerable antero-posterior extent, their extremities overlapping. A short and rather narrow and stout diapophysis is present on the sixth cervical; on the seventh it is larger, especially expanded antero-posteriorly at the base and truncate. There is no parapophysis. The fourth, fifth, sixth, and seventh have strongly opisthocœlian centra; that of the third is injured.

Measurements.

	M.
Length of the cervical series	0.175
Length of atlas, between articular faces	.046
Length of base transverse process	.035
Length of transverse process	.020
Diameter neural canal in front	.021
Diameter of anterior expanse	.050
Diameter of total expanse	.099
Length axis along basis neural arch	.021
Elevation crest (rectangular) from posterior zygapophysis	.036
Length parapophysis of fifth cervical on margin	.051
Extent zygapophyses of fifth cervical on margin	.048
Expanse zygapophyses of fifth cervical on margin behind	.044
Elevation neural spine of C. 6	.056
Elevation neural spine of C. 7	.075
Length centrum below of C. 7	.028
Diameter of cup, about	.032

The measurements indicate that the neural spines of the sixth and seventh are quite elevated, the latter nearly equal to that of the first dorsal.

The spines of the dorsal vertebræ are elevated in the front of the series rising some distance above the scapulæ. They shorten and widen rapidly from the middle of the series backward. The extremities of all from the scapula posteriorly are turned forward. The metapophyses are conspicuously elevated above the diapophysis on the eleventh dorsal, and on the eighteenth, their elevation is about .4 that of the neural spine. The diapophysis is extended beyond the tubercular articulation, on the eighteenth dorsal; the extension and expansion increases rapidly on the lumbars. On the fourth they are as wide at the base as .66, the length of the centrum, and maintain their width, being directed anteriorly. On the sixth and seventh they are still wider and longer, and very thin. They present a projecting transverse surface backward one-fourth the length from the base for articulation with the seventh lumbar and first sacral respectively. The centra of the lumbars are depressed and slightly opisthocœlian, except the last, which is flat. They are contracted and keeled below.

The sacrum is long and narrow, and thoroughly co-ossified in the specimen. The diapophysis of the first and part of that of the second give attachment to the ilium. The intervertebral foramina are rather small.

Measurements.

	M.
Length of dorsal vertebræ along middles of neural spines	0.420
Length of lumbars do	.298
Length of sacrum along centra	.170
Diameter centrum first dorsal, (transverse)	.019
Diameter centrum first dorsal, (vertical)	.019
Diameter centrum fifth lumbar, (vertical)	.020
Diameter centrum fifth lumbar, (transverse)	.0325
Length do	.039
Length diapophysis sixth do	.065
Greatest transverse width of diapophysis sixth lumbar	.030
Length centrum seventh lumbar	.034
Transverse diameter centrum first sacral	.036
Transverse expanse diapophyses do	.086
Transverse diameter end of last sacral	.020
Transverse diameter diapophysis do	.043
Elevation neural spine second dorsal	.095
Elevation neural spine seventh dorsal above scapula	.035
Elevation neural spine eighteenth dorsal, (from arch behind)	.037

The *ribs* are long and slender, the first but little expanded distally and united with the *manubrium sterni* a little behind its middle. They number eighteen, but as the last is quite long, there may have been another pair of shorter ones not yet exposed in the matrix.

Measurements.

	M.
Length first	0.118
Width first, distally	.018
Length eighteenth } from tubercle	.180
Length sixteenth, (end broken) } from tubercle	.223

There are four *sternal segments* preserved, with a fragment of another. They are distinct, and the first is the largest. It is a longitudinal plate, placed on edge, with the anterior border strongly excavated. The inferior margins of the succeeding segments are thickened, but the compressed form remains, the section being triangular.

The *scapula* is large for the size of the animal. It has an approximately triangular form, the base being superior. The posterior angle is right, but the anterior regularly rounded. The apex supports the glenoid cavity on a neck which is contracted by a shallow excavation of the anterior margin. The latter is bounded next the glenoid cavity by the short obtuse coracoid, which stands a short distance above the articulation. The spine is long, rather elevated, with a regular convex border curved backward.

Measurements.

	M.
Length of three sternal segments	0.147
Length of first sternal segments	.084
Depth of first sternal segments in front	.044
Width of first sternal segments below	.004
Width of third sternal segments	.015
Length of scapula, (median)	.215
Width above, (greatest)	.130
Width of neck	.036
Width of glenoid cavity	.035

Humerus.—The head is directed a little inside of directly backward. The bicipital groove is very deep and the inner tuberosity large and directed forward. The external tuberosity is much larger, as usual in this group of ungulates, and rises in a hook-like apex above the level of the head. The external bicipital ridge is lateral, and not very prominent, extending on one-third the length of the shaft. The shaft is moderately compressed at the middle, but transversely flattened below. It is nearly straight. The condyles are narrow, and the inner and outer tuberosities almost wanting; their position marked by shallow concavities. The external continues in a lateral crest which turns into the shaft below the lower third. The inner condyle is both the widest and most prominent; the external has its carina at its middle, and its external trochlear face oblique and narrow; narrowest behind. The olecranar and coronoid fossæ are deep and produce a small supra-condylar foramen.

The *ulna* exhibits a large and obtuse olecranon, concave on the external face. Its glenoid cavity is narrowed and elevated behind; in front it widens, and there the ulna receives the transverse proximal end of the radius, which overhangs it on both sides, leaving the little elevations of the right and left coronoid processes about equal. The vertical diameters of the shaft of the ulna are about equal throughout. Its section is triangular, the base being next the radius for the proximal third. This is followed by an edge next the ulna, and the base of the section is on the outer inferior aspect, on account of the direction of an angle from a short distance beyond the outer coronoid process to the base of the ulnar epiphysis, where it disappears. Distally there are two other very obtuse ridges above this one. The extremity bears two facets—the larger for the cuneiform, the smaller for the pisiform bone.

The *radius* is throughout its length a stouter bone than the ulna and bears much the greater part of the carpal articulation, viz: with the scaphoid, lunar, and part of the cuneiform bones. This articulation is transverse to that of the ulna, which is thus at one side of and behind it. The head is a transverse oval in section, the narrower end outward. The articular face consists of one and a half trochleæ, the latter wider and internal. The shaft is a transverse oval in section, with an angular ridge along the middle externally, and the distal part proximally. A broad groove marks the upper face of the epiphysis, where the shaft has a vertical inner face.

Measurements.

	M.
Length humerus, (axial)	0.270
Diameter head to bicipital groove	.037
Length along crest outer tuberosity, (about)	.052
Transverse diameter, distally	.046
Antero-posterior diameter, inner condyle	.042
Width olecranar fossa	.020
Length ulna	.260
Depth olecranon, distally	.027
Depth at coronoid process	.025
Depth of distal end	.019
Depth at middle shaft	.019
Length radius	.200
Width of head	.036
Depth of head	.021
Width shaft at middle	.021
Width near distal end, (greatest)	.037
Width distal articulation	.030

The elements of the *carpus* are distinguished for length, and for reduction of width. The anterior faces of all are considerably longer than broad, but the longest faces of the cuneiform, scaphoid, and trapezoides are antero-posterior. The facets are as usual in the carpus; scaphoid $\frac{1}{3}$; lunar $\frac{1}{2}$; cuneiform $\frac{3}{1}$; trapezium $\frac{1}{1}$; trapezoides $\frac{1}{1}$ magnum $\frac{2}{2}$; unciform $\frac{2}{1}$. The cuneiform has a rather L-shaped external face. The pisiform has two proximal facets and is enlarged and thickened distally; pressed inward, it reaches the scaphoid. The trapezium is a small subdiscoid bone with convex outer face. The magnum is as broad as deep in front, where its surface is swollen; it is produced behind into a spatulate decurved hook. The unciform has a narrow sub-acute hook behind, with wide base.

Measurements.

	M.
Width of carpals of first row together	0.044
Width of lunare, outer face	.016
Depth of lunare, outer face	.020
Depth of cuneiform, outer face	.020
Width of cuneiform, outer face	.020
Length of pisiform, outer face	.030
Depth distally, outer face	.014
Width three carpals of second row	.038
Width magnum, outer face	.015
Depth magnum, outer face	.014
Depth unciform, outer face	.017
Width unciform, outer face	.020
Length unciform, antero-posterior	·021
Length magnum, antero-posterior	.029
Total length of carpals	.040

The *metacarpals* are quite slender. The first only is wanting; the third is rather stouter than the others, while the fourth is considerably the most slender. Its distal extremity is oblique, with prominent median keel, which is wanting on the superior aspect. The proximal facets of these bones are respectively (2d) 2, (3d) 2, (4th) 1, (5th) 1. There is a short, shallow groove near the proximal end of No. 3. The phalanges corresponding are lost in the specimen.

Measurements.

	M.
Length of fifth metacarpal	0.070
Estimated length of foot	.187
Distal diameter of fifth metacarpal	.012
Proximal diameter of metacarpal	.007
Proximal diameter of fourth metacarpal	.012
Proximal diameter of third metacarpal	.017
Proximal diameter of second metacarpal	.012

The above are taken on the articular faces transversely.

The *pelvis* is perfectly preserved. The ischium is but little over half as long as the ilium, measuring from the middle of the acetabulum. The ilium is a triradiate bone, the superior or sacral plate rather shorter and wider than that forming the "crest," which is subsimilar to the peduncular portion. The crest expands very slightly distally forward and downward. The ischio-pubic suture is a long one, and the obturator foramen a long oval; the inferior pelvic elements do not form a transverse, but meet at an open angle.

Measurements.

	M.
Length ilium to sacral border	0.130
Length ilium to crest	.180
Width crest	.060
Width peduncle	.030
Length ischium from middle of acetabulum	.110
Width ischium posteriorly	.080
Length obturator foramen	.041
Width obturator foramen	.034
Expanse of ischia above at middle	.076

Femur.—The head projects inward on a well-marked neck. The great trochanter is strongly recurved and presents an anterior tuberosity as well. It rises to an incurved apex much elevated above the head. The prominence of the front of the femur is continued into the front of the trochanter. The outer margin of the shaft is thin, and at a point two-fifths the length from the proximal end is produced into a low third trochanter, which is curved forward and thickened on the margin. The trochlea is well elevated, the inner margin a little the more so, and is narrow. It is continuous with the surface of the inner condyle, which is the shorter and more vertical; the external is longer and divergent; its terminal face is marked by two fossæ, one in front of the other just outside the distal end of the ridge bordering the trochlea. Little trochanter moderate.

Measurements.

	M.
Total length	0.285
Proximal width of head and trochanter	.075
Width from front to edge third trochanter	.050
Width just above condyles	.035
Width of condyles	.058
Chord of outer condyle and trochlea	.060

The *tibia* has a broad prominent crest, which is remarkable in being deeply fissured longitudinally at its superior portion. The tendinous notch separates the outer portion of the crest from the spreading margin of the outer cotyloid face. The crest disappears at the proximal third, and the shaft becomes flattened in front and on the inner side. The distal articular extremity is impressed by $1.\frac{2}{3}$ trochleæ, the outer being completed by the fibula. The posterior tuberosity is more nearly median than usual, hence the inner margin of the inner trochlea is low posteriorly, and the inner malleolus has a considerable beveled inferior margin. The *fibula* has a slender shaft, but little compressed. The head is expanded fore and aft, and the malleolus is quite stout.

Measurements.

	M.
Length of tibia	0.244
Diameter from outer angle of head to inner angle of crest	.065
Diameter distal end, (greatest)	.035
Diameter articular face, transverse	.027
Diameter articular face, fore and aft	.026

Both *hind feet* are perfectly preserved. The astragalus is rather elongate and compressed, the lower face truncate with two longitudinal bounding ridges, the outer of which is discontinued before reaching the heel. The surface between them is striate grooved. The outer face is slightly concave. The astragaline facets are much expanded inward; the outer is transverse and strongly convex, and separated by a groove from the inner, which is longitudinal and nearly plane. The posterior edge of this, and convexity of the outer facets are received into a transverse groove of the posterior part of the lower face of the astragalus. The cuboid facet is diagonal, and is bounded within by a third narrow facet for the astragalus. The astragalus has a strongly convex deeply grooved trochlea; the convexity extends over 158°. The trochlea is nearly in the vertical, a little oblique to the longitudinal axis of the foot. The exterior malleolar facet is well marked, and bounds a lateral fossa above. The neck of the astragalus is broad and not contracted, but not wider than the trochlea. Its navicular facet is wide and concave, the cuboid narrow, with a long angle behind. The cuboid is quite elongate, and with a narrow anterior face; it has a large posterior tuberosity not projecting much posteriorly. The navicular is flat, with a sigmoid proximal face, convex on the inner side, concave on the outer. It has the three cuneiform facets below the inner antero-posterior. The inner is a flat bone with antero-posterior plane and apex directed backward, and considerably oblique facet for the second metatarsal. The mesocuneiform is much the smaller, and brings the third metatarsus a short distance proximal to the fourth. The ectocuneiform is a little wider than deep. The metatarsals are three, and are rather slender. The two outer are equal in length, and the median but little wider proximally, the increased width being more obvious distally. They have no proximal grooves, and the outer has a low outer tuberosity. The facets of the second row of tarsals are $\frac{1}{1}$ $\frac{1}{1}$ $\frac{1}{1}$. The phalanges, including ungueal, are 3, 3, 3. The proximal ones are longer than wide and contracted at the ends; the penultimate are still stouter in form. The ungues of middle line are symmetrical and broad, with the margin a segment of an ovoid, and slight contraction at the neck. The proximal articulation is bounded by a fossa on each side, which is in its turn isolated by the elongate process found in the tapir and in the horse. The margin is marked by radiating striæ separated by grooves, of which the median is the most marked. The lateral ungues are contracted on the inner side, and only possess the proximal fossa and hook on the outer side. The median distal groove is well marked.

Measurements.

	M.
Length of hind foot from heel	0.286
Length of calcaneum	.083
Length of cuboid facet of calcaneum	.024

	M.
Depth calcaneum behind	.025
Width calcaneum at astragalus	.035
Greatest axial length of astragalus	.045
Width between trochlear crests astragalus	.022
Length neck between trochlear, outer side	.014
Width head between trochlear	.030
Width navicular	.031
Length navicular at middle	.010
Length cuboid	.022
Depth outside	.025
Length ectocuneiform in front	.013
Width ectocuneiform in front	.019
Width mesocuneiform in front	.019
Length mesocuneiform in front	.008
Length entocuneiform at side	.021
Depth entocuneiform at side	.015
Length of metatarsus II	.102
Length of metatarsus III	.107
Width of metatarsus II proximally	.016
Width of metatarsus III proximally	.020
Width of metatarsus II distally } within fossa	.016
Width of metatarsus III distally } within fossa	.025
Length median phalanges I	.025
Width median phalanges I distally	.015
Depth median phalanges I distally	.009
Length median phalanges II	.015
Length median phalanges unguis	.029
Width of articular facet unguis	.014
Width of neck of facet unguis	.021
Width of greatest expanse facet unguis	.029
Length phalanges of metatarsal II	.060
Length unguis of metatarsal II	.028
Width unguis, (greatest)	.018
Length metarsus and phalanges IV	.158

Restoration.—The following dimensions may be relied on as a basis for a restoration of this species:

Measurements.

		M.
Length	head	0.220
	vertebral column less tail	.063
	equal 42.1 inches	1.283
Height	of neural spines exposed	.035
	of scapula	.215
	of fore leg	.692
	total 31.05 inches inclusive	.947
Height	of hind leg	.770
	of elevation of ilium	.135
	total 29.7 inches	.905
Depth of body at middle manubrium		.255
Depth of body at 15 rib		.250

Allowance being made for the obliquity of the humerus, scapula, femur, and ilium, the elevation in life was—

	M.
At the withers, (26.6 inches)	.872
At the rump	.762

The size of this species was, then, that of a large sheep.

Comparison of the skeleton with that of Tapirus roulini.—For the opportunity of making this comparison I am indebted to the Smithsonian Institution, which possesses a skeleton of the above species of tapir from Ecuador, presented by President Moreno.

Cranium.—In addition to the generic characters mentioned at the commencement of this description, the *H. eximius* and *T. roulini* differ as follows: in *H. eximius* there is (1) a high sagittal crest which is wanting in *T. roulini*, *T. malayanus*, and approximated in *T. terrestris*. (2) The crest of the squamosal part of the zygoma is continuous with the lateral occipital crest, which is not the case in existing tapirs.

Vertebræ.—(1) The arterial canal of the atlas is not isolated in front as in *T. roulini*, but notches the basis of transverse process. (2) The axis is longer than in *T. roulini*. (3) The neural spines and especially the metapophyses of the posterior dorsal vertebræ are more elevated. (4) The end of the centra of the lumbars are flatter, and more depressed. (5) The diapophyses of the same are wider and longer and thinner, and the penultimate articulates with the last by an angular process, which is not the case in *T. roulini*.

Scapula.—(1) This bone is equal in size to that of a *T. roulini*, of considerably greater general dimensions, and is hence relatively larger. (2) The spine is not angulate as in that species, has a larger base, and larger elevated margin. (3) The neck is more contracted, and (4) the coracoid is not recurved as in *T. roulini*. (5) The sinus bounded below by the latter is much shallower, and not bordered above by a recurved hook of the margin.

Humerus.—(1) It is relatively smaller in *H. eximius*. (2) The internal bicipital ridge of *T. roulini* is wanting. (3) The external condyle is much shorter, whence its border is nearer its trochlear rib. The *radius* has a narrower head, (1,) the external articular plane being shortened. (2) The shaft is wider with a more acute longitudinal lateral ridge medially, and more rounded distal end. The *ulna* is (1) absolutely nearly as long as in *T. roulini*, being thus relatively longer. (2) It has three weak, longitudinal ridges on a convex outer face; in *T. roulini* the external face is divided by a very prominent longitudinal angle from the radial cotylus, which spreads distally, sending one angle to the upper and another to the lower base of the distal epiphysis.

Carpus.—This part is (1) absolutely and relatively smaller than in *T. roulini*. (2) The pisiform is more cylindroid distally. (3) The scaphoid is more produced backward on the inner side; the excavation of the inner side is more continued as a concavity of the outer side of the front. (3) The unciform has an acute tuberosity behind; in *T. roulini* it is short, vertical, and obtuse. (4) The trapezoides has a shorter, wider, and more swollen external face. (5) The pisiform is small and convex, instead of being larger and flat.

The *metacarpals* (1) are absolutely and relatively smaller. (2) The inner (II) has a more oblique phalangeal articulation, which is short above and with the keel prolonged upward, instead of being, as in *T. roulini*, distal only.

The *pelvis* is distinguished by the much longer plate of the ilium, whose extremity constitues the crest. (1) The crest is also shorter, and more anterior. In *T. roulini* this plate does not so much exceed the sacral plate in length. (2) The pubes and ilia are not so horizontal, but meet at nearly a right angle, and (3) the ischiopubic common suture is considerably longer. (4) The obturator foramen is a more elongate oval.

The *femur* is very similar to that of *T. roulini*, being no smaller in relative size. (1) The great trochanter is wider fore and aft, and with margin more continued on the anterior aspect of the extremity of the shaft. (2) The third trochanter is nearer the middle of the length. (3) The condyle surfaces are continuous with the rotular, not isolated as in *T. roulini*. The latter also (4) lacks the two fossæ on the outer margin of the external seen in *H. eximius*. (5) The rotular groove is also narrower in the latter and not so deeply excavated as in *T. roulini*.

The *tibia* is (1) reduced in size, and especially contracted distally; the relative widths of the ends are 6 cm : 3.5; in *T. roulini* 7.5 cm to 5. (2) The crest is more prominent, and is deeply fissured by a groove, which is represented by a shallow concavity in *T. roulini*. The groove (3) external to this is deeper. (4) The posterior inner tuberosity of the distal end is more median, hence the inner trochlear groove is further removed from the anterior inner malleolus, which has, therefore, a greater inner (not outer) extent.

The *tarsus* (1) is generally longer and narrower, except in the case of the cuboid bone, (2,) which is shorter than in *T. roulini*. (3) The astragalus has a narrower neck, which, therefore, appears more on the inner side. (4) The facet for the cuboid is smaller. (5) The inner tuberosity of the head is more prominent. (6) The calcaneum is more slender, with larger cuboid facet, especially posteriorly. The *metatarsus* is absolutely nearly as long as in *T. roulini*, and, therefore, relatively longer and more slender. (2) The median (III) is nearly similar to the others in width; in the *T. roulini*, much larger than the lateral.

The *phalanges* of the first cross series are more contracted distally.

The more important differences between the skeleton of the two species in addition to those pointed out under the head of the genus, are those of the ulna, the scapula, the lumbar vertebræ, the ilium, and the crest of the tibia. The scapula is more like that of *Tapirus terrestris*, while the ilium is approximated by that of *T. malayanus* among living species; its form leans toward the Equine series, and not to the *Palæotheroid*.

Conclusion.

From the preceding it is evident that there lived in North America during the Eocene period a type of *Tapiridæ* only differing generically from that now existing in South America. Thus one form of the many peculiar and primitive ones of that time still persists in the tropics and southern hemisphere, which claims more ancient character than the rhinocerus, elephants, and other remains of Miocene time.

The affinities of *Cercoleptes* and *Nasua* to the types of the same period have been already indicated,* and with the present case may be regarded as confirmatory of the proposition stating the early geological state of the existing *Fauna Neotropica*.†

HYRACHYUS IMPLICATUS, Cope.

On some Eocene Mammalia, &c., 1873, p. 5; published March 8.

This tapir is smaller and more slender than the *H. agrestis*, Leidy, but exhibits an equal size of posterior molar teeth, which are thus relatively larger than in that species. It is represented first by both maxillary bones, with most of the molars complete, from Cottonwood Creek, Wyoming; then by the side of the face, with molars of both jaws complete, with symphysis and portions of all the incisors, from South Bitter Creek, and by part of mandibular ramus, with teeth, from Green River, with probably other specimens.

The molars differ from those of the other *Hyrachyi*, and resemble those called *Helaletes*, in the presence of a prominent ridge, which descends on the inner side of the principal (median) outer cusp, not quite reaching

* See on the Primitive Types of the Mammalian Orders, 1873.
† See Origin of Genera, p. 99 and preced.

the valley below. It wears into a prominent loop. The anterior cusp is much less elevated than the median, and is separated from the latter by a considerable ridge. The only cingulum on the molars is on the outer side of the first. Enamel smooth.

Measurements No. 1.

	M.
Length of five molars	0.071
Length of three posterior molars	.0470
Length of last molar	.0159
Width of last molar	.0200
Width of penultimate molar	.0210
Length of penultimate molar	.0168

In the more perfect specimen all of the molars have two transverse crests, except the P. M. 1. The lower molars possess strong anterior prolongations of their posterior crests; the third and fourth premolars have one elevated transverse crest near their middle, and the second is much compressed. The first I cannot find. Symphysis rather short for the genus.

Measurements No. 2.

	M.
Length of superior molar series	0.085
Length of true molars	.046
Length of penultimate	.015
Width of penultimate	.019
Length of inferior molar series	.078
Length of inferior true molars	.047
Length of penultimate	.017
Width of penultimate	.011
Width of last premolar	.008
Length of last premolar	.012
Depth of ramus at last premolar	.0235
Length of diastema	.019
Length of bases of three incisors	.018

HYRACHYUS AGRARIUS, Leidy.

Common everywhere.

HYRACHYUS BOÖPS, Marsh.

Helaletes boöps, Marsh, American Journal, 1872, p. 218; *Hyrachyus boöps, Cope,* On some Eocene Mammals, &c., 1873, p. 6.

Bitter Creek and Black's Fork.

HYRACHYUS NANUS, Marsh.

Lophiodon nanus, Marsh, American Journal Sciences and Arts, 1871, July; *Hyrachyus nanus,* Leidy, Geological Survey of Montana, 1871, p. 361; *Helaletes,* Marsh, l. c., 1872, p. 218.

Cottonwood Creek.

ANCHIPPODUS, Leidy.

Proceedings Academy Natural Sciences, Philadelphia, 1868, p. 232; *Trogosus,* Leidy, Proceedings Academy Natural Science, Philadelphia, 1871, and Geological Survey of Montana, 1871, p. 359.

ANCHIPPODUS MINOR, Marsh.

Palæosyops minor, Marsh, American Journal Science and Arts, 1871, July; *Trogosus castoridens,* Leidy, Geological Survey of Montana, 1871, p. 360.

Cottonwood Creek.

OROHIPPUS, Marsh.

American Journal Science and Arts, 1872, (published August 7.)

Superior molars, with two external crescentoid crests, and two internal cones, which are connected with the former by low oblique crests which are directed to the anterior bases of the outer tubercles.

This genus constitutes an approximation of the *Limnohyus* type to *Anchitherium*, and probably connects effectively the equine and tapiroid divisions.

OROHIPPUS PROCYONINUS, Cope.

Proceedings American Philosophical Society, 1872, p. 466, August 3. (*Helotherium.*) *Orohippus pumilus*, Marsh, l. c., August 7, 1872.

This species is distinguished by its small size, as it did not much exceed the raccoon in dimensions. The size of a right superior molar is as follows:

Measurements.

	M.
Length	0.007
Width posterior	.0085
Width anterior	.006

The crown presents four tubercles, of which the inner are flat on the anterior, the outer flat on the external side. The anterior cross-ridge has a trihedral tubercle, and a low tubercle intervenes between the two posterior in front of them. An anterior and a posterior cingulum. Enamel smooth.

Genera Incertæ Sedis.

OROTHERIUM, Marsh.

American Journal Science and Arts, 1872, p. 217.

OROTHERIUM VASACCIENSE, Cope.

On some Eocene Mammals, &c., p. 3.

Lophiotherium vasacciense, Cope. Proceedings American Philosophical Society, 1872, July 11, (extras.) *Notharctus vasacciensis*, Cope, l. c., 1872, 474.

This species is similar to the next in most respects, the corresponding molars differing in the more elevated yoke between the tubercles of opposite sides, and the presence of a posterior median tubercle.

Represented by a portion of the left ramus of the lower jaw, containing one tooth in perfect preservation. The structure of this indicates it to be the second true molar, and presents certain features of distinction from the same tooth of the *L. sylvaticum*, described by Dr. Leidy. The crown presents four tubercles, which are arranged in pairs, the separation between the right and left lobe of each being slight, thus giving the tooth the appearance of having two transverse crests as in *Hydrachyus*. The two anterior and outer posterior tubercles are fissured by wearing, but the inner posterior consists of two acute crests, which meet, presenting an acute angle toward the adjoining tubercle. The outer posterior tubercle sends a descending crest obliquely to the base of the inner anterior tubercle, as in *L. sylvaticum*. A small tubercle occupies the space behind the interval between the posterior tubercles and gives origin to a cingulum which passes round the bases of the outer tubercles. It extends round the front of the tooth to the outer anterior tubercle. Wear would produce small angular crescents from the two posterior and the outer anterior tubercle. Greatest length of crown, M. 0.008; width, .006. The enamel of the tubercles is rugose.

This ungulate was of about the size of the *L. sylvaticum*, or equal to the raccoon. It differs considerably from that species in the less isolation of the tubercles of the molar, and the crescentic form of the inner posterior.

From Green River beds near Evanston, and the same near Black Buttes, Wyoming, on opposite sides of the Bridger Basin.

OROTHERIUM SYLVATICUM, Leidy.

Lophiotherium sylvaticum, Leidy. Proceedings Acedemy Natural Sciences, Philadelphia, 126; *Orotherium*, Marsh, American Journal Science and Arts, 1872, August 13.

From Black's Fork, Wyoming.

OLIGOTOMUS, Cope.

On some Eocene Mammals, &c., March 8, 1873, p. 2.

Char. gen.—Molars constructed much as in *Hyopsodus* and *Lophiotherium*, viz, with two external subtrihedal cusps, which wear into crescents, the posterior connected by a low oblique ridge with the basis of the anterior cone of the inner side; the latter with two conic cusps. It differs from these genera and *Orotherium* in the possession of but two premolars; the inferior molars are probably six, leaving four true molars.

OLIGOTOMUS CINCTUS, Cope.

Loc. cit.

Char. specif.—In this animal the cusps of the molars are elevated, the external most so, the anterior being somewhat bilobate. Premolars with two fangs. There is a rudimental posterior tubercle in M. 1 and 2, and a strong cingulum round the outer side of the crown. In an adult with worn teeth the enamel is obscurely rugose.

Measurements.

	M.
Length of five molars	0.0326
Length of two premolars	.0120
Length of M. 2	.0067
Width of M. 2 anteriorly	.0050
Width of M. 2 posteriorly	.0050
Depth ramus at front of P. M. 1	.0126

From Cottonwood Creek, Wyoming.

ANTIACODON, Marsh.

American Journal Science and Arts, 1872, p. 210.

ANTIACODON PYGMÆUS, Cope.

Lophiotherium pygmœum, Cope. Proceedings American Philosophical Society, 1872, extras, July 20; *Antiacodon venustus*, Marsh, American Journal Science and Arts, 1872, (published August 13.) *Hyopsodus pygmœus*, Cope, loc. cit., p. 461.

From Cottonwood, Wyoming.

Represented by a portion of the right mandibular ramus, with the penultimate and antepenultimate molars in perfect preservation. These teeth present four cusps, of which the outer are crescentoid in section, the inner conic. They are all elevated, and the inner anterior is in both teeth compressed and bifid. It receives an oblique ridge from the outer posterior crescent, which also sends a ridge to the posterior inner. Enamel smooth.

Measurements.

	M.
Length of penultimate molar	0.0045
Width of penultimate molar behind	.0040
Depth of ramus at posterior margin of penultimate molar	.0070

This is a small mammal, about equal in size to a weasel.

ANTIACODON FURCATUS, Cope.

On some Eocene Mammals, &c., p. 1, March 8, 1873.

Established on a part of the right ramus mandibuli, with the three molars and last premolar in perfect preservation. The crowns of the molars are composed of two external, chevron-shaped tubercles, the apices rising as acute cusps, and two internal cones, the interior of which is flattened and strongly bifid, both points being more elevated than any of the others. The cusps are nearly opposite to each other, and behind the interval between the two posterior rises another, not so elevated as the others, except on the posterior molar. Here it is elevated, and nearly equidistant from the two in front of it. The enamel is smooth, and there is no cingulum on either side. The premolar consists of a principal sectorial cusp, and has a smaller but stout acute anterior cusp, with a small rudiment of another behind; a stout cusp rises from the inner posterior margin of the principal one, giving it a subbifid appearance.

Measurements.

	M.
Length of four molars	0.0195
Length of three true molars	.0149
Length of last true molar	.0055
Length of first true molar	.0043
Width of first true molar front	.0025
Width of first true molar posteriorly	.0031
Depth of ramus at front of M. 3	.0075
Depth of ramus at front of P. M. last	.0055

This species differs from the last in the presence of the posterior tubercles on the M. 2–3, and the absence of external cingulum. The sizes are not very different.

From the bluffs of the Upper Green River.

The genus to which this species belongs differs from *Hyopsodus* in the carnivorous form of the last premolar, which has a well-developed anterior cusp. I refer it to the same genus as the last species, though its characters have never been pointed out by the author of the name, (Professor Marsh,) nor are the characters which distinguish it from *Homacodon* of the same author discoverable. He states that the cusps in *H. vagans* are "isolated," a character which does not apply to *A. furcutus*, in which they are related much as in *Hyopsodus*.

MICROSYOPS, Leidy.

Proceedings Academy Natural Sciences, 1872, p. 20.

MICROSYOPS VICARIUS, Cope.

On some Eocene Mammals, &c., 1873, p. 1.

Founded on portions of the mandibular rami of two individuals from the Bad Lands of Cottonwood Creek, Wyoming. These represent an animal considerably smaller than the *Hyopsodus paulus*, and with probably only three premolars. This is believed to be the fact from the small size of the last premolar, and the anterior contraction of the first molar. The molars have no external cingulum nor antero-external tuberosity described to exist in the *M. gracilis*, by Marsh. The cones have simple apices, and the oblique connecting ridges of both genera.

Measurements.

	H. pulus.	*M. vicarius.*
		M.
Length of three molars	0.0136	0.0115
Length of last molar	.052	.0045
Length of first molar	.040	.0038
Width of first molar anteriorly	.041	.0026
Width of first molar posteriorly	.043	.0029

HYOPSODUS, Leidy.

Proceedings Academy Natural Science, Philadelphia, 1871; Geological Survey Montana, 1871, p. 362.

HYOPSODUS PAULUS, Leidy.

Hayden's Survey Montana, &c., 1871, p. 363.

From Cottonwood and South Bitter Creeks.

RODENTIA.

PARAMYS, Leidy.

Geol. Survey, Montana, 1871, p. 357.

PARAMYS LEPTODUS, Cope.

On some Eocene Mammalia, &c., 1873, p. 3. (Published March 8.)

Established on a right mandibular ramus with all the teeth preserved. It indicates an animal of about the size of the *P. delicatus*, Leidy, and *P. robustus*, Marsh, but with smaller incisors, which have little more than half the diameter of the same tooth in those species. The molars have two anterior separate, and three posterior contiguous, cones, the median smallest. The anterior and posterior of both sides separated by a deep excavation. The anterior tooth is peculiar in its greater compression. The posterior tubercles are not separated, and the anterior inner situate behind the outer, and connected with the posterior inner by a concave ridge.

Measurements.

	M.
Length molar series	0.0221
Length M. 4	.0060
Width M	.0055
Length M. 1	.0060
Width M	.0048
Diameter lower incisor, transverse	.0024
Diameter lower incisor, anterior posterior	.0038

From the South Bitter Creek, Wyoming.

PARAMYS UNDANS, Marsh.

Sciuravus undans, Marsh. Amer. Journ. Sci. Arts, 1871, (June 21.)

A smaller species than the *P. delicatissimus*, Leidy. The dental characters of the mandibular series are generically identical with those of the species of *Paramys*.

From Upper Green River.

PARAMYS DELICATISSIMUS, Leidy.

Black's Fork.

PARAMYS DELICATIOR, Leidy.

Cottonwood Creek and Black's Fork.

PARAMYS DELICATUS, Leidy.

Black's Fork.

PSEUDOTOMUS, Cope.

Proceedings Amer. Philosophical Society, 1872, p. 467, (August 3.)

This genus is represented by the nearly complete cranium, with cast of the brain-case of the typical species. The cranium is of depressed form and with considerably expanded zygomata. The muzzle is broad and but little elevated, so that the nasal meatus is between the alveolæ of the superior incisors. The frontal bone is very short, and the superciliary margin and orbits small, and without postfrontal process. The temporal fossæ are large, and contract the brain-case behind the orbits to a striking degree. Their anterior margins rise from the postfrontal angles and converge backward, meeting in a sagittal ridge opposite the anterior part of the squamosal bone. The parietal bones increase rapidly in width to the squamosals, which also extend horizontally to their zygomatic portion. They do not extend very far on the superior aspect of the skull, nor backward beyond the auditory meatus. The occipital region is concave and surrounded by a prominent crest.

The *foramen infraorbitale exterius* has an inferior position, being a little above the alveolar border; it is rather small and round. There is a prominent tuberosity on the under side of the basal part of the molar bone, just exterior to the position of the second molar of *Arctomys;* its inferior face is truncate. The dentition is I. $\frac{1}{1}$; C. $\frac{8}{8}$; M. $\frac{3}{3}$. The incisors are rather small for the size of the skull, and much as in *Arctomys*. The inner face is truncate, the outer continuous with the anterior by the lack of separating angle. The thin enamel is extended part way on the outer face. At a point twice as far in front of the premaxillo-maxillary suture as the latter is from the line of the zygoma, the incisors are widely separated from each other, whence they are not probably in contact when they issue from the premaxillary bones. The mandibular cutters are less widely separated by a narrow prolongation of the symphysis. The exposure of the tooth is lateral, its direction nearly anterior. It projects anteriorly very little beyond the symphysis, and has a horizontal triturating surface below the level of the latter. There are alveolæ for but three molar teeth, each with three roots. The teeth themselves are not contained in them, but were apparently lost before the cranium was entombed in the Eocene mud. The position of the first molar is occupied by spongy bone in both maxillaries, and appears as though such teeth might have existed earlier in life and been shed. The pterygoid laminæ are prolonged, inclosing a trough. The *foramen ovale* is well developed and simple, and bounded behind and before by a ridge. There are no additional foramina in this region. The space for the otic bulla is moderately large; the basicranial axis is grooved at the junction of the basi-occipital and sphenoid bones. The zygomatic arch is deep and thin. The glenoid cavity is wide but longitudinal. The cast of the brain indicates smooth oval hemispheres which leave the cerebellum and olfactory lobes entirely exposed. The latter are ovoid and expanded laterally. This genus is allied to, if not actually a member of, the *Sciuridæ*. The breadth and depression of its form reminds one of *Arctomys*, but the contraction behind the orbits is very different, resembling rather the form of *Fiber*. The lateral separation of the incisors, superior and inferior, is a marked peculiarity.

PSEUDOTOMUS HIANS, Cope.

Loc. cit.

The enamel of the superior incisors is not grooved, but has a delicate striate sculpture. The inferior incisor does not project as far as the alveolar border of the jaw ; its surface worn by the upper incisor is horizontal and anterior. The inferior diastema is a thin edge, and the ramus is deep there. The temporal surface of the parietal bones is rugose. The cranium is depressed, and has a trace of interparietal crest. The anterior margin of the temporal fossa is marked by a curved angle on each side of the frontal bone. The supra-orbital arch is very short.

Measurements.

	M.
Length cranium, (3.75 in.)	0.095
Width cranium, (without zygomas)	.040
Width cranium, (with zygomas)	.072
Width of occiput	.032
Width cranium near end of nasals	.027
Width upper cutting tooth	.007
Depth upper cutting tooth	.0085
Length exposed part lower tooth	.009
Width exposed part lower tooth	.006

From the Bad Lands of Cottonwood Creek.

MARSUPIALIA.

TRIACODON, Marsh.

Amer. Journ. Sci. Arts, 1871, July.

This genus is placed here on the authority of Marsh.

TRIACODON ACULEATUS, Cope.

Proceed. Amer. Philos. Soc., 1872, p. 460, (July 29.)

Established on two teeth of the molar and premolar series. The molar is subtriangular at the base of the crown, one side being convex;

the opposite angle nearly right and the two remaining sides flat. The crown is divided into three elevated trihedral cones, one at each angle. Their adjacent angles are acute, and the angle of union is fissured like the same point in the sectional tooth of carnivora. The smaller lobes are of equal elevation, but the crown of one is expanded so as to be slightly spade-shaped. The enamel is smooth.

Measurements.

	M.
Elevation of highest cusp	0.009
Elevation of shorter	.007
Long diameter base of crown	.006
Long diameter base of flat side	.005

The premolar is smaller, with shorter cusps, and one of the laterals reduced to a rudiment. This species is near *T. fallax* of Marsh, but the tooth he describes is narrower in proportion to its length, and has the anterior lobe little over half as high. The measurements of this species are somewhat larger than those given by Marsh for his *T. grandis*, (Amer. Journ. Sci. Arts, August 13, 1872.)

REPTILIA.

CROCODIL.

CROCODILUS.

CROCODILUS CLAVIS, Cope.

Proceed. Amer. Philos. Soc., 1872, p. 485, (Aug. 20.)

This is a large species, with a muzzle of narrowed proportions, and sufficient depth to give it a broad oval section. The nasal bones appear to have reached the nasal orifice. The anterior superior teeth are very large, especially the canine. The inferior tooth corresponding is large, and occupies an emargination which approaches near to the nasal suture. The pitting of the muzzle is fine, and the swollen interspaces much the wider. The teeth have stout conic crowns, with well-developed cutting edges, and coarse striate sculpture. The mandible is acuminate to the narrow extremity, and has a long symphysis, which extends to opposite the third tooth behind the notch. The cervical vertebræ preserved have round cups; they have a simple elongate hypopophysis, with a pit behind it; shoulder very prominent.

Measurements.

	M.
Length of ramus, with teeth	
Length of symphysis	.135
Width of ramus at end of symphysis	.085
Width of ramus at end of mandible	.020
Width of maxillary at third tooth above	.020
Width of maxillary at notch above	.020

This species has a more slender muzzle than those described by Marsh and Leidy, and is of larger size.

CROCODILUS ELLIOTTII, Leidy.

Geological Survey Montana, 1871, p. 366.

Abundant in the Bad Lands.

CROCODILUS SULCIFERUS, Cope.

Proceedings American Philosophical Society, 1872, p. 555, (October 12.)

A medium-sized species with cranium deeply and roughly pitted. The chief character is at present visible in the teeth. The larger of these are of subcylindric and short conic crown, which is superficially grooved from basis to near apex; sulci coarse, open.

Upper Green River.

CROCODILUS GRINNELLII, Marsh.

American Journal Sci. Arts, 1871, June.

Cranium from South Bitter Creek.

CROCODILUS LIODON, Marsh.

Loc. cit.

From various localities.

DIPLOCYNODUS, Pomel.

DIPLOCYNODUS SUBULATUS, Cope.

Crocodilus (*Ichthyosuchus*) *subulatus*, Cope. Proceedings American Philosophical Society, 1872, p. 554, (October 12.)

Some of the cervical vertebræ without hypopophyses. Their cups round, with smooth bordering surface of the sides of the centrum. The jaws only are preserved from the cranium; the premaxillary is strongly pitted, but the dentary has remote shallow pits on the outer face and shallow grooves below. Dentition something like that of *Diplocynodus ratellii* from France. There are two very long canine-like teeth in the premaxillary bone near its posterior margin, directed somewhat backward; these are preceded after a space by a medium-sized tooth, which after a similar space is preceded by another large tooth. Anterior to this the alveoli are lost. Two very smooth compressed straight teeth in the front of the ramus mandibuli. These are followed abruptly by a distantly set series of subequal teeth of not one-fourth the size, varying little to the back of the jaw; all the long teeth have subcompressed crowns with opposed cutting edges, and are smooth except at their bases. These are distantly sulcate, the separating ridges being acute. The smaller teeth are cones with cutting edges. There are fourteen alveoli and one pit in the dentary bone from the posterior end to the beginning of the short symphysis.

Measurements.

	M.
Length of alveolar series to beginning of symphysis	0.130
Diameter alveolus of seventh tooth	.008
Elevation eighth tooth	.017
Diameter at base	.0065
Depth of dentary at base	.025
Elevation of first lower canine	.018
Length crown of second upper canine	.017
Diameter crown at base	.007
Length third cervical, (with ball)	.037
Diameter of cup, vertical	.016
Diameter of cup, transverse	.018
Length of a posterior dorsal	.041
Diameter of cup, transverse	.026
Diameter of cup, vertical	.022

Found on the bluffs of Upper Green River.

This species agrees in some respects with the very brief description given by Marsh for his *Crocodilus liodon*. He does not mention the fluting of the base of the crown so remarkable in this species; and states the vertebræ to be "strongly rugose" near the extremity, a character not seen in the present animal.

The *Diplocynodus subulatus* was about as large as the Mississippi alligator.

DIPLOCYNODUS POLYODON, Cope.

Species nova.

Represented by portions of cranium and teeth, with probably some vertebræ found close to them. This crocodile is similar in size to the *D. subulatus*, or our alligator. It differs much from the last in the arrangement of the teeth. There is one pre-eminently large canine opposite the symphysis, (in *D. subulatus* this tooth is opposite the posterior end of the same,) which is followed by nine very small teeth, whose round alveoli are only separated by very thin walls. Following the last of these immediately is another very large tooth, with nearly round alveolus, which is closely succeeded by other smaller teeth of larger size than those in front of it, and not differing in this respect among themselves. The crowns of the teeth are cylindric at base, and have a double ridge on the anterior outer aspect. The enamel is obsoletely rugose, striate at the base. The external surface of the dentary bone is deeply and coarsely pitted; at its anterior part the pits are close, deep, and small; on the inferior face they are deep, short grooves. There is a series of close, small foramina along the inner side of the alveolæ.

Measurements.

	M.
Depth of symphysis	0.014
Diameter "anterior canine tooth"	.008
Distance of same from median "canine"	.030
Depth dentary bone at latter	.027
Width ramus at anterior canine	.025

This species differs in many respects from the one last described. The teeth, anteriorly, are much more closely placed, and the anterior and middle canines are less separated, and more numerous small teeth occupy the interval. The splenial bone has a larger share in the symphysis, and the sculpture is much more profound. The teeth are not fluted.

The type specimen was found on the bluffs of Upper Green River by the writer.

ALLIGATOR, Cuv.

The species described below belongs to this genus, so far as determinable from characters of the cranium and dermal scuta.

The axial portion of the basi-occipital bone is a transverse vertical plate with vertical carina on the distal half. The frontal bone exhibits no crests, and the crotaphite foramina are open. The quadratojugal arch is stout. The dermal scuta are not co-ossified, and with the cranium are deeply pitted.

ALLIGATOR HETERODON, Cope.

Proceedings American Philosophical Society, 1872, p. 544.

The anterior and posterior teeth of this species differ exceedingly in shape; the former are flattened, sharp-edged, and slightly incurved; the edges not serrate. Those of the premaxillary bone are subequal in size, while one behind the middle of the maxillary is larger than the rest. The posterior teeth have short, very obtuse crowns, with elliptic fore and aft outline. They resemble some forms seen in Pycnodont fishes, and are closely striate to a line on the apex. The upper surface of the cranium is pitted, the frontal and parietal bones with large, deep, and closely placed concavities. The former is perfectly plane, and the latter is wide. The squamosal arch is also wide, and the crotophite foramina are large and open.

The dermal scuta are very large for the size of the animal, and were not united by suture. They are keelless and deeply pitted, with smooth margins.

The vertebral centra found with other specimens are round. The co-ossified neural arches indicate the adult age of the animal.

Measurements.

	M.
Height crown premaxillary tooth	.004
Width crown premaxillary at base	.0035
Long diameter crown of a maxillary	.005
Short diameter crown of a maxillary	.0035
Width parietal	.009
Width frontal, posterior	.020
Width frontal, interorbital	.010
Width malar below eye	.008

The variation in the form of the teeth is a slight exaggeration of that seen in the dentition of various species of crocodilians.

This species was about three feet in length, found by the writer in one of the lowest beds of the Green River Tertiary epoch, near Black Buttes, Wyoming.

The dermal scuta of this species are very abundant in some of the beds of the Green River epoch. Some of them exhibit a faint trace of keel. Vertebræ associated with them have subround articular extremities.

TESTUDINATA.

AXESTUS, Cope.

Proceed. Amer. Philos. Society, 1872, p. 462. (Published July 29.)

This is a genus of Trionychidæ, which is represented by a species not fully known. The type specimen is represented by bones of the limbs and various vertebræ, with the postabdominal bone of the left side.

The general characters are those of *Trionyx*. The scapula is elongate, the procoracoid long and narrow, and the coracoid of medium width. The humerus is sigmoid, with widely spreading bicipital ridges and flattened extremity with marginal groove. The femur is also curved, but less strongly than the humerus, and has a median anterior low angular ridge. The claws are large, some curved and some entirely straight. The cervical vertebræ are relatively large and elongate. The two sacrals are free from the carapace above, have broad articular surfaces for diapophyses, and flattened centra. The caudals are procœlian, and have short diapophyses. The postabdominal bone has somewhat the form seen in existing *Trionyx*. It presents two dentate processes forward for the hyosternal, and two inward to its mate in front. It is prolonged backward and inward into a flat process. It is especially distinguished by its tenuity, and the entire absence of the superficial sculpture of *Trionyx*. The usual dense layer is present, but is quite thin, and exhibits the peculiar decussating pattern of lines of deposition characteristic of the same layer of the dermal scuta of *Crocodilians*. No portions were obtained which can with certainty be referred to the carapace. The ilium is short, stout, and recurved, and the pubis is largely expanded.

AXESTUS BYSSINUS, Cope.

Loc. cit.

The procoracoid and scapula are of equal lengths, and the coracoid is much dilated distally.

The portions of the plastron preserved are thin for the size of the animal, and all the bones are dense and smooth. The postabdominal has the free margins acute and senulate. There is an external gently convex edge, with a long process extending backward, and one long, narrow one inward. The enamel is white, and is marked with decussating lines of osseous deposit, as in woven linen. This is not the result of weaving. The cervical vertebra is without spine; it is not pressed in the middle, and is without any pneumatic foramen.

Measurements.

	M.
Length cervical vertebra	0.068
Diameter at middle	.020
Diameter at end	.035
Diameter caudal end at ball	.010
Length	.013
Length of an ungual phalange	.043
Proximal depth ungual phalange	.013
Length postabdominal, (broken)	.180
Width postabdominal	.120

Locality of the last.

TRIONYX, Geoffr.

TRIONYX HETEROGLYPTUS, Cope, sp. nov.

Carapace broad, flat, concavely truncate behind. Free portion of costal bones short. The last pair of costal bones are in contact by a common suture by about two-thirds their width, the anterior portion being separated by the last vertebral bone. There is a great difference between the sculpture of the middle of the carapace and its lateral portions. The former region is coarsely ribbed longitudinally, the intervening grooves being mostly uninterrupted. On the middle portions of the costals the ridges are more or less broken up, and distally they are very delicate, forming an inosculating pattern, inclosing small pits. On the last costal they retain their ridge-like character. The posterior vertebrals are marked by a single groove down their middle.

Measurements.

	M.
Width of carapace at antepenultimate costal bone	0.235
Length from front of carapace backward	.095
Width of carapace, costal, distally	.048
Length of last two vertebrals	.037

Excavated from the Bridger bed, on the summit of Church Butte, by the writer.

TRIONYX CONCENTRICUS, Cope.

Proceedings of the American Philosophical Society, 1872, p. 469; published July 29.

This species reposes on various fragments, in one case representing numerous portions of a carapace. The sculpture is intermediate between those of *T. heteroglyptus* and *T. guttatus*. The costals have subequal and subround pits throughout the entire length of the costal bones, but their interspaces are raised into longitudinal ribs at intervals of from one to three rows of pits. These ribs are equally developed at both ends of the costals.

Measurements.

	M.
Width of a costal bone near the middle	0.020
Thickness of costal bone near the middle	.003

The type specimen is smaller than that of the last.
From Cottonwood Creek.

TRIONYX GUTTATUS, Leidy.

Geological Survey of Montana, 1871, p. 370.

Not uncommon.

TRIONYX SCUTUMANTIQUUM, Cope, spec. nov.

Established on a nearly perfect carapace and part of the plastrum from the Bad Lands of Cottonwood Creek. These indicate the largest species of the genus yet found in North America.

The carapace is a longitudinal oval, broadly rounded in front. The median line forms a marked depression, and the costal bones rise and descend again, forming an arch on each side. The free portion of the ribs is not very long. The sculpture consists of numerous honeycomb-like pits separated by rather narrow ridges. On the middle parts of the carapace these are subequal, but on the middle of the length all the ridges run together longitudinally, and on their distal parts these are broken up so as to produce innumerable irregular tubercles and pits. The bones of the intercostal sutures are smooth. Eight costal bones, the anterior co-osified with the second by its entire width, and sending out a broad costal extremity which curves backward; its anterior margin is smooth. Eight vertebrals, the last separating the anterior portions of the last costals.

Measurements.

	M.
Length carapace	0.425
Greatest width carapace, axial	.410
Thickness of fifth costal	.0075
Thickness of fourth vertebra	.034
Thickness of centrum of fourth vertebra	.010

PLASTOMENUS, Cope.

Allied to *Trionyx*. No (?) marginal bones of the carapace except a nuchal; extremities of ribs little, or not projecting beyond costal bones. Plastron united with carapace by one or two tooth-like processes of the hyosternal and hyposternal bones. An anterior production of the hyosternal inclosing a median fontanelle and uniting by broad suture with a clavicle, (episternal.)

This genus is highly interesting as connecting more or less nearly the genus *Trionyx* with the *Chelydrine* form *Anostira*. It is represented by several species in the Bridger Eocene, all of which have the sculpture of both of the genera named. The plastron is ossified nearly as in *Anostira*, but in the numerous specimens obtained there was not one marginal bone. Nevertheless the strong emargination of the proximal end of the second costals proves the presence of a nuchal marginal, which does not exist in *Trionyx*; if there were other marginals they must have been small and inclosed in a cartilaginous margin. The first costals were much shorter than the second and much as in *Trionyx*. A costal process of the first dorsal extended backward and was attached by suture to the second costal bone just in front of its capitulum as in *Trionyx*, *Chelydra*, &c. A singular sternal bone accompanies the specimens of *P. thomasii* and *P. trionychoides*, but partially fractured in both cases so as to leave its position uncertain. It can be nothing else than the median portion of a hyosternal with the outer extremity wanting. It bounds a fontanelle interiorly, which nearly reaches the hyposternal; anteriorly it has sutures for both mososternum and clavicle. It is entirely unlike anything in *Trionyx*; it is thickened toward the median line, and strongly sculptured externally. The hyosternal or hyposternal of the "bridge" indicates that portion to have been long, and about as wide as is usual in *Trionyx*. Its free edge is thin; the sutural union with the other component bone complete.

The type of the genus is *P. thomasii*, (*Trionyx thomasii*, Cope.) Other species have been referred by me to Anostira. The largest species (*P. multifoveatus*) was about as large as the snapper; the smallest (*P. molopinus*) as large as *Chrysemys picta*.

PLASTOMENUS THOMASII, Cope.

Trionyx thomasii, Cope. Proceed. Amer. Phil. Soc. 1872; 462. (Published July 29.)

Represented by various parts of three individuals, a sufficient number of identical pieces being present in all to insure their specific unity.

The bones of both carapace and plastron have a honeycomb pattern of reticulation, with shallow pits, which on weathering become punctæ. The intervening ribs tend to connect into ridges running diagonally across the costal bones. The pits tend to form linear series parallel to the borders on some of the bones of the plastron. The latter are flat at the transverse suture. The last costal is very wide and in contact with its fellow on the median line, as in other species of the genus, except a sutural emargination behind, apparently for a pygal bone. The outer border is straight, truncating the last rib extremity.

Measurements.

	M.
Thickness of a costal	.004
Width last costal distally	.048
Width hyosternal	.018
Thickness hyosternal	.005
Length of a vertebral	.018
Width of a vertebral	.014

Two of the specimens from the Bad Lands of Cottonwood Creek, Wyoming. Named for Dr. Jos. Thomas, of Philadelphia, my former tutor.

PLASTOMENUS TRIONYCHOIDES, Cope.

Anostira trionychoides, Cope. Proceed. Amer. Philos. Society, 1872, p. 461. (Published July 29.)

The original specimen of the species was found mingled with one of *Anostira ornata*, and being of about the same size the two were supposed to pertain to a single species. I now distinguish the fragments clearly, and find portions of three other individuals from other localities to pertain to the same. One of these presents the two sternal elements described in the preceding account of *P. Thomasii*.

The sculpture of the costal bones consists of reticulated ridges which inclose coarser pits than in the last species, and show no tendency to run into ribs extending obliquely across the bones. The second costal exhibits a greatly leveled suture for the first, and its alar portion behind its costal rib is twice as wide as the latter. The last costal differs from that of *P. Thomasii* in being angulate instead of truncate at the rib extremity, and the latter projects strongly beyond the angle. In the second specimen the sternal bones are much more convex than in *P. Thomasii* and more thickened inwardly. Those of the specimens from the Bad Lands of Cottonwood Creek.

PLASTOMENUS MULTIFOVEATUS, Cope, spec. nov.

Represented by the costal bone of a specimen of much larger size than the preceding and following species. Its sculpture is a shallow but sharply impressed honeycomb pitting, smaller than in the preceding species. Thus there are seventeen or eighteen pits across the middle to seven or eight in *P. trionychoides*. No ribs whatever.

Measurements.

	M.
Width costal at middle	.0240
Width costal at end	.0350
Thickness at middle	.0035

PLASTOMENUS ŒDEMIUS, Cope.

Anostira œdemia, Cope. Proceed. Amer. Philos. Soc., 1872, p. 461, (July 29.)

Represented by most of the important parts of three specimens. These all display the last and middle costals, and two of them the second costals. Sternal bones are wanting, except, perhaps, in one.

From these it appears that the anterior costals have a distantly punctate sculpture, with rib-like swellings running diagonally across them. On the middle costals the punctæ disappear and the ribs grow thicker; on the last costals the ribs are broken into a number of smooth tubercular swellings whose axes are nearly at right angles to that of the carapace. The second costal has its posterior alar portion twice as wide as the rib portion; its suture with the first costal is very oblique and bounded behind by a rabbet edge. The last costals are peculiar in their union throughout their entire length without emargination for pygal, and in the gently convex posterior outline, with projecting rib end, differing in these respects markedly from *P. Thomasii* and *P. trionychoides*.

Measurements.

		M.
No. 1.	Length last costal, common suture	0.045
	Length last costal, anterior	.063
	Length last costal, exterior border	.052
	Width middle costal	.020
	Thickness middle costal	.004

		M.
No. 2.	Width first costal, proximally	.026
	Width first costal behind rib, distally	.014
No. 3.	Width middle costal	.021

Two of the specimens from Cottonwood Creek.

PLASTOMENUS MOLOPINUS, Cope.

Proceed. Amer. Philos. Soc., 1872, p. 461, (July 29,) *Anostira.*

First costal bone with wide rib, the aliform border behind it not more than half its width. Suture for first costal distal, obliquely truncating end of rib, vertical and not oblique. External surface of the same coarsely pitted, and with obscure oblique ribs. Median costals with approximated thick cross-ribs, with obsolete punctations between.

This species is near the *P. oedemius*, but differs considerably in the form of the first costal bone. The type is smaller than those of the latter.

Measurements.

	M.
Width first costal at extremity	.0120
Width first costal, .75 inch from end	.0210
Width of a middle costal	.0140
Thickness of a middle costal	.0055

From the Bridger group, Wyoming.

ANOSTIRA, Leidy.

Proceedings Academy Nat. Sci., 1871, p. 102

In this genus the epidermis was thin and adherent to the bones, and not divided into scuta. The carapace is composed as in *Emydidæ* of costal vertebral and marginal bones, the last united to the first by suture and gomphosis. The series of vertebrals does not continue to the caudal, except by the intervention of a pygal. The sternum is cruciform, with narrow, longitudinal prolongations, or lobes, and narrow bridges. It appears not to have possessed any fontanelles, but the presence of mesosternum is not yet fully made out. The cranium and limbs are unknown. This genus must be regarded as an interesting intermediate type, connecting *Plastomenus* and *Chelydra*, or *Dermatemys*. In skin and sculpture it is identical with the first; in carapace and plastron, most like *Chelydra*.

Two species, a large and a small, are known.

ANOSTIRA RADULINA, Cope.

Proceed. Amer. Philos. Society, 1872, p. 555, (published October 12.)

Based on two marginal bones, one from the front, the other from the rear, of the carapace of an animal of twice the bulk of the largest *Anostire* yet found. Apart from size, the sculpture is peculiar. It consists in the anterior of closely packed vermicular ridges which run out flat on the posterior and upper edge. In the posterior it consists of only closely placed minute tubercles over the whole surface.

Measurements.

	M.
Length front on free edge	0.025
Width front on free edge	.028
Length posterior on free edge	.025
Width posterior on free edge	.025

Bad Lands of Ham's Fork, Wyoming.

ANOSTIRA ORNATA, Leidy.

Loc. cit.

From Bad Lands of Upper Green River and Cottonwood Creek.

BAËNA, Leidy.

Geological Survey, Wyoming, 1870, p. 367; Survey, Montana, 1871, p. 368. *Chisternum*, Leidy. Proceed. Academy Nat. Sciences, 1872, p. 162.

Family *Baenidæ* agreeing with the *Adocidæ** in the presence of intergular scuta, and the absence of coössification of the ischium and pubis with the plastron, but differing in the presence of an intersternal bone on each side, as in the *Pleurodira*. As generic characters, it possesses two marginal intergular plates, which resemble the gulars of *Emydidæ;* it has a series of intermarginal scuta, and the free lobes of the sternum are narrowed and shortened; the bridge is very wide. The dermal scuta are everywhere distinct. The mesosternal bone is in form between T-shaped and sagittate. The last pair of marginals, instead of being in contact, are separated by a wide emargination.

The affinities of this genus are complex and interesting. It would be a pleurodire, but for the fact that the pelvis is not coössified with the plastron; nevertheless there are rudiments of this union in the form of a shallow pit on each. The posterior or ? ischiadic is near the posterior end, and on the lateral margin of the postabdominal bone; it is of a narrow oval form. The anterior is shallow, and sublaterally impressed into the side of the upright septum, which supports the carapace. Whether it received the pubis or not is uncertain.

The double intergular scuta is not found in any existing genus of *Pleurodira*.

The posterior margin of the carapace is excavated, as in *Chelydra*, but the margin is more arched in this position in *Chisternum*. The form suggests the presence of a large tail, and the serrate margin of the carapace posteriorly reminds one again of *Chelydra*. There are in *B. arenosa* fourteen marginal scuta, without the nuchal; in *Chelydra serpentina*, as in *Emydidæ*, but thirteen.

There are prominent axillary and inguinal septa, as in some *Emydidæ*. They are composed of the produced edges of two coössified costal bones.

The affinities appear to be to *Adocus* on the one side, and *Hydraspididæ* on the other, perhaps as descendant of the former and ancestor of the latter. It also possesses traces of other relationships of *Adocus*, *i. e.*, to *Dermatemys*, and more remotely to *Chelydra*.

BAËNA HEBRAICA, Cope.

Baëna hebraica. Proceed. Amer. Philos. Society, 1872, p. 463, (published July 29.)

General form depressed and discoid, as wide as long. Bridge wider than long, but the length equal to the width of the bases of the sternal lobes. Anterior lobe longer than wide at the base, and narrowed at the extremity. The inguinal and axillary septa are very prominent. The edge of the carapace from the front to the inguinal region is without emargination. All the osseous elements are coössified.

The scuta are well distinguished. The unchal is very small and wider than long; the first marginal is shorter but more prominent. The second and third are larger but narrow; the fourth and fifth are wider, but the

*Proceed. Amer. Philos. Soc., 1870, p. 547.

sixth widens by an inward projection of its border so as to meet the intercostal suture between the second and third costal scuta. From this one to the ninth (as far as preserved) the inner margins are produced so far as to make the scuta nearly twice as wide as long, when viewed from above. The first costal is small, its posterior border is curved. The first vertebral is pyriform, truncate in front. It is (perhaps abnormally) divided by a transverse suture into a quadrate anterior and cordate transverse posterior portion. The other vertebrals are somewhat longer than broad and are separated by sutures convex anteriorly.

The intermarginal scuta are all wider than long; their number is normally four, but a narrow one is intercalated behind the inguinal on one side. The longitudinal suture of the acutes of the plastron is exceedingly tortuous, winding between points more than an inch apart. The gulars and intergulars are transverse and bounded by transverse sutures. They cross the median suture (which is straight on the anterior lobe) some distance apart. The humerals are long and the humeropectoral scutal suture is convex backward, its extremities reaching the margin in front of the axillæ. The anterior extremity of the anterior sternal lobe has a quadrilobate outline.

The surface is smooth except along the lines of intercostal sutures, where short grooves parallel to the general axis alternate with protuberances having the same direction, the whole having somewhat the appearance of sculptured characters.

Measurements.

	M.
Length carapace (axial) (19 inches)	0.500
Width carapace (axial) (19 inches)	.500
Length of plastron from groin	.295
Width of base anterior lobe	.155
Width extremity anterior lobe (at gulars)	.080
Length of anterior lobe (at gulars)	.123
Width of nuchal scute	.011
Length nuchal scute	.024
Length third marginal	.038
Width third marginal	.015
Width eighth marginal	.090
Length eighth marginal	.063

This species, when compared with its nearest ally, *C. undatum*, differs in the greatly wider marginal scuta; in the latter the corresponding ones (6–7–8–9) are much longer than wide, as in most other tortoises. The intermarginal scuta are of more elongate forms, and the normal number is five in *B. undata*, instead of four. The sculpture in the longer-known species is entirely distinct, consisting of pits and tubercles scattered generally over the surface, while the peculiar sculpture of the suture lines is wanting. *C. hebraicum* is relatively wider.

Bad Lands of Cottonwood Creek.

BAËNA UNDATA, Leidy.

Geological Survey, Montana, 1871, p. 369.

A partially complete specimen of this species presents the following characters. The anterior lobe of the plastron is as wide as that of *B. hebraica*, but little more than half as long. The posterior lobe is truncate at the extremity. The nuchal scute projects beyond the first marginal; the reverse is the case in the type of *B. hebraica*. The posterior sutures of the intergular and gular scuta have a common center, and that of the gular has a rectangular curvature, the nearly transverse middle portion slightly convex forward. The suture separating the femoral and anal scuta is similar, but reversed in direction, presenting two obtuse right angles, two portions being transverse and one longitudinal on each side.

From Black's Fork and other localities.

BAËNA ARENOSA, Leidy.

Loc. cit. Baëna affinis, Leidy, *ibid.*

A perfect specimen of smaller size than those of the preceding species, and one about equal to the *Ptychemys rugosa*, is not dissimilar in form. The carapace is strongly convex, and all its component parts, as well as those of the plastron, are co-ossified. The sutures of the intersternal bones are visible. The posterior end of the carapace is arched upward, and smoothly excavated; the postero-lateral borders are thin, and deeply notched as the ends of the scutal sutures. Similar but shallower emarginations mark the borders of the marginal scuta. The anterior margin is slightly concave. The lobes of the plastron are narrow, the posterior wider and slightly emarginate. The bridge is wide, and not more than half as long as the width of the base of the posterior lobe.

The general surface is minutely rugose or shagreened, on the plastron strongly so, and without other sculpture. The carapace is marked by strong grooves disposed in a regular manner. A double groove extends along the median line of the second, third, and fourth vertebral scuta. Other grooves are nearly parallel to this one, whose extremities diverge to the angles of the vertebral scuta. At the anterior angles of the costal scuta oblique grooves converge toward the vertebrals, and are continued backward as parallel to the median line. They are separated by parallel tuberosities. On the first and last vertebral scuta there are transverse grooves next the adjacent vertebrals, and longitudinal ones toward the margins of the carapace.

The scuta are well marked. The marginals are all longer than wide, except the four preceding the last, which are all wider than long. The last is suboval, and is very small, while the anal is altogether wanting. The nuchal is divided, (it is single in *B. hebraica;*) the first marginal is very small and projecting; the third is longer, while the fourth, fifth, and sixth are rather short. The vertebral scuta are all longer than wide, and the fourth is deeply emarginate to receive the last scute. The first is a broad triangle with anterior angle truncate, and the two basal ones cut off to a less degree.

The scutal sutures of the plastron are but little sinuous. The intergulars have precisely the form of gulars of *Emydes*. The posterior gular suture crosses the median line a short distance posterior to those of the intergulars, and each half consists of an obtuse V directed backward. The posterior humeral suture originates in front of the axilla. There are four intermarginal scuta on the one side and three on the other, the additional one being a small one behind the left axillary. The femoro-anal suture is nearly straight.

Measurements.

	M.
Length of carapace, (axial)	0.450
Width of carapace, (axial)	.240
Length of plastron	.290
Length of anterior lobe	.082
Length of posterior	.085
Width of extremity anterior lobe	.038

	M.
Width of extremity posterior lobe	.057
Length of nuchal scuta	.030
Length of third marginal	.023
Width of third marginal	.020
Width of fourth marginal	.024
Length of fourth marginal	.028
Length of eighth marginal	.050
Width of eighth marginal	.035

This species differs in many details from the preceding species, notably in the form of the marginals. The anterior are wider than in either species, while the median are narrow as in *C. undatum*. The sculpture is very distinct from that of either.

From the Bad Lands of Ham's Fork, Wyoming.

BAËNA PONDEROSA, Cope, sp. nov.

Established on numerous fragments of a specimen of a species which I cannot refer to this genus with certainty, but which agrees with the species already known in some particulars of structure. Thus the last marginal plates were separated by an excavation of the posterior border; at least this is the only position to which I can refer a portion of the margin of the carapace where the marginal scutes suddenly cease; the lateral ribs of the bridge are received into a deep pit between two costals.

The marginal and other bones are very massive, much more so than in any other known water-tortoise of this formation. The margins of the former are thickened, especially at the last marginal scute, which is on a massive protuberance. The sutures are entirely regular. The lateral marginal scuta are about as long as broad. The surface of the shell is marked with irregular impressions, which are sometimes like rain-drop pits. A posterior vertebral bone possesses a median rib similar to that in *Dermatemys vyomingensis*.

Measurements.

	M.
Length of an anterior marginal scute	.045
Width of an anterior marginal scute	.039
Thickness of bone at anterior marginal scute	.023
Length of a free marginal bone	.050
Width of a free marginal bone	.057
Length of first marginal of bridge	.060
Thickness at simple end	.023

From the Bad Lands of Ham's Fork, Wyoming.

DERMATEMYS, Gray.

Baptemys, Leidy, loc. cit.

This genus is similar to Emys in the structure of the carapace and plastron, except that the lobes of the latter are narrower and shorter. The scuta are similar, excepting that there is a series of intermarginals on the bridge on each side. There are thirteen marginals on each side, those of the last pair in contact throughout. In a specimen of the only species known, I find a trace of an intergular scute as is sometimes seen in *D. berardii*, now living in Mexico.

DERMATEMYS WYOMINGENSIS, Leidy.

Loc. cit.

From various localities.

EMYS, Brong.

Section *Palæotheca*, Cope.

Proceed. Amer. Philos. Society, 1872, p. 463; *Notomorpha*, l. c., 1872, p. 474.

This genus is composed of *Emydidæ* in which the marginal and costal bones are united by suture with the weak gomphosis of many of the recent forms of the family. The plastron is united by sutural attachment of the prolonged borders of the bridge to one or two adjacent costal bones, in an elongate pit of greater or less elevation. This elevation may be so produced as to constitute axillary and inguinal septa as in the recent genus *Batagur*. In many of the species the anterior or axillary suture is on a single costal, the posterior on the produced margins of two. Several of the species are of small size and with strongly convex carapace. Some of these might be suspected to be young of others already known, but for the fact that their component pieces are generally more massive and their sculpture more pronounced. They resemble in several superficial respects our *Cistudines*.

I formerly (Extinct *Batrachia* and *Reptilia* N. A., &c.) described a genus *Agomphus* of the Cretaceous period as having the character of articulation of the marginal bones without gomphosis; in this some Eocene forms agree with it. Additional specimens of *A. petrosus*, Cope, the type, show that it possesses a series of intermarginal scuta as in *Adocus* and *Dermatemys*.

Some of the species (*E. testudinea*, &c.) I originally placed in a separate genus, *Notomorpha*, on the supposition that they were pleurodire. The costal articulations of the bridge are identical in form with those of the pubis in many pleurodire genera, (*Taphrosphys*, *e. g.*,) and are so oblique as to be similar to these in position also in relation to the lateral sutures when the flat costal is not complete. The species appear to belong to the present genus.

Most of the smaller species were found in strata of the Green River epoch, near Black Butte and Evanston; the larger species occur in the Bridger beds proper. The following is a synopsis of the species:

I. The bridge sutures not or moderately elevated on a single costal at one extremity of the carapace only.
  a. Dorsal line with a projecting keel.
    E. polycyphus; E. terrestris; E. megaulax; E. pachylomus.
  aa. Dorsal line not keeled.
    β. Mesosternal not reached by gular scuta.
      E. testudineus; E. euthnetus.
    ββ. Mesosternal entire, bearing part of gular scuta.
      E. gravis; E. wyomingensis; E. latilabiatus.
II. The bridge sutures on prominent septa, which are composed of adjacent parts of adjacent costal bones.
    E. septarius.

Emys septarius, Cope.

Established on a nearly complete specimen of the size of *Ptychemys rugosa*. The carapace is rather thin and the sutures not obliterated. The vertebræ are sessile on the vertebral bones. The form is quite convex. The plastron is flat and rather stout. The mesosternum is rhombic, the longer angle anterior on the outer side, but posterior on the inner side. Its anterior angle is embraced by the gular scuta. The anterior lobe of the plastron is contracted near the axillæ, and flared with a thin edge in front of it; then contracted to the rather narrow lip of the middle front. The posterior lobe is somewhat flared and has a wide beveled margin, and is deeply notched behind, the notch being close and the lobes projecting.

The surface is delicately sculptured with obsolete ridged lines across the axis of the costal bones. The vertebral region is somewhat swollen between the cross-sutures, which present an obtuse angle in the same direction, both before and behind. The scuta are longer than wide, and have bracket-shaped outlines. The surface has the obsolete ridges, which diverge in every direction from the median inlooking angle of one end, but are mostly longitudinal.

In old specimens this delicate sculpture might become obsolete.

Measurements.

	M.
Length of plastron	0.325
Width of, at groin	.150
Width lip	.054
Length lip	.030
Width clavicular bone behind	.041
Width mesosternal externally	.058
Length mesosternal externally	.045
Thickness hyosternal behind	.015
Length of vertebral scutum	.072
Width of vertebral scutum	.068
Width of a costal bone	.029
Thickness of a costal bone	.006

Found in the Bad Lands of South Bitter Creek by the writer.

EMYS LATILABIATUS, Cope.

Proceedings Amer. Philos. Soc., 1872, p. 471.

Represented by a perfect specimen of a tortoise of a broadly oval form, and somewhat terrestrial habit. Its prominent characters are to be seen in the plastron, of which the posterior lobe is deeply bifurcate. The anterior lobe is peculiar in the unusual width of the lip-like projection of the clavicular ("episternal") bone, which is twice as wide as in *E. wyomingensis*, and not prominent. Bones all smooth; margins of lobes of plastron thickened.

There are three scars, perhaps of muscular insertions near the posterior margin of the plastron, one oval one opposite to each lobe, and one round one opposite to the notch.

As compared with *E. septarius* this species has no such septa nor sculpture; the emargination of the plastron is more open, and the lip much shorter and wider.

Measurements.

	M.
Length of carapace	0.255
Width of carapace	.250
Width of lip of plastron	.06
Depth of posterior notch	.02

From near Black's Fork of Green River.

EMYS WYOMINGENSIS, Leidy.

Geological Survey Montana, 1871, p. 367.

Abundant in the Bridger formation.

EMYS GRAVIS, Cope.

Notomorpha gravis and *N. garmanii*, Cope, Proceed. Amer. Philos. Soc., 1872, p. 476, 477.

The preceding names were used to designate what were supposed to represent different species, which were stated to differ in the form of the episternal bone. This difference appears with further observation to be less important than was supposed.

This species is known by portions of several specimens. The type is larger than any of the last described, and equaled some of the *Chlonidæ* of the ocean in dimensions. The right hyosternal bone indicates both resemblance and difference from the *N. testudinea*. The former is seen in the internal thickening parallel to the margin, bounded behind by a deep groove extending to the axilla. A peculiarity, in which it differs from the *N. testudinea*, is seen in the posterior position of the humero-pectoral dermal suture, which originates at the axilla. The epihyosternal suture is concave. The thickened portion of the episternal margin is shorter and wider than in the species just named, the width being to the length as 2.5 to 2; in *N. testudinea*, as 1.5 to 2.

Measurements.

	M.
Thickness of hyosternal anteriorly	.011
Width of costal, (?) second specimen	.058

Surfaces not sculptured.

From Green River strata, near Evanston, Wyoming.

EMYS TESTUDINEUS, Cope.

Notomorpha testudinea, Cope, *loc. cit.*, p. 475.

Represented by portions of four or more individuals. In one of these the anterior lobe of the plastron is in part preserved. The mesosternum is a transverse oval, the posterior margin regularly convex, the anterior with three equal borders. The median of these is concave. The sutures are radiating, and the groove separating the humeral scuta appears to traverse the entire length of the bone. The outer surface is gently convex. The free margin of the episternal and hyposternal bones is acute, and with an internal thickening, as in *Cistudo*, *Testudo*, &c., forming a ridge, with abrupt inner face. This face extends backward as a groove to the axillary process of the hyosternal, forming a characteristic mark. Although the extremity of the episternal bone is lost, and the mesosternal exhibits no trace of the intergular scute, the outer sutures of the gular scuta are so far posterior as to render it highly probable that the intergular plate existed. At the point where this suture reaches the margin the latter is openly emarginate. The posterior suture of the humeral scute crosses the margin half way between the axilla and the episternal suture, and is not marked by a notch. The last-named suture is transverse. On the xiphisternal bones the groove of the anterior suture of the anals is plainly visible. It is regularly convex forward, and in one specimen is double.

In a second specimen of about the same size parts of two costal bones are preserved. They are thick, and display the usual costal and vertebral scute-sutures, the latter one in a groove, for the middle of the vertebrals is elevated, and the costals project shoulder-like just outside the groove.

In a third specimen, a little larger, xiphisternals with several marginals are preserved. A free posterior marginal is regularly recurved, and the scute-sutures are deeply impressed. The marginal scuta have evidently been marked with concentric grooves within their margins. The first marginal bone of the bridge has a very obtuse edge.

In none of the specimens are the surfaces sculptured.

Measurements.

No. 1.

	M.
Width plastron at axilla	0.056
Length plastron from axilla, (approximate)	.05
Thickness hyosternal at mesosternal	.009
Thickness hyosternal at hyposternal	.0065
Width mesosternal	.037
Length mesosternal	.026
Thickness of a vertebral	.006
Thickness of xiphisternal, (normal)	.004
Thickness of xiphisternal at pubis	.007

No. 2.

Thickness costal at hump	.0075
Width of costal	.0175

No. 3.

Width of posterior marginal	.027
Length of posterior marginal	.019

The mesosternal, though found with No. 1, does not fit it exactly and does not belong to it.

From Green River formation near Evanston, Wyoming.

EMYS EUTHNETUS, Cope, sp. nov.

Represented by numerous portions of several specimens. These pertained to a species of about the size of the salt-water terrapin, *Malacoclemmys palustris*. There is no dorsal keel, and the scutal sutures, though distinct, are not very much impressed, nor the interspaces swollen. The lip of the plastron is narrow, thick, and not notched; the sutures of the gular scales do not extend on to the mesosternum. The margins of the lobes of the plastron are a little thickened and the sutures of the bones coarse, and at the hypoxiphisternal junction, &c., with gomphosis. (It is fine and close at this point in *E. testudineus*.)

The costal sutures for the bridge are projecting and curved in one position; in the other straighter, and very near the margin of the costal bone. Surfaces smooth.

Abundant in the red beds which lie between those of the Green River and Bridger epochs at Black Buttes, Wyoming.

EMYS MEGAULAX, Cope, sp. nov.

Represented by remains of two specimens. They pertained to a species of about the size of that last described. The marked peculiarity consists in the broad and abruptly sunken sutures which separate the dermal scuta of the carapace. This is visible on vertebral, costal, and marginal bones, where the areæ between the sutures are abruptly separated. The sutures partially interrupt the dorsal carina. This is wide and low. The sculpture is otherwise smooth. The scutal sutures are not so impressed on the plastron, and those of the gular scutes extend on the mesosternal bone.

Measurements.

	M.
Length of a marginal	.016
Width of a marginal	.023
Width of a vertebral	.018
Length of a vertebral	.017

The vertebrals are subquadrate in form. Neither carapace nor plastron is thick. The mesosternal is transverse, diamond-shaped, and angular in front.

Measurements.

	M.
Length	.023
Width	.034

From the Green River beds at Black Buttes. A third but uncharacteristic series of fragments, from the first lignite-bed above the Cretaceous, probably belong to this species.

EMYS PACHYLOMUS, Cope, sp. nov.

Established on fragmentary specimens of a species similar in size to the last. The principal difference is to be seen in the scutal sutures, which, though strongly marked, are not so widely and deeply impressed. Though they are fine, they interrupt the dorsal carina, which swells up from it, and divides the flat proximal portion from the much swollen marginal part of the marginal bones. The mesosternal bone is similar in form to that of the last species; the only specimen is obtusely rounded in front, and bears part of the gular scuta.

From Green River beds, near Black Buttes.

EMYS TERRESTRIS, Cope.

Palæotheca terrestris, Cope. Proceed. Amer. Philos. Soc., 1872, p. 464.

In this species, and the following, the lip only is inclosed by the gular scuta, which only reach the apex of the mesosternal. In neither are the articulations of the bridge with the costals known. Represented by three individuals, one of which may be regarded as the type. They are all thinner than the *E. polycyphus*, and larger, being about equal to the *Aromochelys odoratus* of our ponds.

In the type specimen the carina of the vertebral bones is interrupted by a deep sutural groove, which is less pit-like than the *E. polycyphus*. The bone itself is broader than long, being, perhaps, from the hinder part of the carapace. The clavicular (episternal) bone is preserved. It is characterized by the considerable and abrupt projection of that part inclosed by the gular scutum, which resembles what is sometimes seen in *Testudo*. The edge of this part is entire and acute. The posterior part of the projection forms a step-like prominence behind, on the superior or inner face. The bone is almost as wide as long, and the mesosternal causes a very slight medium truncation, but overlapped much on the inner side. The gular dermal suture does not reach it.

Measurements.

	M.
Length vertebral bone	.009
Width vertebral bone	.018
Length episternal	.02
Width episternal, (transverse to axis of body)	.017
Width of a costal	.011
Thickness proximally	.003

In the second specimen, a strong groove is seen to bound the lip of the front lobe of the plastron, as in the species of *Notomorpha*. In it the marginal is seen to be stout, a little recurved, and sharp-edged. A vertebral differs from those described in being longer than wide. In a third individual, the gular lip is not so prominent as in the type, and the mesosternal bone truncates the clavicular extensively, giving it thus a more elongate form. The gular scuta expands to its front margin. The marginal bone is stout and sharp-edged, and is not so deeply impressed by the dermal suture as in *P. polycypha*.

EMYS POLYCYPHUS, Cope.

Palæotheca polycypha, Cope. Proceed. Amer. Philos. Soc., 1872, p. 463.

This species of tortoise is indicated by vertebral, costal, and marginal bones of very small individuals. These bones are, however, not only thoroughly ossified, but are very stout, indicating the adult age of the animal. The deeply-impressed scutal sutures, and heavy proportions, as well as the elevated carina of the carapace, indicate affinity with *Cistudo*, or, perhaps, *Testudo*. As another generic character, it may be noted that the vertebral bones are subquadrate and support the neural canal without intervening lamina.

The carina of the carapace is abruptly interrupted occasionally; sometimes with, sometimes without, a pair of pits, one on each side. The marginal bones are well recurved, and the scutal sutures are deeply impressed on them.

Measurements.

	M.
Length of vertebral bone	.009
Width of vertebral bone	.0085
Length of marginal bone	.01

This is the least of the tortoises of the Bridger formation.

HADRIANUS, Cope.

Proceed. Amer. Philos. Soc., 1872, p. 468.

This genus resembles *Testudo* in form, but has two anal scuta, as in most *Emydidæ*. The claws are short and stout; an ungual phalange is a long oval viewed from above, and is oval in section, with obtuse edges. The articular surface is subinferior. A cervical vertebra is of moderate length, and has a very prominent anterior zygapophysis. The centrum presents two distinct convex articular surfaces anteriorly, and one transverse one behind. A sacral is free from the carapace above; it presents two subround articular cups posteriorly and outwardly; the anterior are broken off. These characters are observed in a large specimen of *H. Corsonii*.

HADRIANUS ALLABIATUS, Cope.

Proceed. Amer. Philos. Soc., 1872, p. 471.

This large land-tortoise is nearer in general form to the *H. corsonii* than to the *H. octonarius*, but differs from both in the absence of the projecting lip of the anterior lobe of the plastron, which is thus simply truncate. The mesosternum is not cordate, but has much the shape of that of *H. corsonii*, that is, rhombic. The scutal sutures are deeply impressed. The plastron is strongly concave. Carapace without irregularities of the surface. Length 18 inches.

From the Bad Lands of Cottonwood Creek, Wyoming.

HADRIANUS OCTONARIUS, Cope.

Proceed. Amer. Philos. Soc., 1872, p. 468.

The *H. octonarius* is distinguished from its congener in many ways. It is of elongate form, strongly contracted at the bridges, but expanded and arched above the limbs. The carapace in quite convex. The plastron has the posterior lobe emarginate rather than bifurcate, as seen in *H. Corsonii.* Each projection represents a right-angled triangle rather than a wedge. The anterior lobe presents an elongate lip, which is expanded, and slightly emarginate at the end. The mesosternal bone is heart-shaped, the posterior emargination being wide and deep.

The anterior margin of the carapace is somewhat flared above the limbs. The nuchal scutum is very narrow transversely, but elongate. The carapace descends and is incurved in the middle of the posterior margin.

Measurements.

	M.
Length, (below)	.730
Width at middle	.437
Width at hind limbs	.525

This species differs from the *H. Corsonii* in many important points. It is, perhaps, the largest of our extinct land-tortoises, and is founded on a beautifully perfect specimen from the bluffs of Cottonwood Creek.

HADRIANUS CORSONII, Leidy.

Geological Survey, Montana, 1871, p. 366; *Testudo hadrianus*, Cope. Proceed. Am. Philos. Soc., 1872, 463; *Hadrianus quadratus*, loc. cit., 468.

Indicated by many individuals, two nearly perfect, another chiefly represented by a complete plastron. This proves the existence of a very massive species of the terrestrial genus Testudo. The plastron presents a short wide lip in front, which is turned outward, forming a strong angle with the plane of the upturned front of the lobe. This lobe is bordered by a thickening of the upper surface, which cuts off the basin from the lip, as a higher ridge. The posterior lobe is deeply bifurcate, each postabdominal projecting as a triangle. There is a notch at the outer angle of the femoral scute. The hyposternal bone is greatly thickened within the margin above, and an elevated ridge bounds the basin of the plastron behind, as before. The middle of the plastron is thin.

The carapace is without marked keel or serrations. It is remarkable for its expanded and truncate anterior outline, which is nearly straight between two lateral obtuse angles.

Length carapace, M. .750=29 inches; width, .630. The marginal scuta are narrow, and there is a large nuchal plate.

Abundant in the Bridger beds.

LACERTILIA.

NAOCEPHALUS, Cope.

Proceed. Amer. Philos. Soc., 1872, p. 465, (July 29.)

Established on an incomplete cranium, with vertebræ found associated. No teeth are preserved, nor any part of the mandible. The remaining portions of the cranium are, however, highly characteristic.

The occipital descends posteriorly, and bears a pair of lateral ridges, which converge rapidly posteriorly. This bone is united with the parietal by suture, which is transverse; its outline is rectangular, so as almost to reach the frontals, which are prolonged backward on each side the parietal, leaving but a narrow exposure of the posterior processes of the parietal. These extend backward, and are broken off in the specimen, but they probably formed parts of arches. The parietal is single, and there is no parietal fontanelle. The bone is triangular in outline, with the apex anterior, dividing the frontals. These are contracted at the orbits, and have a projecting supercilliary head; anteriorly they are thickened. The postfrontals are of remarkable form. They are massive, and, compressed from before backward, they rise considerably above the level of the front, and bear on their summits a cotyloid cavity, which is transverse to the axis of the cranium; the use of this projection is obscure. There is an exoccipital foramen, and a large one in the posterior part of the frontal opposite the postfrontal elevation.

The sphenoid is a compressed keel-shaped bone, rounded below, and with broad alæ along much of its length. The occipital condyle is subcondate, depressed in outline, with a vertical obtuse angle in the middle, and the sides somewhat plane.

A dorsal vertebra preserved has a single vertical capitular process, and a short hypopophysis. The neural canal is large, and the neurapophyses are attached by sutures. The cup is nearly round, very slightly transverse, and vertical.

This genus differs from *Glyptosaurus*, Marsh, in the total lack of cranial shields, and from *Saniva*, Leidy, in the nearly round vertebral centra.

NAOCEPHALUS PORRECTUS, Cope.

Loc. cit., p. 465.

The cranium is smooth above, except the anterior part of the frontals, which are finely rugose.

Measurements.

	M.
Width cranium at postfrontals	.072
Width parietal behind	.012
Depth postfrontals	.018
Depth presphenoid anteriorly	.014
Diameter dorsal vertebra, (cup)	.007

From the Bad Lands of Cottonwood Creek.

SANIVA, Leidy.

Geolog. Survey, Wyoming, 1870, p. 368.

SANIVA ENSIDENS, Leidy.

Loc. cit.

Vertebræ, &c., from Black's Fork. The characters agree with those of *Iguanavus*, Marsh, except in the greater depression of the vertebral centra.

THINOSAURUS, Marsh.

American Journ. Sci. and Arts, October, 1872.

THINOSAURUS LEPTODUS, Marsh.

A considerable number of remains from Mammoth Buttes (Bitter Creek) agree nearly with Marsh's description, l. c.

OPHIDIA.

PROTAGRAS LACUSTRIS, Cope.

Proceed. Amer. Philos. Soc., 1872, p. 471, August 7.

A serpent of about the size of the existing pine snake, (*Pityophis melanoleucus*,) and allied to the water-snakes of *Tropidonotus* and allied genera.

A vertebra before me has the longitudinal hypopophysial keel of that group, which terminates in a very obtuse point. The ball looks extensively upward. The upper articular extremity of the parapophysis is short and obtuse, and the inferior equally so, and directed shortly downward, their articular faces being continuous with each other. It sends an obtuse latero-inferior keel backward, which terminates in front of the ball. The angle connecting the diapophysis and zygapophyses is strong, while the former was narrow; in the specimens it is broken.

Measurements.

	M.
Length of centrum with ball, (below)	.0090
Elevation behind, (total)	.0135
Elevation before, (total)	.0110
Width between parapophyses below	.0055
Width of articular cup	.0054
Depth of articular cup	.0043
Depth of inferior keel	.0020

From the Bad Lands of Cottonwood Creek.

This species is allied to the *Boavus* of Marsh.

BATRACHIA.

The vertebral column and part of the cranium of a probably incompletely developed tailless Batrachian were procured by Dr. F. V. Hayden, from the fish-shales of the Green River epoch, from near Green River City, Wyoming. They are not sufficiently characteristic to enable me to determine the relation of the species to known forms, and it is the oldest of the order yet discovered, the fossil remains of the known extinct species having been derived from the Miocene and later formations.

PISCES.

CLASTES, Cope.

Order *Ginglymodi:* Mandibular ramus without or with reduced fissure of the dental foramen, and without the groove continuous with it in Lepidosteus. One series of large teeth, with small ones exterior to them in the dentary bone, the inner superior aspect of that bone without prominent dentiferous or rugose rib.

The species of this genus resemble in many ways the *Lepidostei* of the present day. Their scales are rhombic and pierced by a duct on the lateral line. The cranial bones are ornamented by tubercles of ganoine, distributed variously according to the species. Some of these fishes reached a large size, exceeding any now living; others resembled the true *Lepidostei* in this respect.

The characters assigned to this genus are derived from the under jaw, and I have observed it in two species, one which I suppose to be the *Lepidosteus glaber*, Marsh, and the other C. *cycliferus*, Cope.

CLASTES ANAX, Cope, spec. nov.

Represented by some cranial bones, and especially by a posttemporal, which indicate a very large species of gar, two or three times as large as the alligator-gar of the Mississippi, (*Atractosteus ferox.*) The bone has a free ovate posterior outline, and its superior surface is covered with a thick layer of dense bone, which has not the brilliant surface of ganoine. This substance is thrown into elevated corrugated ridges, which are generally transverse to the long axis of the bone, and inosculate and are interrupted frequently. The spaces between are as wide as the bases of the ridges.

Measurements.

	M.
Width of bone	.042
Thickness of bone	.012

Found in the Bad Lands of Ham's Fork.

CLASTES ATROX, Leidy.

Lepidosteus atrox, Leidy. Proceed. Acad. Nat. Sci., Philada., 1873.

Abundant, and represented by both rough and smooth scales, the former from the anterior part of the body.

CLASTES CYCLIFERUS, Cope.

Established on numerous remains of a small species, in which the scales are rather wide, and generally with obtuse extremital angles, and frequently in certain regions of the body entirely rounded at the posterior border. Fragments of the cranial bones are ornamented with scattered tubercles of ganoine of rounded form, and not distributed in lines, as in some species. In a fragment from the posterior part of the mandible there is a single row of large teeth, with a series of minute ones between them, on the outer edge of the bone. The external face presents a smooth superior surface, and a rugose inferior portion which is marked by irregular lines of points of ganoine.

Measurements.

	M.
Depth of dentary bone	.0070
Width of dentary above	.0055
Length of a scale, (exposed face)	.0060
Width of a scale, (exposed face)	.0060
Thickness of cranial bone	

From Mammoth Buttes.

CLASTES GLABER, Marsh.

Lepidosteus glaber, Marsh. Proceed. Acad. Nat. Sci., 187.

Abundant.

PAPPICHTHYS, Cope.

Gen. nov. Halecomorphorum.

Family *Amiidae:* Vertebræ short, the dorsal with prominent diapophysis; the sides of the centrum striate-grooved. Maxillary bone with a supplementary bone on its distal upper border, and supporting a single series of teeth. Dentary bone with but one series of teeth; surface of cranial bones sculptured.

This genus differs from the existing *Amia*, in the presence of only one series of teeth, instead of several, on the bones about the mouth. The posterior part of the dentary bone, or perhaps another element, is covered with fine graniform teeth, as in *Amia calva*.

Species of the genus are numerously represented in the beds of the Bridger Eocene. Some of them have been referred to *Amia* by Marsh.

PAPPICHTHYS PLICATUS, Cope, spec. nov.

Established on a series of bones of the skull and vertebræ. The cranial bones are deeply grooved, and with parallel ridges between. The outer face of the dentary is roughly grooved on the inferior half of its posterior two-thirds. The inner face is marked by a strong groove near its middle to the symphysis, above which it is very convex; below it extends to a thin edge. The dental alveoli are shallow and in close contact; there are six in .025^{m} at its middle, where it is also .019 deep. The teeth become smaller at the symphysis. The maxillary bone is rod-like proximally, but flattens out much distally, and is there slightly rugose on the outer face. The teeth are smaller than the mandibulars, there being at the middle fourteen in .025^{m}. The alveoli are larger proximally. The depth of the bone at the beginning of the suture for the supplementary maxillary is .020^{m}. The superior extremity of the hyomandibular is broad and flat. The inferior quadrate is thickened behind, and has a sublongitudinal condyle distally. The squamosal suture of the pterygoid adjoins it.

Number cranial ridges in .010^{m}, 10. The vertebræ preserved are quite short, and have sessile diapophyses; they are broader than deep. Width, .026^{m}; depth, .019; thickness, .005. The articular surfaces for the neural arches are confluent, so as to have a subquadrate outline.

Another specimen is represented by numerous fragments. One of these is the proximal half of the *os maxillare.* This extremity rises in a curve, is somewhat depressed, and is excavated below. The inner face is very convex, the outer flatter and with squamosal suture for premaxillary external to the extremity a half inch. A fragment of the palatine exhibits a series of large marginal teeth and a plate of smaller ones within them, thus resembling *Amia;* the superior face exhibits a deep longitudinal groove, which opens out posteriorly. The proötic bone is a half disk, thickened on the straight edge, and with concave sides, with a flat tuberosity on one of them. On some of the cranial bones the ridges are interrupted. The dorsal vertebræ of this specimen have the centra broader than deep, and with projecting diapophyses. The neural articular faces are for its own arch and that of the next vertebra, and there are two narrow grooves on the inferior face. They are nearly or quite distinct. As this is observed on vertebræ with elongate diapophyses, and they are confluent, or one is wanting on those with sessile diapophyses, it is probable that the position of the neural arches is shifted on the dorsals, an arch being confined to a single centrum on the posterior ones, as occurs on the caudals only in *Amia calva.*

The specimens came from distinct localities on Cottonwood Creek.

PAPPICHTHYS SCLEROPS, Cope, sp. nov.

Established on a ramus of the mandible of one, and other similar specimens of other individuals. These indicate a large fish, equal in size to the alligator-gar of the Mississippi. The dentary bone is more compressed and deeper than in *P. plicatus.* The longitudinal groove runs above the middle line, and the portion of the bone below it thins to an edge. The upper portion is thickened, and the alveolar border is wide and bounded by an angle on the inner side. The alveoli are large and shallow; in .025^{m} scarcely three find place. Near the symphysis is a smaller one, which is separated by a considerable diastema from the succeeding one, (perhaps abnormally.) The external face of the bone is rough and somewhat tubercular.

Measurements.

	M.
Depth dentary at symphysis	.033
Depth dentary at middle	.038
Depth dentary at eleventh tooth	.048
Thickness dentary at eighth tooth	.018

PAPPICHTHYS LÆVIS, Cope, spec. nov.

Represented by various fragments including dentary and vertebral bones. The former differs from that of the species just described in the smaller size of its teeth, there being six in a space occupied by but four in it, at a point where the dentaries of equal depth. In other words, there are four in .0250^{m}. The alveolar faces are also much more oblique, being in fact continuous with the inner face of the bone. The external face of the dentary is smooth, and thus different from that of *P. sclerops.* A dorsal vertebra is but little wider than deep, and is truncate below, presenting a prominent infero-lateral angle.

Measurements.

	M.
Depth of dentary near middle	.037
Thickness of dentary near middle	.012
Depth centrum of vertebra	.029
Width centrum of vertebra	.038
Length centrum of vertebra	.009

From the bluffs of Cottonwood Creek.

PAPPICHTHYS SYMPHYSIS, Cope, species nova.

Established on a number of vertebræ of an individual of much smaller size than any of the preceding, and which was about the size of the largest growth of *A. calva.* The form of the dorsal centra is a little wider than deep; the caudal deeper than wide. What distinguishes these from the vertebræ of the species above described is the lack of distinction between the articular facets of the adjacent neurapophyses. These are almost confluent, instead of nearly or quite isolated as in the *P. lævis* and *P. plicatus.*

Measurements.

	M.
Length of centrum, dorsal	.006
Depth of centrum, dorsal	.014
Width of centrum, dorsal	.018
Depth centrum, caudal	.0115
Width centrum, caudal	.0105
Length centrum, caudal	.0040

The dorsals of the above specimen have short diapophyses and might be regarded as posterior, and the anterior might be anticipated to present a different type of articulation with the neurapophyses as in *P. plicatus.* But a vertebra of the same size and form, but with long diapophyses, from another locality, (Upper Green River,) presents the same subquadrate articular faces slightly constricted in the middle. Hence I suspect this character to be characteristic of the species.

PAPPICHTHYS CORSONII,* Cope, spec. nov.

This species is, perhaps, rather smaller than the last. A dorsal vertebra with inferior diapophyses is but little wider than deep. The

* Dedicated to Dr. Joseph Corson, formerly stationed at Fort Bridger, to whom I am under many obligations, professional and otherwise.

articular surfaces for the neurapophyses are 8-shaped, the area confluent. A marked peculiarity is seen in the dentary bone. It is much curved in the vertical plane as well as in the horizontal, and must have inclosed a wide mouth. The groove is median, and the inferior and superior surfaces reach it by a nearly equal slope. The former leaves the alveoli without horizontal border, though the latter themselves open on a horizontal plane. There are four and a fraction in .010^{m}.

Measurements.

	M.
Depth of ramus at middle	0.013
Thickness of ramus at middle	.006
Length posterior dorsal vertebra	.006
Depth posterior dorsal vertebra	.012
Width posterior dorsal vertebra	.013

From Upper Green River.

PHAREODON, Leidy.

Proceedings Academy Nat. Sciences Phila., 1873.

This genus belongs to the order of *Nematognathi*, as I discovered by various specimens in my possession.

The usual modification of the anterior vertebræ exists in this genus. The mass is carinate below, and bears two longitudinal cavities separated by a low partition above. The palatine bones support a mass of teeth, there being one external series of large ones rather abruptly pointed, and several series of small ones of little elevation, whose size diminishes inward. The dentary bone is narrow and deep and supports a single series of closely placed slender teeth, which together form a comb. The bases of these teeth are rugose-striate, and the apices abruptly acuminate.

The vertebræ are short, and with reticulate ridges on the sides. There is a pit on each side, and there are two pits on each of the sides above and below. The vertebra appears to be a caudal, and the connate hæmapophysis issues from between the lateral and inferior pits and has a round pit at its base.

The remains of spines are of rather small size, and are strongly striate and weakly serrate. The pectoral had the hinge arrangement of *Amiurus* and *Rhineastes*.

The single series of long conic teeth in the dentary bone is a peculiar feature, shared by few if any recent genera.

PHAREODON ACUTUS, Leidy.

Represented by numerous remains. The teeth as preserved are black, with white, translucent, slightly incurved apices. The dentary bones are deep, incurved, and with an erect elevated point at the symphysis; their outer surface is rugose, with deep longitudinal grooves and pits of irregular sizes.

Measurements.

	M.
Depth dentary at symphysis	.009
Depth dentary at fourteenth tooth	.015
Length of eighth tooth	.0056
Diameter of right tooth at base	.0015
Diameter of a caudal vertebra	.0085
Length of a caudal vertebra	.0055
Six teeth in	.0100

From Upper Green River.

PHAREODON SERICEUS, Cope, spec. nov.

Established on three teeth which differ from those of the *P. acutus* in their large size and stout conic form; also in having the basal striation finer, parallel, and extending over half the length of the crown. The basal portions as preserved are black, the apex white, and with a slightly abrupt contraction.

Measurements.

	No. 1.	No. 2.	No. 3.
Length of crown	.0050	.0090	.0070
Diameter of crown at base	.0035	.0040	.0040

From Upper Green River.

RHINEASTES, Cope.

Proceed. Amer. Philos. Soc., 1872, p. 486. (Published August 20, 1872.)

A genus of *Nematognathi* which differs from *Phareodon* in possessing the usual band of bristle-like teeth on the dentary bone, the series being numerous, (in *R. calvus*.) The basi-occipital bone exhibits a pit on the middle line below, and a surface for attachment for the inferior branch of the posttemporal on each side, (*R. calvus*, *R. smithii*.) The modified anterior vertebral mass is deeply grooved below, (*R. smithii*.) The cranium is covered with a rugose exostosis, (*R. peltatus*, *R. calvus*, *R. smithii*,) and has a strong closed groove in the position of the usual fronto-parietal fontanelle. The vertebræ (*R. smithii*) are short, and the sides of the centra only striate with the circumference. There are no lateral pits, but a pair above and a pair below, with a co-ossified apophysis at the base of one of them.

The spines preserved belong chiefly to the pectoral fin. They are strongly striate and weakly dentate, and have the usual hinge with superior recurved flange above, and two embracing processes below, at the base. The dorsal spine is weaker in *R. calvus*, but strong in *R. peltatus*.

This genus is allied to the recent *Ichthælurus*, but differs (*R. smithii*) in the vertebræ, and in the rough exostoses of the cranial bones. In *R. peltatus* the supra-occipital shield has a great mass and extent, but in *R. calvus* it is not much more extended than in *Ichthælurus*.

The expedition obtained remains of four or five species of this genus, the first of the order found extinct in this country.

I. *Rhineastes*; a large, massive nuchal shield.
  - Cephalic ossification pappilliform .... *R. peltatus*.
  - Ossification in rugose lines .... *R. radulus*.

II. *Astephus*; nuchal shield narrow and short.
  - Cephalic ossification in smooth lines; one basi-occipital pit; pectoral spines serrate on both edges .... *R. smithii*.
  - Three basi-occipital pits; pectoral spines serrate on both edges .... *R. calvus*.
  - Pectoral spines serrate behind only; curved .... *R arcuatus*.

The cephalic bones of the last named are unknown, as well as the spines of *R. radulus*.

RHINEASTES PELTATUS, Cope.

Proceed. Amer. Philos. Soc. 1872, 486.

Established on cranial and other bones, with spines of a siluriform fish of the size of the largest species of *Amiurus*. The form in the excessive rugosity of the external long surfaces reminds one of some of the Brazilian *Dorades*. The frontal fontanelle is closed, though very distinctly marked by a groove of the surface not rugose. The rugosity consists of innumerable, packed osseous papillæ. The cranial ossification is continued posteriorly as a shield, which is strongly convex from side to side. The spine is symmetrical, and probably dorsal. It is compressed and curved antero-posteriorly, and is deeply grooved behind. Laterally it is closely striate-grooved; the anterior face is narrowed, obtuse, and minutely serrate with cross ridges; each side of it is rugose, with several irregular series of pronounced tubercles arranged transversely.

Measurements.

	M.
Width frontal bone near front of fontanelle	0.012
Thickness at do	.004
Thickness at of casque	.004
Width spine	.005
Depth spine	.009

From South Bitter Creek.

RHINEASTES RADULUS, Cope, spec. nov.

Represented by numerous broken cranial bones, which present a pattern of exostosis quite distinct from that observed in other species. This consists of closely placed crenate ridges, which radiate from various points and are sometimes broken up, but always rough or serrate on the edges. The bones are not so thick as in the last species; *i. e.*, .0025^{m}.

From Bad Lands of Cottonwood Creek.

RHINEASTES SMITHII, Cope.

Proceed. Amer. Philos. Soc., 1872, p. 486, (August 20.)

Represented by remains of several individuals, including one with vertebræ, basi-occipital, opercular, and other cranial bones with spines. They indicate a fish of the size of the large cat-fishes of the Ohio River. The pectoral spines are quite compressed and distinctly striate-grooved on the sides. The posterior groove is occupied by short, spaced, recurved teeth; the anterior by an acute edge bounded by a groove on each side, which has a fine, close serration. The surface of the modified vertebral mass is striate-ridged; that of the basi-occipital still more strongly ridged. There is a median pit behind, and the points of attachment of the inferior limb of the posttemporal is in front of it, smooth, and without reverted edges. The operculum has a large, compressed, sessile cup, and its external surface is strongly ridged and grooved, radiating from above in front.

Measurements.

	M.
Diameter of a vertebra	.021
Length of centrum	.009
Diameter of modified vertebra	.013
Diameter of groove of vertebra	.005
Diameter of occipital articulation	.015
Length of cup of operculum	.013
Diameter spine at base	.008
Diameter spine at .004 from base	.0037

Another pectoral spine is larger; diameter at base, .010.

From the Mammoth Buttes and Laclede, on South Bitter Creek.*

RHINEASTES CALVUS, Cope, sp. nov.

Represented by numerous specimens, including most parts of the cranium, spines, &c.

One of these shows the supra-occipital production to have the form of an equilateral triangle, with a sinus of the posterior border on each side of it which advances in front of the epiotic bone below. Shortly in front of this point the deep groove representing the fontanelle commences. The cranial rugæ are lines parallel to the fontanelle, which diverge to the margins of the occipital prolongation, and are frequently connected by cross-ridges. The frontal portion of the skull is much expanded laterally, and the part beneath inclosed by the prefrontals particularly wide. The fontanelle in this region does not appear to have been entirely closed. The surface is here also strongly rugose. The vomer has a T-shaped anterior extremity, which is immediately followed by two transverse parallelogrammic patches of premaxillary brush-teeth in several rows. They are about twice as long as wide and in contact medially. The anterior margin of the premaxilla projects their length beyond them, and is perfectly smooth and has a smooth rounded border. The basi-occipital has a subcordate cotylus. In front of the median inferior pit are three groove-pits; the articular face for the posttemporal is opposite the former, and is rugose and has strongly reverted edges.

Measurements.

	M.
Diameter occipital articulation	.0082
Diameter base supra-occipital shield	.0130
Width front above orbits	.0043
Length from vomer to premaxillary border	.0110
Length of both tooth patches	.0120
Diameter pectoral spine at base	.0031

The pectoral spine is serrate on both edges. The base of the dorsal is symmetrical and articulates with its interneural bone by two lateral flat and one convex median anterior condyles, whose surfaces are curiously rugose. The interneural has a rugose median superior keel, which terminates in a point which is received into a pit of the base of the spine; there is a similar production on the posterior side for a similar purpose. The basis of the spine proper is smaller than that of the pectoral, and is about as wide as deep.

In a number of fragments of another individual, found together, the basi-occipital has the characters already described. The dentary bone is curved inward, and is acute below, widening regularly to the alveolar border. There is no groove on the inner face, while the outer is striate-grooved and has a series of pits along its lower middle.

Measurements.

	M.
Diameter occipital articulation	.009
Width alveolar face	.004
Depth of ramus at middle	.008

* Named for my respected friend Daniel B. Smith, of Germantown, many years principal of Haverford College, and a student and lover of natural sciences.

A part of the operculum of a third individual (with similar spines) displays great rugosity and elevated radiating ridges; length of articular cup, M. .0065.

The specimens are chiefly from the Bad Lands of the Upper Green River.

RHINEASTES ARCUATUS. Cope, spec. nov.

There are numerous spines about the size of those of the last species, which differ in the want of the fine serrated anterior edge. I select one as the type, which belonged to the pectoral fin of the right side. It is unbroken, and is curved from base to apex. The latter is acute by an oblique posterior truncation. The surface is strongly striate, and the teeth of the posterior edge are closely set; the proximal point distally, the distal proximally. In this specimen there is a trace of anterior serration; in many specimens none whatever. The external surfaces of the epiclavicular and coracoid bones are strongly rugose-striate, as is the case in all the species of this genus, and the most characteristic fragment is that portion of the scapular arch at the base of the pectoral spine.

	M.
Length of spine on curve	.052
Diameter at base, long	.006
Diameter at base, short	.004

The recurved plate of the base is rugose, as in other cat-fishes. Specimens generally from Upper Green River.

The spines are less compressed than in *R. calvus*.

TRICHOPHANES. Cope.

Proceed. Amer. Philos. Soc., 1872, p. 479.

Allied to *Erismatopterus*, Cope, and to the family of *Cyprinodontidæ*. Dorsal and anal fins short, each with a long and short spinous ray on the anterior margin. Ventrals beneath the dorsal. Operculum with a longitudinal keel above. Mouth with a wide gape, extending beyond orbit. Scales wanting, represented by rigid fringes or hair-like bodies. Several important characters of this genus are not very distinctly displayed by the specimen described. This is especially the case with the maxillary region. The premaxillary bone evidently forms a large part of the arcade of the mouth, but whether the whole, is not certain. The presence of teeth and number of branchiostegal radii cannot be stated. Other points, more definitely exhibited, are a preoperculum without serrations, directed a little obliquely backward; a coracoid of little width; an inferior postclavicle with a superior (proximal) conchoidal expansion, and long, slender shaft, extending to the anterior extremity of the femora. The latter are quite slender and acuminate anteriorly, and grooved to the apex, but apparently not furcate. They do not present any marked posterior union. Vertebræ not elongate.

Caudal fin furcate. Interneural spines wanting in front of dorsal fin; those of the anterior rays very strong. Interhæmals of the anterior anal rays similarly strong. Caudal fin embracing one vertebra, and supported by separated hæmal spines. The characters which separate *Tricophanes* from *Erismatopterus* are seen in the large mouth and short muzzle and in the peculiar covering of the body. In the former character it resembles some of the *Scapeli*, while the latter is not seen in any genus. The bristle-like bodies are scattered over the whole extent of the fish, excepting the head and the fins, and are arranged in little aggregations, which are irregularly disposed. The processes themselves lie irregularly together, as though free from each other, and are evidently not the impressions of keels of the scales. Traces of other scales are not visible, and the bodies described would suggest the existence of an ossified ctenoid fringe on a less fully calsified scale, or possibly without such basis.

TRICHOPHANES HIANS. Cope.

Loc. cit., 480.

Vertebræ, D., 9; C., 15; six between interneural spine of dorsal and interhæmal of anal fin. Radii, D. II, (?) 6, (soft rays somewhat injured;) A. II, 7; V. and P. not all preserved; caudal rays numerous, forming a deeply bifurcate fin. The ventrals reach a little over half way to the anal, and the latter about half way from its basis to that of the caudal fin. The dorsal fin, laid backward, reaches the line of the base of the first anal ray. The first dorsal ray is a little nearer the end of the muzzle than the origin of the caudal fin. The muzzle is very obtuse, and, if the specimen be not distorted, not longer than the diameter of the orbit. The gape extends at least to the posterior line of the orbit. The suborbital region is deep posteriorly. In its present somewhat distorted condition, the specimen measures in—

	M.
Total length	0.059
Head	.016
Vertebræ	.029
Caudal fin	.0142
Length dorsal spine	.008
Length anal spine	.008
Length hair-like bodies	.0005

From the paper-coal of Osino, Nevada.

AMYZON. Cope, Gen. Nov. Catostomidarum.

Proceed. Amer. Philos. Soc., 1872, p. 480.

Allied to *Bubalichthys*. Dorsal fin elongate, with a few fulcral spines in front, and the anterior jointed rays osseous for a considerable part of the length; a few short osseous rays at front of anal fin; scales cycloid; caudal fin emarginate; mouth rather large, terminal.

The characters of this genus appear to be those of the *Catostomidæ*. There are three broad branchiostegals. The vertebræ are short, and the hæma spines of the caudal fin are distinct and rather narrow. In one specimen a pharyngeal bone is completely preserved. Not having it before me at the moment, I merely observe that it is slender, and with elongate inferior limb. The teeth are arranged comb-like, are truncate, and number about thirty to forty. This and other portions of the structure will be more fully described when the whole series of specimens is investigated. The bones bordering the mouth above are a little displaced, and the lower jaw projects beyond them, and is directed obliquely upward. The dentary bone is slender and toothless, and the angular is distinct. The premaxillary appears to extend beneath the whole length of the maxillary. Should this feature be substantiated, it will indicate a resemblance to Cyprinidæ. The maxillary has a high expansion of its superior margin, and then contracts toward its extremity. Above it two bones descend steeply from above, which may be out of position. The preoperculum is not serrate. The superior ribs are well developed. This form approaches, in its anterior mouth, the true Cyprinidæ through *Bubalichthys*. It is the first extinct form of Catostomidæ found in this country.

AMYZON MENTALE. Cope.

Loc. cit., p. 481.

This fish occurs in considerable numbers in the Osino Shales, and numerous specimens have been procured. Two only of these are before me at present; they are of nearly similar length, viz, M. O. .12 and .105. The most elevated portion of the dorsal outline is immediately in front of the dorsal fin. From this point the body contracts regularly to the caudal fin. The dorsal fin is long, and is elevated in front and concave in outline, the last rays being quite short. They terminate one-half the length of the fin in front of the caudal fin. The interneural spines are stout in front and weak behind. Radii, III. 26, and (?) II. 23. There are about twenty-three vertebræ between the first interneural spine and the end of the series in the former specimen, in which, also, there are no distinct remains of scales. In the second, scales are preserved, but no trace of lateral. There are six or seven longitudinal rows above the vertebral column. The anal fin is preserved, somewhat damaged; the rays are not very long, and number II. 7. The anterior interhæmal is expanded into a keel anteriorly; ventral fins injured. The ribs and supplementaries are well developed. The inferior quadrate is a broad bone, with deep emargination for the symplectic. Depth No. 2 in front of dorsal fin, M. .025; length basis of dorsal, .026.

From the paper-coal of Osino, Nevada.

REVIEW OF THE VERTEBRATE FAUNA OF THE EOCENE OF WYOMING.

The number of species above recorded, as obtained by the expedition, is as follows:

MAMMALIA, (45.)

	Species.
Quadrumana	3
Carnivora	6
Proboscidia	8
Perissodactyla	14
Rodentia	6
Marsupialia	1
Incertæ sedis	7

AVES, (3.)

Incertæ sedis	3

REPTILIA, (44.)

Crocodilia	8
Testudinata	32
Lacertilia	3
Ophidia	1

BATRACHIA, (1.)

	Species.
Incertæ sedis	1

PISCES, (26.)

Ginglymodi	4
Halecomorphi	5
Nematognathi	7
Plectospondyli	2
Isospondyli	3
Percesoces	3
Percomorphi	2
Total number vertebrata	120

Character of the types of Vertebrates.—Professor Leidy, in his report on this subject in 1871, (Geological Survey of Montana, p. 353,) announced the presence of *Carnivora*, *Insectivora*, *Rodentia*, *Perissodactyla*, and *Artiodactyla Omnivora*, concluding that *Quadrumana*, *Chiroptera*, *Proboscidia*, *Artiodactyla*, *Ruminantia*, *Edentata*, and *Marsupialia* were wanting. He also observed the entire absence of horses. The results of the survey of the present year confirm these statements as to the presence of the orders first mentioned by Professor Leidy, excepting that of the *Artiodactyla*, the existence of which in any form at the period in question remains uncertain. The entire absence of the *Ruminantia* and of the single-hoofed equines is fully confirmed. On the other hand, I have been able to add *Quadrumana* and *Proboscidia*, while Marsh, who discovered the former nearly coincidentally with myself, has obtained, in addition, *Chiroptera* and *Marsupialia*. Thus the fauna embraced an extensive series of types of Mammalia, whose characters it will be well to glance at in review.

Of the quadrumana none are typical forms, and all are much more generalized than the existing families. Of the six carnivora, two, at least, are far from recent forms, and combine important features now found in distinct families. The proboscidia are all remote from Miocene and recent forms, combining features of perissodactyles. Of the perissodactyles, six species (*Hyrachyus*) pertain to a persistent type, which still exists, while eight species (*Palæosyops*, *Limnohyus*, and *Orohippus*) combine the characters of the tapirs with the bunodont type with powerful canine teeth, from which also the artiodactyla omnivora sprung. The genera marked "Incertæ sedis" are all or nearly all generalized forms, having affinities to the group in question. The rodentia, so far as known, appear to be more or less similar to living types. Of the forty-five species of Mammalia enumerated, at least twenty-eight may be regarded as generalized in a high degree, while not a few others will probably be found to present the same peculiarity within a lesser range of variation.

The ordinal characters of the *Reptilia* are well defined, and there is nothing known among *Crocodilia* remarkably distinct from those existing at the present time. The same may probably be said of the *Lacertilia* and *Ophidia*, though their genera are not so well known. It is in the tortoises that we have evidence of generalized forms again, which only relate, it is to be noted, to the subdivisions of the order, and not, as in the Mammalia, to other orders. Of the thirty-two species, ten belong to typical forms now existing, and nine (*Trionyx*, *Dermatemys*, and *Hadrianus*) to forms which exist or closely resemble existing genera, but which are somewhat mixed in character. Thirteen represent genera (*Baëna*, *Anostira*, *Plastomenus*, *Axestus*) which are extinct and generalized in character, the first three in an especial manner, as has been pointed out.

The orders of the fishes are equally well distinguished, and so far as known, the types differ only in minor respects from those at present inhabiting North American waters. Generalized types are unknown, excepting, perhaps, in the very highest division. (*Erismatopterus*, *Asineops*.)

As a result of this and other palæontological investigations conducted largely in North America, and substantiated by those in other countries, the periods of establishment of the existing order of things in the history of the vertebrata, may be stated as follows:

The recent orders of fishes were in existence in the Cretaceous period, and probably earlier. Their period of evolution was in the Devonian, and perhaps in the Carboniferous periods. The existing orders of reptiles were all established in the Eocene; the period of evolution was the three Mesozoic ages, especially the Trias. The orders of birds were inchoate in the Cretaceous, but when they were fully differentiated is unknown. The existing orders of Mammalia were established in the Miocene period; during the Eocene they were in process of differentiation and were less or scarcely distinctly defined.

On the Phylogeny of the Mammalian Orders.—So much light is thrown on this subject by the researches into the structure of the fossil Mammalia of the Eocene formation, that it seems opportune to call attention to the subject. I deem it demonstrated to a certainty, that the case with the mammals of this formation is the same as with the reptiles of the Trias, *i. e.*, that the family types are all more generalized, and the orders not nearly so widely distinguished as in later periods of the world's history.

The succession of later forms which has terminated in the horse, has been clearly pointed out by Professor Huxley, as well as the line which has given the world the beautiful order of the *Artiodactyla;* but the approximate lineal predecessors of the *Proboscidia*, of the Ungulate animals as a whole, of the *Quadrumana*, (including man,) and of the *Carnivora*, have not been clearly pointed out.

The genus *Eobasileus* has been shown* to be a Proboscidian which combines some important features of the *Perissodactyla* with those of its own order, thus standing in antecedent relation to the elephants, &c., of the present day. The number of such characters was shown to be somewhat increased in *Bathmodon*, which therefore stands still nearer to the common point of departure of the two orders. This point is to be found in types nearer the clawed orders, (Unguiculata,) in the number of their digits, (4–5,) and in which the transverse and longitudinal crests of the molar teeth are broken up into tubercles more or less connected, either type of dentition being derived according as such tubercles are expanded transversely or longitudinally. We have several genera which answer this description so far as the teeth are concerned, but unfortunately the digits are unknown; such are *Oligotomus*, *Orotherium*, &c.

The type of *Tomitherium*, already described, evidently stands between Lemurine monkeys and such small allies of *Palæotheriidæ*, with conictubercular teeth, and which abound in the Eocenes of Wyoming and France. The dentition of the two types is indeed but little different in the Quadrumanous and Ungulate types respectively, being a continu-

* On the short-footed Ungulata of Wyoming, page 3.

ous series of I. 2 or 3; C. 1, P. M. 3–4; M. 3; the canines but moderately developed.

A comparison with *Nasua* reveals no distant affinity. As above remarked, the fore-limb presented a great similarity in this genus and *Tomitherium*. The teeth, though less numerous, in the molar series have the cutting type anterior and tubercular posterior, in both genera. *Notharctus*, Leidy, resembles *Nasua* still more than does *Tomitherium*, and occurs in the same Eocene strata. Professor Leidy originally regarded it as a Carnivore, and subsequently (Hayden's Survey Montana, 1871) placed it among Ungulates. He was probably nearly correct on both occasions, and that only a technical line will ultimately decide whether it be not a monkey.

But the genus which associates more definitely the orders *Carnivora* and *Quadrumana* is the *Cercoleptes*, which F. Cuvier* placed between the two. Its two cutting premolars and three true molars, with the co-ossified rami of the mandible, are truly Quadrumanous features, although it should on other grounds be regarded as a plantigrade Carnivore. Several of the extinct genera of the Wyoming Eocene will prove to be allied to this form.

Cercoleptes does not, however, present us with the *ultimate* original type of the *Carnivora*. Such a type must also generalize the seals, with their longitudinal, cone-bearing molars, and flat, fissured claws. Some of the seals also unite the scaphoid and lunar bones later in life than other *Carnivora*; hence we would reasonably look for the division of these bones in their predecessors. The flat-clawed genera of Wyoming† answer these demands. The genera *Mesonyx* and *Synoplotherium* present us with a series of molar teeth which repeat each other in form, are compressed below, and bear conical cusps. The jaws in the latter genus are slender, and the canines tend to the great development seen in many seals; but principally, the scaphoid and lunar bones are distinct, and the claws flat and widely fissured. The tympanic bone is more like that of the bear and some seals, than that of the digitigrade Carnivora. These genera, though probably good swimmers, were well removed from the seals in the structure of the long bones of the limbs, and were probably remote in their ancestry.

In *Oligotomus*, *Orotherium*, *Hyopsodus*, and similar forms, the conic tubercles have a slight alternation, and the posterior, which has a crescentoid section in wearing, inclines to connection with both the inner-conic tubercles by low ridges. These ridges are fully developed in *Palæosyops*, so that we have a dental crest of two V's in the inferior molars. This, in wearing, produces the two crescents of *Palæotherium*. The addition of two tubercles on the inner side takes place in the higher forms, which terminates in the four crescent-bearing molars of the Ruminants. How this is done is best proven by examples from the maxillary teeth.

In *Orotherium vasacciense*, there is a tendency for the conic tubercles to be connected in pairs by low cross-ridges. These ridges, fully developed, produce the two cross-crests of *Hyrachyus* and *Tapirus*. In *Rhinocerus*, the outer portion retains a crescentoid form, giving rise to an L-shaped crest. In *Bathmodon* diagonal ridges appear, which would result in two V's, as in *Palæosyops*, were it not that both transverse and oblique elements of the posterior V disappear, leaving but one such in

* Dentes des mammifers, p. 31.

† See the Flat-clawed Carnivora of Wyoming, by E. D. Cope, April, 1873.

the middle and posterior part of the mandibular series. In *Uintatherium* the diagonal from the posterior crest never appears, leaving a transverse crest and a V on the true molars.

In the superior molar series, the exterior flattening of the exterior tubercles may proceed so far as to give crescentoid sections on wearing, and their longitudinal extent may be such as to cause them to unite at their bases. A similar succession of form may be seen in the inferior molars, *e. g.*, in *Orotherium sylvaticum*. In both *Palæosyops* and *Hyrachyus*, these tubercles (of the upper molars) are confluent into two V's (more or less open) when unworn. In the former, and in *Limnohyus*, the inner tubercles retain their primitive conic tubercular form; but in *Palæotherium*, *Rhinocerus Lophiodon*, *Hyrachyus*, and *Tapirus*, they elongate transversely so as to meet the corresponding outer tubercles, (now crests,) forming the familiar cross-crests of those genera. If the tubercles are alternate, they produce the oblique crest of *Palæotherium;* if opposite, the cross-crest of *Tapirus*. An interesting annectant form is seen in *Orohippus procyoninus*, where the two intermediate tubercles, which separate the inner cones from the outer V's in *Limnohyus*, are so developed as to constitute parts of an incomplete pair of transverse ridges, which disappear in front of the bases of the outer V's. These represent the oblique crests of *Palæotherium* and *Anchitherium*, and thus the genus *Orohippus* furnishes a station on the line from *Palæosyops* to the horses.

If, on the other hand, the inner tubercles flatten like the outer on wearing, we have the quadricrescentoid type of *Anoplotherium* and the Ruminants.

But it is important to observe that the lower types of *Quadrumana* and *Carnivora* present the quadrituberculate crown with tendency to flattening of the outer tubercles, as seen in these lowest *Ungulata*. In the *Carnivora* the sectorial tooth is produced by the greater flattening and partial confluence of the outer tubercles, and the *entire loss* of the inner, the "heel" being in the dogs and cats, *e. g.*, their only representative. In the Quadrumanous families, including man, the primitive quadrituberculate type of molars is preserved, the flattening of the outer tubercles being finally lost.

It is to be observed that the lines of *Ungulata*, *Quadrumana*, and *Carnivora* originate in plantigrade types, a state of things quite predominant among the lower series, or *Lissencephala*. It is universal in *Edentata* and very usual in *Rodentia* and *Insectivora*. The lower forms of *Marsupialia* and all of the *Monotremes* present it. In the Marsupials, Rodents, Ungulates, and Carnivores, we have series whose highest expression is in the most highly digitigrade genera.

The accompanying diagram is designed to express to the eye more clearly the propositions made above. By comparing it with a similar table published by Professor Gill, (Proceedings of the American Association for the Advancement of Science, for 1871, p. 295,) a close resemblance between the two may be observed, as well as certain differences.

I wish to be understood that the genera named in it as ancestors are to be regarded in the light of types of groups. There is no other mode of explaining the facts than that in accordance with the law of "homologous groups," *i. e.*, that several genera of one group have undergone similar modification into corresponding ones of a second group.*

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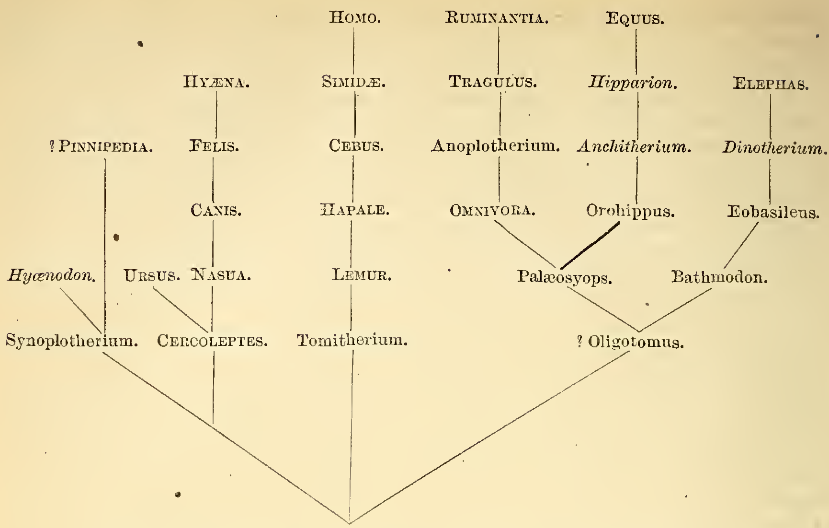
* See Origin of Genera, page 79, Prop. V.



NOTE.—Recent genera in SMALL CAPITALS; Miocene in *italics;* and Eocene in roman.

On the phylogeny of the genera of Testudinata.—The extinct tortoises of the Cretaceous and Eocene throw considerable light on the probable origin of various existing genera,* and while much remains obscure, the following observations may be derived from the study of the forms in question:

The order makes its appearance in the Triassic period, for I am assured by Dr. F. Endlich, of Reading, Pennsylvania, that the species obtained by Professor Quenstedt in Würtemburg belong undoubtedly to the *Testudinata*. With their special structure we are not yet fully acquainted. A number of genera appear in the Jurassic, and there is a successive increase in the number of species in the Cretaceous and Tertiary formations. Three structural features of importance mark the earlier forms. First, the incomplete union and ossification of the elements of the plastron and carapace; second, the reduction in size of the lobes of the plastron; third, the natatory character of the phalanges, by their truncation and union in a single plane. Genera, retaining some or all of the peculiarities, persist to the present day; but the ossified types, with distinct digits, are far more abundant, and are comparatively rare in the period of the Jura. *Sphargis*, which is without carapace and has a greatly reduced plastron, may be regarded as nearest the primitive types of the order, though it still exists. *Protostega*, of the Kansas Cretaceous, is its nearest extinct ally known. *Protostega* is superior in the well-developed marginal bones, and prepares the way for consideration of the various genera, with incomplete shields of the present period (Chelone) or of the Jurassic; the former possessing the natatory extremities, some of the latter assuming a terrestrial modification of limbs. Those with ambulatory limbs lead us at once to the existing *Chelydra*, the closing of the sternal fontanelles being accompanied by a contraction of its extent, in respect to the bridges and lobes. In *Propleura* of the Cretaceous we have a state of things intermediate between some of the Jurassic *genera*, as *Idiochelys* and *Chelone.*

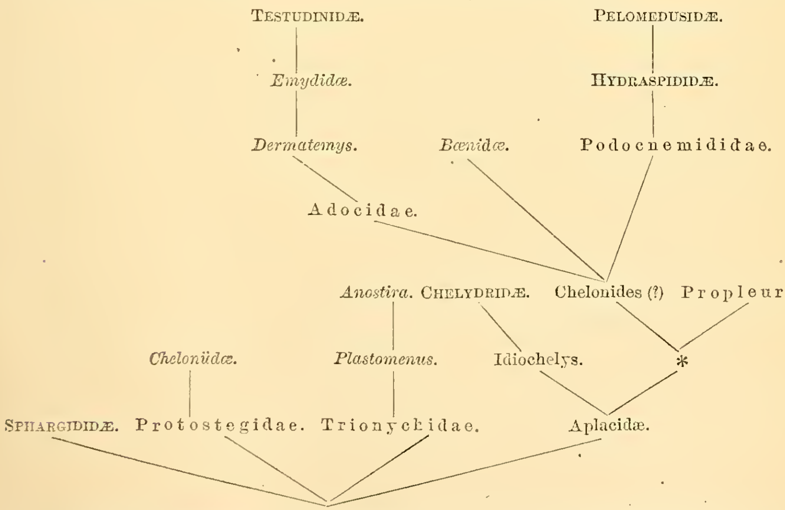
* See on the Extinct Tortoises of the Cretaceous of New Jersey; Proceedings Amer. Assoc. Adv. Science, 1871, p. 344.

These genera had a common origin near the Jurassic predecessor of *Protostega*.

Trionyx appears to represent another point of departure. Its plastron presents a grade of development near to that of *Propleura*, and its nine costal bones have a similar significance. Its half-ossified carapace, wanting the marginals, is inferior. Its peculiar sculpture is seen in the Eocene *Anostira*, (which is much like *Chelydra* in form,) and in *Adocus* of the Cretaceous, which adds Chelydrine and Pleurodire characters in a remarkable manner. It is closely joined by *Plastomenus*, which is in turn near to *Anostira*.

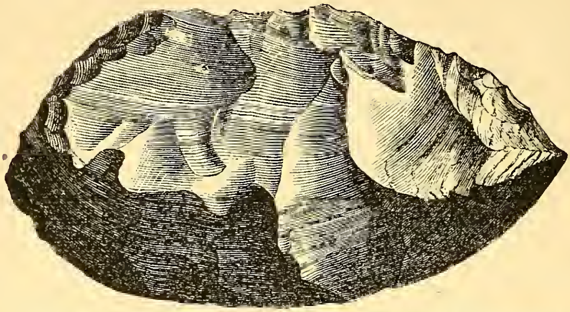
The Jurassic genus *Aplax* Myr., is nearly as deficient in ossification of carapace and plastron as *Protostega*, and is allied to the Chelydrid series, which existed cotemporaneously and during the Cretaceous. *Idiochelys* represents a rather more advanced form, with distinct marginal bones, and with affinities to *Chelydra* of a decided character. It was probably its ancestor. Allied to it we have such forms as *Adocus* and *Bæna*, which, while furnished with fully ossified shell, still present the contracted form of plastron seen in *Idiochelys* and *Chelydra*, and several points of affinity to the Pleurodire series. From some common ancestor of these sprang also the true Pleuroderes of the Cretaceous, as *Taphrosphys*; while, by the omission of most of the tendencies toward that series, we have the genus of *Emydidæ* near to *Adocus*, *Dermatemys*. From this point we pass to true *Emydidæ*, and thence, by the loss of a series of phalanges, to *Testudo*. From *Taprosphys* we pursue the Pleurodire series to the similarly modified type, *Pelomedusa*.

The accompanying table expresses the relations indicated, supposed to be genetic, and in accordance with the theory of evolution:



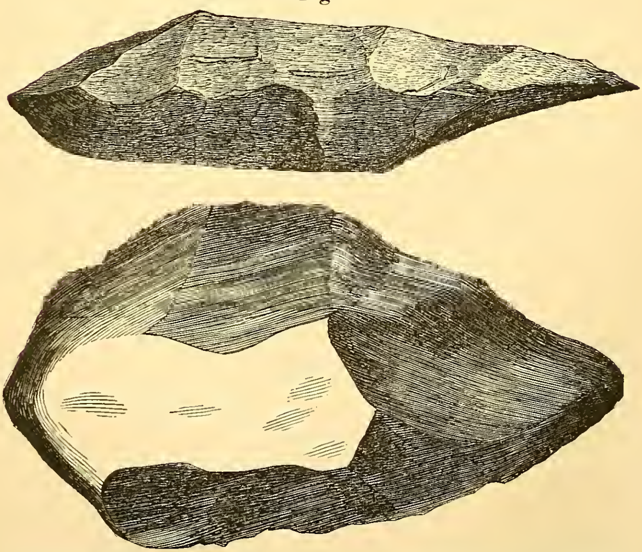
NOTE—Jurassic types in roman; Cretaceous to recent, s p a c e d; Eocene to recent, *italics*; Miocene to recent, SMALL CAPITALS.

Fig. 1.



Wrought flake of gray and black striped jasper, one-half the natural size. One of many similar specimens found by Professor Hayden's party, on Henry's Fork of Green River, Wyoming, during the geological exploration of 1870.

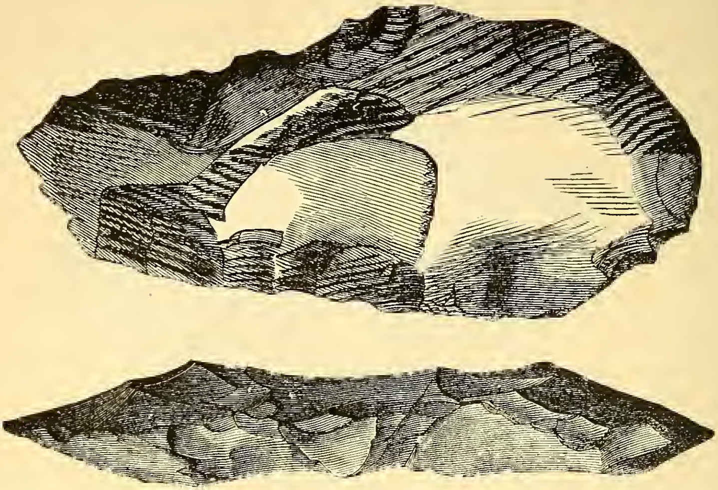
Fig. 2.



Implement of pinkish quartzite, made from a bowlder of the drift from the Uintahs. Two views; one-half size. From the plain near Dry Creek, about eight miles from Fort Bridger.

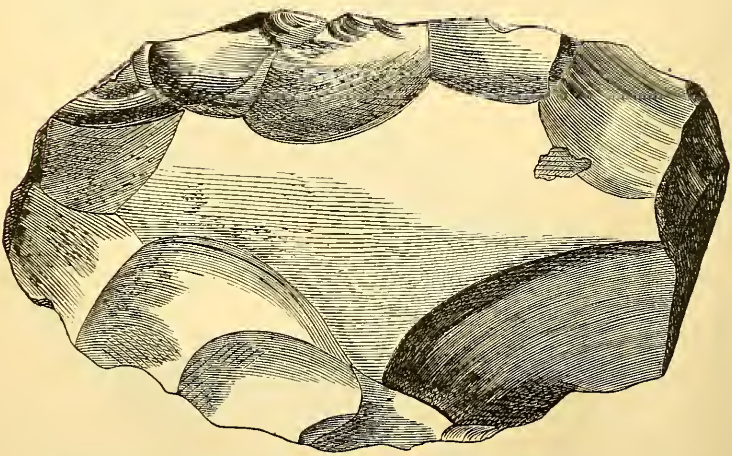
Plate 8.

Fig. 3.



Flake of gray and black striped jasper, much weathered; white and yellow on the surface. Two views; one-half size. From the buttes west of Dry Creek Cañon, forty miles from Fort Bridger.

Fig. 4.



Wrought flake of brownish-yellow jasper, natural size. From the head of Dry Creek.

ON REMAINS OF PRIMITIVE ART IN THE BRIDGER BASIN OF SOUTHERN WYOMING.

By Professor JOSEPH LEIDY.

Fort Bridger occupies a position in the midst of a wide plain at the base of the Uintah Mountains, and at an elevation of upward of 6,000 feet above the sea-level. The neighboring country, at a remote geological period, appears evidently to have been occupied by an immense fresh-water lake, and the ancient lake-deposits now form the basis of the region. These deposits have been subjected to a vast amount of erosion, resulting in the production of deep valleys and wide basins, which are traversed by Green River and its tributaries. From the valley of Green River, the ancient lake-deposits rise in succession as a series of broad table-lands, or terraces, and narrower flat-topped hills, which extend to the flanks of the surrounding mountains.

The snows of the Uintah, Wahsatch, and other mountain-ranges are a never-failing source of supply to the principal streams; but most of the lesser branches, dependent for their supply on the winter snows of the lower hills and plains, completely dry up on the advance of summer.

The country for the most part is treeless, and destitute even of large shrubs, except along some of the water-courses and in some of the narrower valleys. At a greater elevation the higher foot-hills and flanks of the Uintah Mountains are covered with a dense forest growth, from which the rocky summits of the latter project, as bare of vegetation as the plains below.

The elevation of the Bridger Basin and the very little rain-fall of the region are conditions unfavorable to a luxuriant vegetation. The principal growth of the plains consists of sage-bushes, (*Artemisia tridentata*,) intermingled, however, with many other less abundant, and, in proper season, bright-flowered plants. Wide, bare, path-like intervals separate the bushes, or the interspaces are occupied by scanty grasses.

The flat-topped hills or table-lands arising from the valleys and extended plains, independent of the higher mountain-ranges, form the most characteristic feature of the landscapes in Southern Wyoming.

The flat-topped hills or terraces, worn into all sorts of shapes, sometimes appearing in the distance as extensive fortifications, at others as great walled cities, huge castles, pyramids, mounds, &c., are familiarly known under the name of buttes. This word is of French origin, and signifies a bank of earth or rising ground. Similar features under similar conditions are frequent in many parts of the continent west of the Mississippi.

The buttes in the neighborhood of Fort Bridger are composed of nearly horizontal strata of various colored indurated clays and sandstones. In most localities visited by the writer the clays predominate, and are usually greenish, grayish, ash-colored, and brownish. When unexposed they are compact, homogeneous, and of stony hardness. In composition they vary from nearly pure clay to such as are highly arenaceous, and gradate into those in which sand largely predominates. Exposed to atmospheric agencies they readily disintegrate, and the declivities of the buttes, generally destitute of vegetation, are usually invested with crumbling material from a few inches to a foot or more in depth.

The sandstones are more frequently of various shades of green, but are also yellowish, and pass into shades of brown. They are compact and hard when unexposed to the weather, and are usually fine-grained, but also occur of a gravelly character. Disintegrating less rapidly than the contiguous clays, masses are often seen resting upon narrow cones of the latter, contributing greatly to the picturesque and ofttimes fantastic appearance of the buttes.

The buttes in some localities contain beds of impure limestones, highly calcareous clays, and harder siliceous clays. In others they contain thin seams of fibrous arragonite, brown and striped jaspers, flint, and not unfrequently nodules of agate and chalcedony. Many of the table-lands and lesser buttes in the vicinity of the Uintah Mountains are thickly covered with drift from the latter, consisting of gravel and bowlders of red and gray compact sandstones or quartzites. The bowlders are generally small, but assume larger proportions approaching the Uintahs. In many cases the drift completely covers the buttes, descending upon the declivities so as entirely to conceal their structure. Usually, however, it is accumulated in the ravines of the declivities, leaving bare the intervening ridges of light-colored clays and sandstones.

Many buttes in other localities are nearly or quite free from drift materials. Others, again, are strewn with more or less angular fragments of rock, consisting of the harder materials from the terraces themselves, and these likewise occur with the mingled drift from the mountains. In some localities the stones strewn over the lower buttes and plains are broken and flaked in such a manner as in many cases to assume the appearance of rude works of art. With them there are mingled implements of art of the rudest construction, together with a few of the finest finish. In some places the stone implements are so numerous, and at the same time are so rudely constructed that one is constantly in doubt when to consider them as natural or accidental and when to view them as artificial. Some of the plains are so thickly strewn with the natural and artificial splintered stones that they look as if they had been the battle-fields of great armies during the stone age.

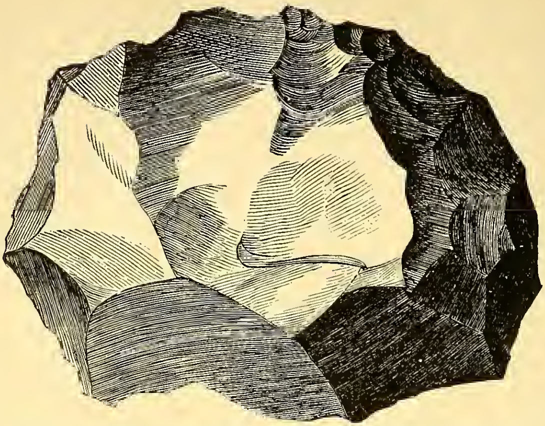
Representations of a few of the flaked stones are given in Figs. 1 to 12. These with little doubt may be viewed as rude implements of art. The vast numbers of similar stones to be found on the buttes and plains near Fort Bridger, and their gradation to undoubted accidental fragments with which they are mingled, alone renders it improbable that they should be considered as such.

The splintered stones, including the implements of art, appear greatly to differ in age. Some of the specimens of black and brown and striped jaspers, and of black flint, resembling the chalk-flint of Europe, are as sharp and fresh in appearance as if they had been but recently broken from the parent block. Others are worn, and have their sharp edges removed, and are so deeply altered in color as to look exceedingly ancient. Thus some of the specimens composed of brown or black jasper have the surface of a dull, chalky aspect extending to the depth of the fourth of an inch.

The question arises who made the stone implements and when, and why should they occur in such great numbers in the particular localities indicated.

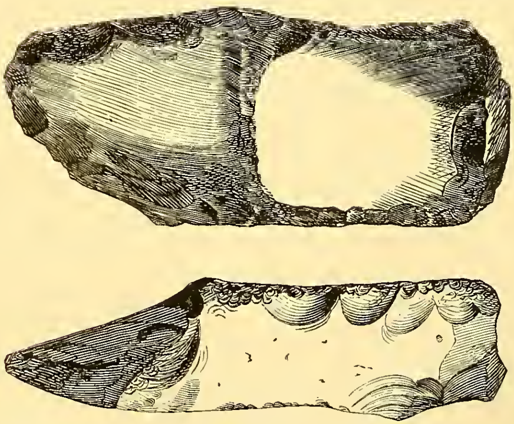
My friend, Dr. J. Van A. Carter, residing at Fort Bridger, and well

Fig. 5.



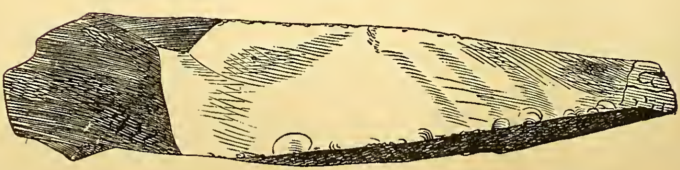
Flake of black flint, natural size. From the plain near Dry Creek.

Fig. 6.



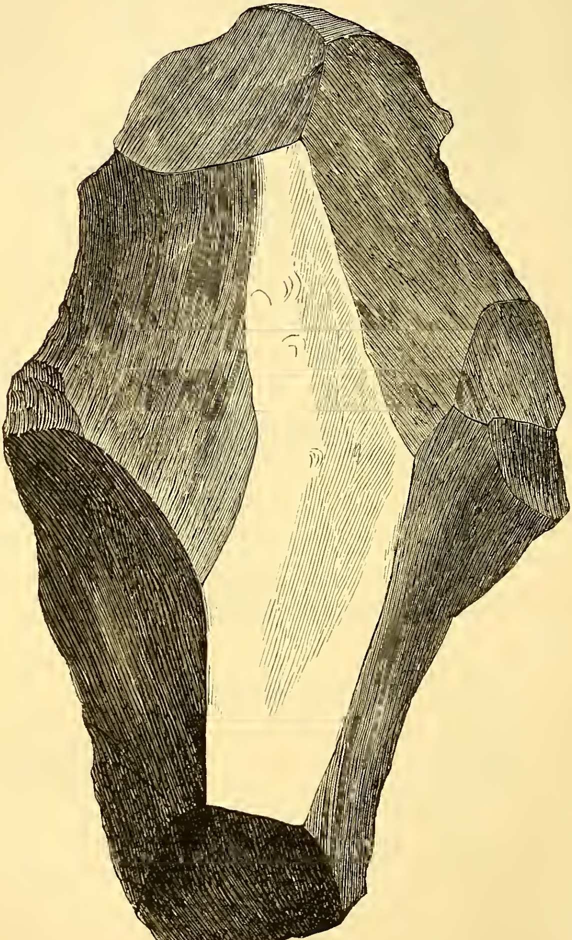
Implement of yellowish flint; apparently an ax of exceedingly rude character. Two views; one-half size. Found in the same locality as the preceding specimen.

Fig. 7.



Flake of brownish-black flint, natural size. Found with the preceding.

Fig. 8.



Chipped stone, of chocolate-brown quartzite, natural size. Found in the same locality as the preceding.

acquainted with the language, history, manners, and customs of the neighboring tribes of Indians, informs me that they know nothing about them. He reports that the Shoshones look upon them as the gift of God to their ancestors. They were no doubt made long ago, some probably at a comparatively late date, that is to say, just prior to communication of the Indians with the whites, but others probably date centuries back. Their great numbers in particular localities may perhaps be accounted for from the circumstances that the neighboring buttes may have been especially the places resorted to for the materials of which the implements are made, and the ruder ones were perhaps cast aside. The decomposition of the surface of some of the jasper and flint specimens may be looked upon as indicative of considerable age, though this change may have taken place more rapidly than ordinarily, from the action of alkaline matters with which the soil of the country is often much imbued.

In an excursion to Grizzly Buttes, about ten miles from Fort Bridger, I observed what appeared to be the remains of the basin of a large pond or lake. The surrounding buttes were low mounds, the remains of the once more elevated boundaries to the supposed lake. Upon the edges of this I noticed numerous spawls of stone, and among them a number of well-finished stone arrow-heads. They appeared to me to be the traces of a people who once camped on the shores of the lake, which, perhaps, has been drained for some centuries.

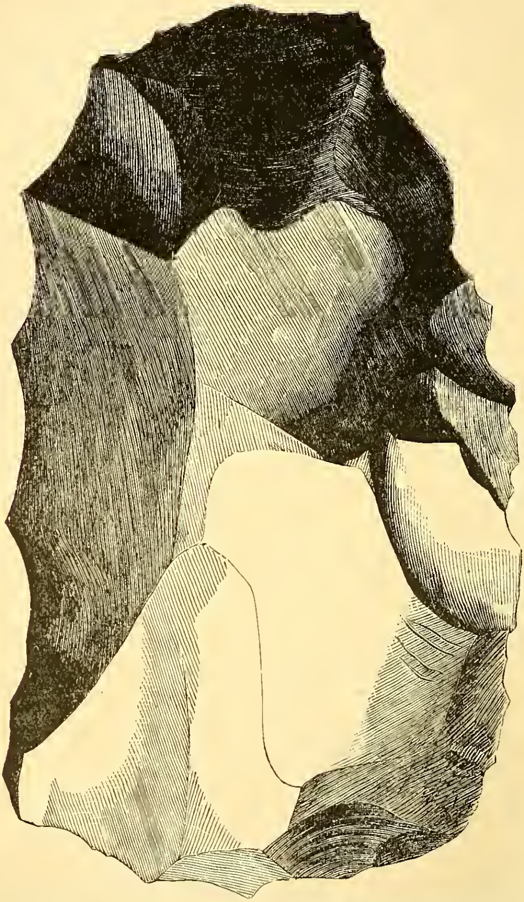
The Indians, in seeking a site for their temporary or more permanent abodes, would naturally select places where there was a supply of water and fuel, as well as of game. In repeated instances, after traversing a desert waste, I have been led to look upon some sheltered valley, or a hollow in the hills, green with vegetation and furnished with a spring of water, as having been formerly occupied by Indian lodges, and in all cases the view was confirmed by the discovery of a number of characteristic stone implements.

In this relation I may take the opportunity of speaking of a stone implement of the Shoshone Indians, one of so simple a character that had I not observed it in actual use and had noticed it among the materials of the buttes, I would have viewed it as an accidental spawl. It consists of a thin segment of a quartzite bowlder, made by striking the stone with a smart blow. The implement is represented in Fig. 13, and is circular or oval, with a sharp edge, convex on one side and flat on the other. It is called a "teshoa," and is employed as a scraper in dressing buffalo-skins. By accident I learned that the implement is not only modern, as I obtained one of the same character, together with some perforated tusks of the elk, from an old Indian grave, which had been made on the upper part of a butte, and had become exposed by the gradual wearing away of the latter.

The perforated tusks of the elk are also a subject of some interest in connection with the history of primitive man. The tusks are worn in the form of a necklace, as ornamental trophies, by the Shoshone and other Indians of the West. In a recent number of the American Journal of Science and Art for 1872, in a notice "On fossil man of the cavern of Broussé-roussé, in Italy," it is stated that besides a human skull associated with the bones of many extinct animals, there were also found several flint knives and a number of perforated canines of the stag. It would thus appear that primitive man in Europe as well as in this country used the same kind of ornaments, as he did the same kind of stone implements.

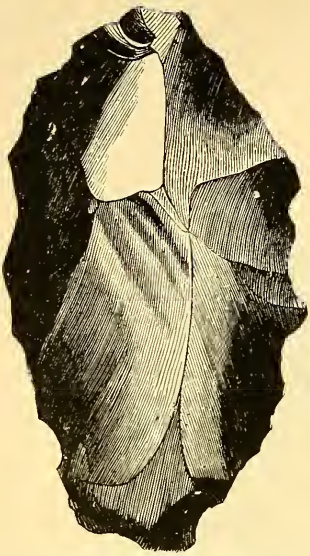
Fig. 14 represents one of the perforated canines or tusks of the elk, found in the Indian grave as above indicated.

Fig. 9.



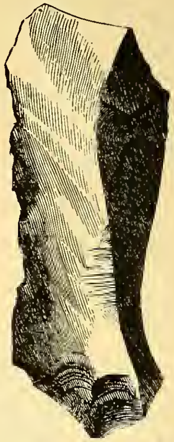
Chipped stone, of gray flint or jasper, natural size. Found with the preceding.

Fig. 10.



Flake of brownish-black flint, natural size. Found with the preceding.

Fig. 11.

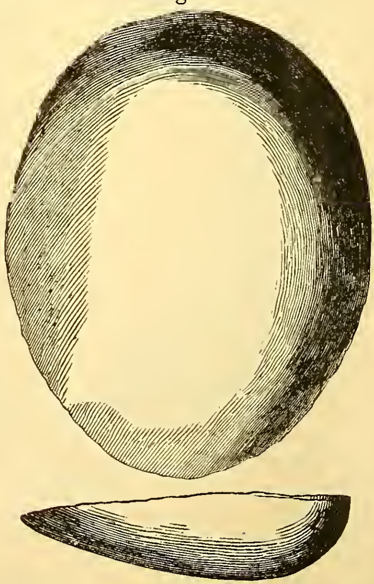


Flake of black flint, natural size. Found with the preceding.

Fig. 12.

Flake of gray jasper, much weathered; black and yellow on the surface. Two views; one-half size. Found with the preceding.

Fig. 13.



A modern stone implement of gray quartzite; a simple flake from a drift-pebble of the Uintahs. Called by the Shoshone Indians a "teshoa," and used by them as a scraper in dressing skins. Two views; one-half size. One of half a dozen similar specimens obtained from the Shoshones.

ANCIENT MOUNDS OF DAKOTA.

By C. Thomas, Ph. D.

While at the Northern Pacific crossing of James River, in Dakota Territory, during the past summer, I was informed by the officers of the military post at that place that there were some mounds in the vicinity which were supposed to be artificial.

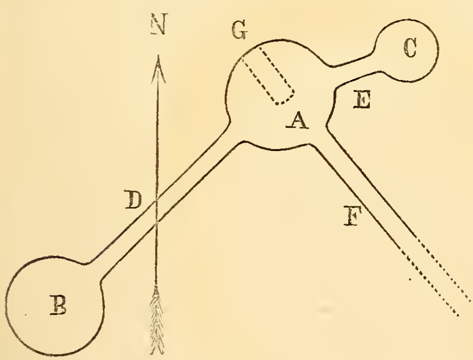
Colonel Burke, who was in charge of the post, very kindly consented to allow several soldiers and some Sioux scouts, who were willing to accompany us to assist in opening one of these to test the correctness of this opinion; and General H. W. Thomas, who took great interest in the subject, agreed to conduct the operations.

These mounds are situated on a high prairie east of Pipestone Creek, about two miles southeast of Jamestown, near the bluff which overhangs the narrow valley of the creek. The position is a commanding one overlooking a large extent of country toward the north and west, but to the south and east the prairie rises a little higher than at this point, but between this point and the higher ground in the latter direction there is a broad slight depression.

The three mounds in this group are situated in relation to each other as represented in the annexed wood-cut, and are connected with each other by low ridges, evidently the remains of walls of some kind.

A, the central mound, is the largest, being about 210 feet in circumference at the base, as I judged by carefully pacing it; it is about 8 feet high in the center, the top having evidently been worn down considerably by the wind, rain, &c., and the material deposited around the base perhaps slightly enlarging its original circumference. A badger-hole entered near the apex, penetrating it obliquely some 4 or 5 feet.

Fig. 56.



B, situated to the southwest of *A*, about 144 feet distant, is nearly as large as the latter, and apparently similar in every respect except that it appears to be more worn and not quite so regular in its outlines.

C, the third, is situated about 36 feet almost directly east of *A*, and is about half the size of that mound.

D and *E* are the low ridges connecting these mounds; they are about 15 to 18 feet broad, and from 2 to 3 feet high. Another broad and somewhat indistinct ridge, marked *F* in the cut, runs southeast from *A*, fading out at the distance of about 400 feet.

Commencing on the north side of *A* at *G*, we made an opening about 3 feet wide and extending a little beyond the center. About 2 feet from the surface, near the center, we began to find human bones and the bones of an animal, apparently those of the buffalo; the remains of only one or two individuals were found here. Below these a few rocks, but by no means regularly placed, were found; next we came upon the remains (human) of a number of individuals, at which point we ceased operations. Some six or seven individuals were disinterred. There did not appear to be any great regularity as to the position of the skeletons; in one case the face was upward, two on the side, and one perpendicular, (though in this instance the body did not conform to the position of the skull.) In most cases the heads appear to be toward the south. Over the bodies there was a layer of some hard mixture, much like mortar, containing a white or ashy substance resembling the alkaline deposits of this section. Mingled with the bones near the top, as before stated, were those we supposed to be of the buffalo; a beaver-tooth was also found, but no implements of any kind were obtained; yet, as we did not go to the bottom, we could not say there were none there. Some bones of small animals were found near the surface, but these had evidently been carried into the badger-hole.

The Sioux scouts, who were full-blood and unable to speak English, showed no disgust or hesitancy at the work, handling the bones without objection, and when asked if they knew anything about these mounds shook their heads in reply.

The layer of hard ash-colored earth is somewhat difficult to account for unless we suppose fires were kindled here after the bodies were buried and covered, for funeral rites or some other purpose.

We dug into and for some distance along the middle of the ridge or embankment *D*, but could discover nothing to indicate that it had ever been more than a simple dirt embankment or wall, possibly of sod, as we often see the settlers of the present day make in these western prairies.

As I have not studied these ancient remains of the former inhabitants of this country, and do not desire to speculate in regard to them, I take pleasure in adding the following notes furnished by General Thomas respecting these and some other mounds he opened in this section previous to my arrival:

"Lewis and Clarke reported seeing Indian mounds 1,000 miles above the confluence of the Mississippi and Missouri, bnt this report is not verified." So says Mr. John D. Baldwin, A. M., in his work entitled "Ancient America."

I now and here propose to contribnte my mite toward the verification of the statement of Lewis and Clarke.

The few men whom duty or wild inclination have from time to time brought into this, for the most part, uninhabited region of treeless prairie, have all known of the existence of thousands of artificial mounds. What was in them they knew not, and but two or three, to my knowledge, have ever been opened. On August 16, 1872, I opened one on the high table-lands that spread out on both sides of a little stream called the James. The point is about 47° north latitude, and 98° 38′ longitude west from Greenwich. It is within three miles of the line of the North Pacific Railroad. The mound is circular in form, $30\frac{8}{10}$ feet in its shorter, and $35\frac{3}{10}$ feet in its longer diameter, and five feet high. I opened four trenches, three feet wide, from the outer edge, meeting in the center, forming a cross when finished. I then excavated the entire mound from the center ontward, nntil there was nothing more to find. For results I had several two-bushel bags full of bones, eight sknlls, many pieces of sknlls too small to be of valne, (there must have been at least twenty-five bodies buried there,) a rough-hewn stone 10 inches high and $5\frac{1}{2}$ inches in diameter, in shape resembling  closely a conical shell, a cntting half an inch deep around the center, thus, (This was evidently tied with thongs to a stout handle, and nsed in pulverizing their maize.) A portion of a shell necklace, two flints, two heads of beaver, and some bones of animals unknown, and a large quantity of bivalves, much like the clam (*Mya oblongata*) of our Atlantic coast, but thicker, and the interior surface mnch more pearly.

Is this mound, and its thousands of duplicates all over this conntry, the work of the present race of Indians, or is it not?

1. The Indians here and their habits have been known for some eighty years. They always have buried their dead in trees and on slight and insecnre scaffoldings, and they never meddle with them afterward.

2. I had two Sionx Indians (mounted sconts) with me. I made them help dig.

They had not the slightest objection, were full of curiosity, and said they knew nothing of who was buried there. Had these been their ancestors, tradition would have preserved the fact. They take any meddling with their dead in high dudgeon, as was instanced lately. A surgeon at a neighboring post took the body of a little papoose off a scaffold where it lay. The tribe pursued him, represented themselves as outraged, and the post commander wisely ordered it given up. If, then, mounds had been the burial-places of the ancestors of the present Indians, they would have known it and certainly objected to the desecration. Two half-breeds also rode up, watched me some time with the greatest curiosity, said they knew nothing of these mounds, and finally rode away on their little Indian ponies, their long lariats of untanned buffalo-hide trailing behind them on the ground, and examined with unfeigned curiosity other neighboring mounds. They had evidently received a new revelation as to them.

Again, the Dakotas or Sioux are supposed, on good authority, to be a branch of the Iroquois. This tribe and their habits have been known ever since the eastern coast of North America was discovered and settled, and we hear of no such custom among them.

3. The mounds and their contents are apparently of great antiquity. They are, in every case, on the very highest point in their immediate neighborhood, and perfectly drained. The climate is excessively dry; so dry that the James River is entirely dry at a point about 500 feet above the contemplated railroad-bridge across the river. Notwithstanding this, many of the bones crumbled into white dust on being brought to the air, like those found in Herculaneum and Pompeii, and it was absolutely impossible to get out a single one in anything like perfection. Around and over these bodies stones and sticks were placed, doubtless to preserve the remains from the coyote and the fox. The wood could be rubbed into fine yellow-brown dust between the thumb and forefinger. Any trace of excavation around the mound for dirt to heap it with had been entirely obliterated. The upright position of the skulls also indicated that the bodies were buried in a sitting posture. The leg-bones, however, lay lower and horizontal.

4. The number of mounds indicates a denser population than ever has been known here, or than the natural resources of this region can now support by the chase. At the same time the number of dry lakes scattered all over would indicate that at some remote period the country may have been a better one than now, and supported a larger population.

5. The crowning argument, however, comes with the skull. It is unlike that of any human being to-day alive on this continent; the frontal bone being low, receding, growing narrow and pinched from the brows up; the top of the head depressed in the center. The cavity of the cranium is full seven inches long, and a scant four and a half inches wide. The orbital ridges or eyebrows are excessively developed, like those of the great Gibbon monkey. In fact the whole skull resembles that of the great Gibbon monkey. The malar or cheek bones run down very low and deep toward the lower jaw, are set very far to the front, and are not wide at top, but widen very much toward the bottom. The nose, and here is the anomaly, is much more aquiline than that of the Indian. The superior maxillary is one-third deeper and much more prominent than the Indian's. The inferior maxillary is of uncommon prominence, depth, and power far exceeding that of the Indian. The mouth is narrow and long, more dog-shaped than the Indian's. The *foramen magnum* or aperture at base of skull, where the spinal cord enters the head, is peculiarly small. The *condyloid processes* are full, oblong, flat on the working surfaces, and at such an angle as to set the head upward and back more than any race we know to-day on this continent. Set one of these skulls, without the lower jaw, on the table, and a line drawn from the upper jaw perpendicularly upward would be a good inch and a half in front of the forehead. Set on the lower jaw and it would be two inches. Mr. R. D. Guttgisal, formerly an engineer on the Mexican Central Railroad, in connection with some friends, opened a mound at Chihuahua, on the line of that railroad. The skulls resembled those I have described (so he informs me) in every particular. He especially remembers the somewhat bird-shaped head, and the excessively small *foramen magnum*. The bodies were not interred horizontally there, but leaning backward as if in a rocking-chair. Professor H. H. Smith, University of Pennsylvania, has one of the skulls.

On the east bank of the James, three miles from the mound described, is one four or five times as large. A heavy embankment, some 12 or 15 feet wide by 3 high, runs nearly southwest 150 feet, connecting it with another mound. There is also another embankment at right angles, running southeast about 400 feet, growing flatter until lost in the prairie.

Accompanied by Professor Cyrus Thomas, of the United States geological survey, under Dr. F. V. Hayden, I opened one of these mounds, at the end of August, 1872, and found the same kind of skulls, similarly disposed in all respects. The whitish color of the superincumbent earth astonished the professor, who is inclined to the opinion that funeral rites were celebrated here. He was unable to account for the peculiar character of this rich earth and the ash-colored layer on any other hypothesis.

We cut through one of the embankments, and, turning a right angle, followed it up along its center sufficiently to satisfy us that it contained no human remains.

Who, then, were these northern mound-builders? This question must be answered by those abler than I. I cannot refrain hazarding the opinion, however, that they were an offshoot of the mound-builders whose larger works are seen as far north as Northern Ohio at least; that they deteriorated century after century in this barren northern section, until they became the people their skulls show them to have finally been; and so poor that a flint-headed weapon, a shell necklace, and a stone for grinding their food, were all their starving, surviving relatives could afford them on their sorrowful journey to the spirit land.

H. G. THOMAS,
Captain Twentieth Infantry, Brev. Brig. Gen. U. S. A.

PART III.

SPECIAL REPORTS

ON

ZOÖLOGY AND BOTANY.

REPORT ON THE MAMMALS AND BIRDS OF THE EXPEDITION.

BY C. H. MERRIAM.

SIR: I take pleasure in presenting my report on the mammals and birds collected during the past season for publication in your report.

I desire to tender my thanks to Mr. S. W. Jaycox for his assistance in the collections. I collected, from the 5th to the 21st of June, one hundred and twenty bird-skins, and fifty-two nests with eggs.

I wish to express my indebtedness to Mr. Platt, whose collections in my department would have been larger had he not also had charge of the alcoholic and botanical collections made by that branch of the expedition under your immediate control. I wish also to state that I am under great obligations to Professor S. F. Baird and Mr. Robert Ridgway, of the Smithsonian Institution, for aiding me in various ways.

The total number of bird-skins collected is three hundred and thirteen; of nests, with eggs, sixty-seven. I found no birds at Téton or Fire-Hole Basins specifically different from those collected at other places on our route.

I remain, yours, very respectfully,

C. HART MERRIAM.

DR. F. V. HAYDEN,
United States Geologist.

MAMMALS.

Order I.—RAPACIA.

(Sub-order CARNIVORA.)

Family 6.—MUSTELIDÆ.

(Sub-family *Martinæ.*)

Putorius pusillus, Aud. and Bach., (least weasle:)

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
7	12416	11102	Juv.	July 22, 1872	Téton Basin, Idaho.

Hab.—Minnesota to Puget's Sound; New York, (De Kay.)

Gulo luscus, Sabine, (Wolverine:)

No.	Catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
54	11094	11094	♂ ?	Aug. 10, 1872	Yellowstone River, Wyo.

Hab.—Salt Lake and Black Hills, Nebraska, to Arctic America; (Northern New York, Aud. and Bach.)

(Sub-family *Melinæ*.)

Mephitis mephitica, var. *occidentalis*, Bd., (California skunk:)

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
28	12409	11095	♂	Aug. 13, 1872	Lower Geyser Basin, Wyo.
45	12410	11096	♂	Sept. 8, 1872	Shoshone Lake, Wyo.
55	....	....	—	June 5, 1872	Ogden, Utah.

Hab.—High central plains to the Pacific.

Mephitis bicolor, Gray, (little striped skunk:)

No.	Catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
57	....	11136	—	June 28, 1872	Marsh Valley, Idaho.

Hab.—Southern Texas and California; northward to Idaho on western slope of Rocky Mountains.

Family 7.—URSIDÆ.

Ursus horribilis, Ord., (grizzly bear:)

No.	Catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
12	12397	....	♀	July 24, 1872	Téton Cañon, Idaho.

Hab.—Plains of the Upper Missouri to the Rocky Mountains, and along their base; thence to the coast of California.

Ursus Americanus, Pallas, (black bear:)

No.	Catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
25	12398	....	♂	Aug. 10, 1872	Henry's Lake, Idaho.

Hab.—United States generally.

Order III.—RODENTIA.

Family 9.—SCIURIDÆ.

Sub-family, *Sciurinæ, the true squirrels.*

Sciurus hudsonius, Pallas., (red squirrel:)

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
23	12421	11107	♀	Aug. 8, 1872	Henry's Lake, Idaho.
30	12422	11108	♀	Aug. 17, 1872	Upper Geyser Basin, Wyo.
31	12423	11109	♀	Aug. 20, 1872	Lower Geyser Basin, Wyo.
37	12424	....	—	Aug. 30, 1872	Fort Ellis, Mont.
38	12425	....	♂	Aug. 31, 1872	Lower Geyser Basin, Wyo.
51	12429	11113	—	Sept. 17, 1872	Snake River, Wyo.

Hab.—Labrador (latitude 56°) to Mississippi, and in the United States from the Atlantic to the western slope of the Rocky Mountains.

Tamias quadrivitattus, Rich, (Missouri striped squirrel:)

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
1	12444	11130	—	June 14, 1872	Ogden, Utah.
29	12426	11110	♂	Aug. 17, 1872	Upper Geyser Basin, Wyo.
39	12427	11111	♂	Sept. 2, 1872	Do.
40	12428	11112	♂	Sept. 2, 1872	Do.
43	....	11117	Juv.	Sept. 15, 1872	Head-waters of the Madison, Wyo.
48	....	11118	♂	Sept. 16, 1872	Snake River, Wyo.
52	....	11119	—	Sept. 18, 1872	Do.

Hab.—Upper Missouri to Rocky Mountains, and west to the Cascade Range; along the Rocky Mountains as far south as Fort Stanton, New Mexico.

Spermophilus grammurus, Bach., (line-tailed squirrel:)

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
2	12445	11131	—	June 15, 1872	Ogden, Utah.
3	12446	11132	♀	June 15, 1872	Do.
4	12447	11133	—	June 17, 1872	Do.
56	12449	11135	♂?	June 8, 1872	Do.

Hab.—Head of Arkansas River; along the Rocky Mountains to Sonora; northward to Idaho Territory.

Spermophilus lateralis, Rich, (Say's striped squirrel:)

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
25	12417	11103	—	Aug. 10, 1872	Henry's Lake, Idaho.

Hab.—Rocky Mountains to Cascades, and between about latitude 38° 26′ to latitude 42°.

Spermophilus mollis, Kennicott:

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
6	12448	11134	♂	July 3, 1872	Ross Fork, Idaho.

Hab.—Rocky Mountain region.

Spermophilus townsendii, Bach., (Townsend's spermophile:)

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
16	12418	11104	—	July 29, 1872	Téton Cañon, Idaho.
18	12431	11115	—	Aug. 1, 1872	Do.
19	12432	11116	♂	Aug. 1, 1872	Do.
24	12419	11105	♂	Aug. 9, 1872	Henry's Lake, Idaho.

Hab.—Rocky Mountains, to the north.

Arctomys flaviventer, Bachman, (yellow-footed marmot:)

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
20	12406	....	—	Aug. 4, 1872	Téton Basin, Idaho.
22	12407	....	—	Aug. 7, 1872	North Fork, Idaho.
58	12753	11197	♂	July 27, 1872	Near Fort Ellis, Mont.
59	12754	11198	♀	July 27, 1872	Do.

Hab.—Black Hills, Nebraska.

(Sub-family *Castorinæ.*)

Castor canadensis, Kuhl, (American beaver:)

No.	Catalogue-number.	Sex.	Date.	Locality.
	Skull.			
8	12404	—	July 22, 1872	Téton Basin, Idaho.
9	....	—	July 22, 1872	Do.
11	12403	♀	July 24, 1872	Téton Cañon, Idaho.

Hab.—Throughout the entire area of North America.

Family 10.—SACCOMYIDÆ.

(Sub-family *Geomyinæ.*)

Thomomys fulvus, (mountain pocket rat:)

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
17	12420	11106	♀	July 30, 1872	Téton Cañon, Idaho.
34	12433	11126	—	July 8, 1872	Fort Ellis, Mont.

Hab.—San Francisco Mountains, New Mexico, to Fort Yuma and San Diego, northward in Rocky Mountains to Montana.

Family 11.—MURIDÆ.

(Sub-family *Dipodinæ.*)

Jaculus hudsonius, (jumping mouse:)

No.	Smithsonian catalogue-number.	Sex.	Date.	Locality.
	Skin.			
35	11120	♂	Aug. 31, 1872	Upper Madison Cañon, Wyo.
56	11125	♀	July 14, 1872	Fort Ellis, Mont.

Hab.—Nova Scotia, (Labrador, Pennant,) to Southern Pennsylvania, and west to the Pacific Ocean.

(Sub-family *Murinæ.*)

Mus musculus, Linn., (common mouse:)

No.	Catalogue-number.	Sex.	Date.	Locality.
60	11199	—	....	Mont.

Hab.—North America generally.

Hesperomys leucopus, var. *sonoriensis*, Lec.:

No.	Catalogue-number.	Sex.	Date.	Locality.
42	11121	—	Sept. 3, 1872	Lower Geyser Basin, Wyo.
49	11122	♂	Sept. 16, 1872	Snake River, Wyo.
61	11200	♂	—— —, 1872	Mont.
62	11201	♂	—— —, 1872	Do.

Hab.—Upper Missouri and Rocky Mountains to El Paso and Sonora.

(Sub-family *Arvicolinæ.*)

Arvicola riparia, Ord., (bank mouse:)

No.	Catalogue-number.	Sex.	Date.	Locality.
33	11123	♂	Aug. 30, 1872	Lower Geyser Basin, Wyo.
36	11124	—	July 10, 1872	Fort Ellis, Mont.

Hab.—United States to Rocky Mountains.

Family 12.—Hystricidæ.

Erethizon epixanthus, Brandt, (yellow-haired porcupine:)

No.	Catalogue-number. Skull.	Sex.	Date.	Locality.
26	12405	♀	Aug. 10, 1872	Henry's Lake, Idaho.

Hab.—Upper Missouri; whole Pacific coast.

Family 13.—Leporidæ.

Lepus callotis, (?) Wagler, (jackass or mule rabbit:)

No.	Catalogue-number. Skull.	Sex.	Date.	Locality.
5	12436	—	June 21, 1872	Ogden, Utah.

Hab.—Northern Mexico, through Southern Texas, and west through New Mexico to the Rocky Mountains, north to the Yellowstone; Fort Boise, Oregon, (?) Southern Sonora. (?)

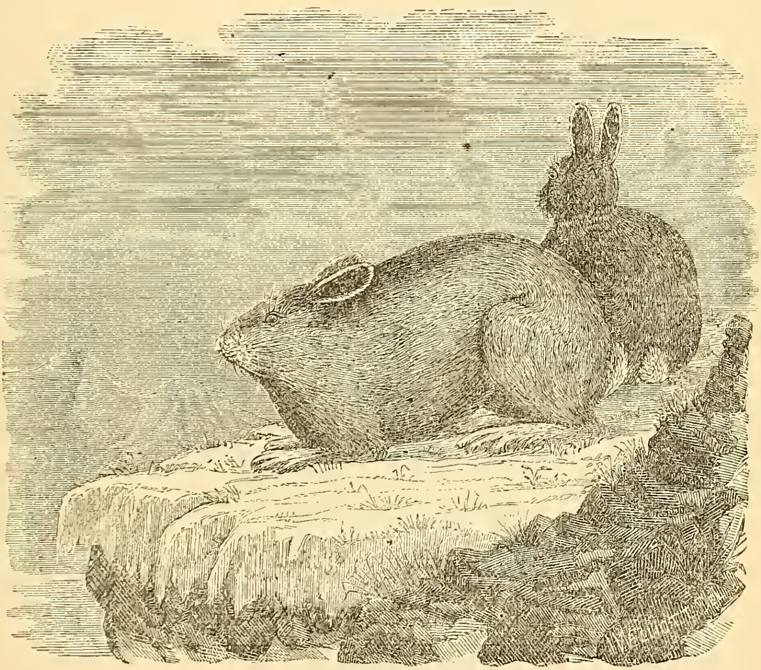
Lepus bairdii, Hayden, (Baird's rabbit:)

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
32	12411	11097	♂	Aug. 29, 1872	Lower Geyser Basin, Wyo.
44	12412	11098	♂	Sept. 7, 1872	Shoshone Lake, Wyo.
46	12413	11099	♂	Sept. 11, 1872	Lewis Lake, Wyo.
47	12414	11100	♂	Sept. 15, 1872	Snake River, Wyo.
50	12415	11101	Juv.	Sept. 17, 1872	Hart Lake, Wyo.

Hab.—Pine regions about the head-waters of the Wind and Yellowstone Rivers.

I was fortunate enough to secure five specimens of this rare and remarkable rabbit. Heretofore but one specimen of this species has been

Fig. 57.



LEPUS BAIRDÜ, HAYDEN.

brought before the scientific world, and it (No. 4263) is now on exhibition in the Smithsonian Institution. It was collected in the Wind River Mountains by Dr. Hayden in the month of June, 1860, and was described by him in the American Naturalist, (vol. iii, No. 3, May, 1869.) Unfortunately the sex of this specimen was not determined.

One very curious fact relating to *Lepus bairdii* is that all the males have teats and take part in suckling the young. I say *all* the males, because four out of the five specimens procured were adult males, and *all* had large teats full of milk, and the hair around the nipple was wet and stuck to it, showing that they were then nursing their young.

As we found no females, we thought this might be an hermaphroditic form; so Dr. Josiah Curtis and myself dissected a large male—No. 44, (12412, 11098)—which we found to contain the usual genital organs of the male, but no uterus, ovaries, or other female organs. I dissected another old male—No. 46, (12413, 11099)—with the same result. I regret exceedingly that I was unable to procure a female specimen; but, from the limited number of specimens examined, I should infer that both sexes take part in suckling their young.

I publish the following letter from Dr. Curtis, verifying the above statements:

WASHINGTON, D. C., *February* 20, 1873.

DEAR SIR: When upon that part of our explorations last summer which embraced the region about the head-waters of the Snake River, I saw several specimens of the rabbit (*Lepus bairdii*, Hayden) which you had secured, and the adults gave external signs of having been suckled, but gave every other evidence of being true males.

To satisfy you, as well as myself, beyond a doubt upon this point, I very carefully dissected one unmistakably-marked specimen, and found conclusive evidence of its having been recently and for some time suckled. Milk was abundant in its udders. It, however, possessed no other organs characteristic of the female sex, but it did have all the male organs complete and well developed.

Yours, respectfully,

JOSIAH CURTIS,
Naturalist United States Geological Survey.

MR. C. HART MERRIAM.

Lagomys princeps, Rich, (little chief hare:)

No.	Smithsonian catalogue-number.		Sex.	Date.	Locality.
	Skull.	Skin.			
10	12430	11114	—	July 24, 1872	Téton Cañon, Idaho.

Hab.—South Pass of Rocky Mountains, northward.

Order VI.—RUMINANTIA.

Family 16.—CERVIDÆ.

(Sub-family *Cervinæ*.)

Alce americanus, Jardine, (American moose:)

No.	Catalogue-number.	Sex.	Date.	Locality.
	Skull.			
13	12399	♀ ad.	July 26, 1872	Teton Cañon, Idaho.
14	12400	♀ juv.	July 26, 1872	Do.
15	....	♂ juv.	July 26, 1872	Do.

Hab.—Northern portions of the Eastern United States to Labrador, whence it extends west to the Pacific Ocean.

Family 17.—CAVICORNIA.

(Sub-family *Antilopinæ.*)

Antilocapra americana, Ord, (prong-horn antelope:)

No.	Catalogue-number. Skull.	Sex.	Date.	Locality.
21	12402	Juv.	Aug. 5, 1872	Middle Fork, Idaho.
53	12401	♂	Oct. 4, 1872	Cañon Creek, Idaho.

Hab.—Plains west of Missouri, from the Lower Rio Grande to the Saskatchewan, and west to the Cascade and Coast Ranges of the Pacific slope.

Order IX.—CHEIROPTERA, THE BATS.

Family.—VESPERTILIONIDÆ.

Nycticejus crepuscularis, Allen.

No.	Catalogue-number.	Sex.	Date.	Locality.
1	11127	—	Aug. 31, 1872	Lower Geyser Basin, Wyo.

Hab.—United States, from Atlantic to Pacific.

Vespertilio lucifugus, Leconte, (the blunt-nosed bat:)

No.	Catalogue-number.	Sex.	Date.	Locality.
2	11128	♂	Aug. 31, 1872	Lower Geyser Basin, Wyo.

Hab.—North America generally.

Vespertilio yumanensis, Allen, (the Gila bat:)

No.	Catalogue-number.	Sex.	Date.	Locality.
3	11129	♂	July 25, 1872	Hot Springs, Montana.

Hab.—Eastern slope of Rocky Mountains to Pacific coast.

BIRDS.

Sub-class I.—INSESSORES, PERCHING BIRDS.

Order 1.—PASSERES, PASSERINE BIRDS.

(Section OSCINES, SINGERS.)

Family 1.—TURDIDÆ, THE THRUSHES.

Turdus (Planesticus) migratorius, Linn., (common robin:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
102	61650	♂	June 18, 1872	$10\frac{1}{8} \times 15\frac{7}{8}$	Ogden, Utah.
200	62275	♀	July 30, 1872	$9\frac{3}{4} \times 16\frac{1}{4}$	Téton Cañon, Idaho.
255	62276	♀	Sept. 6, 1872	$9\frac{1}{4} \times 15\frac{3}{4}$	Source of the Madison.
274	62277	♂	Sept. 16, 1872	$10\frac{3}{8} \times 16\frac{3}{4}$	Snake River, Wyo.

Hab.—Continent of North America to Mexico.

We found a flock of about thirty robins near the head-waters of the Madison River, Wyoming Territory, on the 6th of September. The snow was about an inch in depth, and the flock—one of which I shot (No. 255)—seemed to be moving southward. They were quite abundant on Snake River during the latter part of September. At all other places on our route robins were seldom met with.

Galeoscoptes carolinensis, Linn., (cat-bird:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
99	61653	♂	June 18, 1872	$8\frac{7}{8} \times 11$	Ogden, Utah.

Hab.—Eastern United States to Salt Lake Valley and Washington Territory. I was surprised to find cat-birds as common in the Salt Lake Valley as they are in all our Eastern States. At Ogden I found one of their nests—No. 52, (16310); it was on a bush in a marsh, about four feet above the ground, and contained five fresh eggs.

Oreoscoptes montanus, Baird, (mountain mocking-bird:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
41	61651	♂	June 11, 1872	$9\frac{3}{16} \times 12\frac{5}{8}$	Salt Lake, Utah.
42	61652	♂	June 11, 1872	$9 \times 12\frac{1}{2}$	Do.

Hab.—Rocky Mountains; south to Mexico, and along valley of Gila and Colorado, and to San Diego, California.

This plain-colored songster is quite numerous about Salt Lake, where we found them breeding; we also found them northward to Snake River and in the Téton Basin. I found its nest—No. 26 (16296)—near the shore of Salt Lake; it was placed at the foot of a sage-brush; was built of sticks, lined with fibrous roots; it was unusually large for the size of the bird, (measuring over eight inches in diameter,) and contained four fresh eggs.

Family 2.—CINCLIDÆ, THE DIPPERS.

Cinclus mexicanus, Swains., (water-ouzel:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
307	62341	♂	July 14, 1872	$7\frac{7}{8} \times 12\frac{1}{2}$	Mystic Lake, Mont.
308	62342	♀	July 14, 1872	$7\frac{1}{16} \times 10\frac{7}{8}$	Do.

Hab.—Rocky Mountains from British America to Mexico.

The American dipper, or water-ouzel, is a rare bird in the district through which we passed, being met with only at Ogden Cañon, Mystic Lake, and in a little cañon east of the Téton Range, near Jackson's Lake. It is truly a wonderful bird, being able not only to walk, but also to fly, into the water. During the latter part of September, when the snow was about an inch deep and was still falling, I took my gun and entered one of the cañons a few miles north of Jackson's Lake, in the hope of meeting some rare birds. I had not gone far, when, to my great delight, I saw a pair of water-ouzels on a rock in the middle of a rapid stream which flowed out of the cañon. To my great surprise one of these birds dove directly into the rapids, and in a few moments returned with a worm in its mouth. I shot one of the birds, which, to my great chagrin, fell into the water and was carried under by the current, and I was unable to secure it.

[The nest of the water-ouzel (*Cinclus mexicanus*) was discovered by our artist, Mr. W. H. Holmes, about half a mile from Mystic Lake, Montana Territory, while he was sketching a beautiful little fall made by one of the mountain streams. The bird was observed to fly directly through the falling water, disappearing from view. Suspecting that a nest must be there, we returned the following day, when, with the assistance of Mr. Holmes, I secured the nest, containing three young, and shortly after shot both the old birds. The nest was made of moss, measuring nearly a foot in diameter and six inches in depth. It was built upon the edge of a narrow shelf of rock, and so near the fall that the outside was constantly wet with spray, while the interior was dry and warm. The birds entered it by a small lateral opening in the lower half of the nest, the top being built up against a projecting rock.—W. B. PLATT.]

Family 3.—SAXICOLIDÆ, THE SAXICOLAS.

Sialia arctica, Sw., (Rocky Mountain blue-bird:)

No.	Catalogue-number.	Sex and age.	Date.	Measurements.	Locality.
214	62330	♂	Aug. 4, 1872	$7\frac{3}{16} \times 13\frac{1}{2}$	Middle Fork, Idaho.
246	62331	0	Aug. 28, 1872	$6\frac{3}{8} \times 11\frac{5}{8}$	Lower Geyser Basin, Wyo.
248	62332	0	Aug. 28, 1872	$6\frac{5}{8} \times 12\frac{1}{4}$	Do.

Hab.—High dry central plains; Upper Missouri to Rocky Mountain Range and south to Mexico. Rare on the coast of California.

The Rocky Mountain blue-bird seems to prefer a country which has been burnt over, and is covered with stumps and fallen timber. It is not a common species in the district through which we passed.

Family 4.—SYLVIDÆ, THE WARBLERS.

Regulus calendula, Licht., (ruby-crowned kinglet:)

No.	Catalogue-number.	Sex and age.	Date.	Measure-ments.	Locality.
231	62333	0	Aug. 20, 1872	$4\frac{1}{8} \times 7\frac{1}{4}$	Lower Geyser Basin, Wyo.
267	62334	♂	Sept. 14, 1872	$4\frac{5}{8} \times 7\frac{5}{16}$	Snake River, Wyo.

Hab.—North America from Atlantic to Pacific.

This pretty little bird is probably abundant in early spring and in October, although I saw but two of them during the summer. It is evident that they breed in the Yellowstone country, from the fact that I obtained a young one—No. 231, (62333)—there on the 20th of August.

Family 5.—PARIDÆ.

(Sub-family *Parinæ, the Titmice.*)

Parus montanus, Gambel., (mountain titmouse:)

No.	Catalogue-number.	Sex.	Date.	Measure-ments.	Locality.
211	62349	♂	July 31, 1872	$5\frac{3}{4} \times 8\frac{3}{4}$	Téton Cañon, Idaho.
212	62350	♂	July 31, 1872	$5\frac{9}{16} \times 8\frac{3}{8}$	Do.
256	62351	♂	Sept. 7, 1872	$5\frac{3}{8} \times 8\frac{1}{4}$	Shoshone Lake, Wyo.
279	62352	♂	Sept. 18, 1872	$5\frac{3}{4} \times 9$	Snake River, Wyo.

Hab.—Pacific coast of United States to Rocky Mountains.

Téton Cañon was the first place where we observed this species, probably because it was the first place on our route where we found coniferous trees.

The mountain chickadee is an abundant species in the Fire-Hole Basin, and also from the source of Snake River to where it leaves the wooded mountain sides and flows through an open plain. This bird, like our "chickadee," (*P. atricapillus*,) is very tame, and evidently likes the company of man, as they flit about from limb to limb in search of their food within a few feet of you, without even looking up, or showing any signs of fear or even surprise at your presence. This species may easily be distinguished from our eastern *P. atricapillus* by the white front and the white line over the eye, cutting off a black one through it.

(Sub-family *Sittinæ, the Nuthatches.*)

Sitta aculeata, Cassin, (slender-billed nuthatch.)

No.	Catalogue-number.	Sex.	Date.	Measure-ments.	Locality.
240	62297	♂	Aug. 27, 1872	6×11	Lower Geyser Basin, Wyo.

Hab.—Pacific coast of United States to Rocky Mountains.

This may be considered as a rare bird in the tract of country through which we passed, as I saw but one specimen, which I shot—No. 240, (62297.)

Family 7.—TROGLODYTIDÆ, THE WRENS.

(Sub-family *Campylorhynchinæ.*)

Salpinctes obsoletus, Cab., (rock-wren.)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
64	616654	♂	June 14, 1872	$6\frac{1}{8} \times 9$	Ogden, Utah.

Hab.—High central plains through the Rocky Mountains to the Coast and Cascade Ranges, (but not on the Pacific coast ?)

This bird is very properly called the "rock-wren," for high up the mountain sides and among the rocks it lives, lays its eggs, and teaches its young the use of their tiny wings. They are noisy creatures, and seem to take great pleasure in darting from rock to rock, keeping generally out of sight.

I shot the first of this species that I saw on one of the rocky spurs of the Wahsatch Range, near Ogden—No. 64, (61654.) They were quite abundant on the rocky hills near the Hot Sulphur Springs, ten miles north of Ogden.

(Sub-family *Troglodytinæ.*)

Cistothorus palustris, Cab., (long-billed marsh-wren.)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
302	62327	♂	Oct. 14, 1872	$5\frac{1}{2} \times 7$	Fort Hall, Idaho.

Hab.—North America from Atlantic to Pacific, north to Greenland.

Fort Hall is the only place where I found the long-billed marsh-wren. I saw several of them there, but succeeded only in obtaining one specimen—No. 302, (62327.) This bird, though not gay in colors, is a sweet songster.

Troglodytes parkmanni, Aud., (Parkman's wren :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
172	62328	♀	July 18, 1872	$4\frac{1}{2} \times 6\frac{5}{8}$	North Fork, Idaho.
306	62329	♂	July 9, 1872	$4\frac{1}{2} \times 6\frac{1}{2}$	Fort Ellis, Mont.

Hab.—Western America, from the high central plains and Upper Missouri to the Pacific.

This little bird, very similar to our house-wren, (*T. ædon*,) was quite common at North or Henry's Fork of Snake River, Middle Fork, Téton Cañon, and Fort Ellis. I found its nest, on the 20th of July, at Middle

Fork; it was in the hollow of a small tree that had broken off about ten feet high and still rested against its stump. The nest contained five young birds, and was composed of small sticks laid loosely together. The parent-birds were greatly incensed at my approach, and darted about my head in an angry manner.

Family 8.—MOTACILLIDÆ, THE WAGTAILS.

Anthus ludovicinus, Licht., (tit-lark:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
281	62298	♂	Sept. 21, 1872	$6\frac{1}{8} \times 10\frac{1}{2}$	Snake River, Wyo.

Hab.—North America generally; Greenland, (Reinhardt.) Accidental in Europe.

We met with this bird only on Snake River and in the vicinity of Jackson's Lake; there we found a few flocks of from ten to fifty.

Family 9.—SYLVICOLIDÆ, THE WOOD-WARBLERS.

Geothlypis trichas, Cab., (Maryland yellow-throat:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	No. of nest and eggs.	Locality.
83	61661	♀	June 17, 1872	$5\frac{5}{8} \times 7$	44	Ogden, Utah.
309	62343	♂	July 9, 1872	$3\frac{3}{4} \times 7$	....	Fort Ellis, Mont.
310	62344	♂	July 11, 1872	$4\frac{3}{4} \times 7$	....	Do.

Hab.—North America, from Atlantic to Pacific.

This little warbler is quite abundant at Ogden, Utah, and also on the Madison River, and at Fort Ellis, Montana Territory; I saw none elsewhere. I obtained the nest of this bird at Ogden—No. 44, (16308) ♀; No. 83, (61661,) shot. It was found in a clump of bushes in a marsh, about six inches above the ground, and was composed of dried grass and rushes; it contained four fresh eggs.

Icteria longicauda, Lawr., (long-tailed chat:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
20	61658	♀	June 7, 1872	....	Ogden, Utah.
37	61656	♂	June 9, 1872	$8 \times 10\frac{5}{16}$	Do.
44	61655	♂	June 11, 1872	$7\frac{3}{4} \times 10$	Do.
113	61659	♀	June 20, 1872	$5\frac{3}{4} \times 9\frac{3}{16}$	Do.
129	61794	♂	June 28, 1872	$7\frac{3}{4} \times 10\frac{1}{4}$	Devil's Creek, Idaho.
30	61657	♂	June 8, 1872	$7\frac{1}{2} \times 10\frac{1}{8}$	Ogden, Utah.

Hab.—High central plains of the United States to the Pacific; south into Mexico.

The long-tailed chat is a common bird in the scrub-oak bushes at the foot of the Wahsatch Range, near Ogden. It is a peculiar bird, and like our eastern species, (*Icteria virens*,) is always heard, but seldom seen. They are shy, suspicious creatures, and although, when disturbed, they flit about in a scolding, angry manner, they generally manage to keep out of sight. You hear them in the bushes, imitating the mewing of a cat, the shrill notes of the jay, sometimes singing like a cat-bird, and yet again, they sing sweetly in their own peculiar manner. They have a strange habit of elevating themselves in the air to the height of thirty or forty feet, then, poising themselves for a moment, they descend again to the bushes; during their descent they jerk themselves about in the air, at the same time uttering clear, ejaculated notes, which can be heard for quite a distance, and are not altogether unpleasant to the ear. I found the nest of this bird on the 15th of June; it was on a scrub-oak near a small stream; was about four feet above the ground, and contained three young birds and one egg. The egg resembled, in size and color, that of our eastern species, (*I. virens*.)

Dendroica auduboni, Baird, (Audubon's warbler:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
258	62345	—	Sept. 7, 1872	$5\frac{3}{4} \times 9\frac{5}{8}$	Shoshone Lake, Wyo.
268	62346	♂	Sept. 15, 1872	$5\frac{3}{4} \times 9$	Snake River, Wyo.

Hab.—Pacific coast of United States to central Rocky Mountains, south to Mexico.

Audubon's warbler, though similar in most respects to our eastern yellow-rump warbler, (*D. coronata*,) is easily distinguished from it by having the chin and throat *yellow* instead of *white*. During the latter part of September I saw several flocks of these birds on Snake River; they appeared to be on their way south.

Dendroica æstiva, Baird, (yellow warbler:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	No. of nest and eggs.	Locality.
36	61660	♂	June 8, 1872	$5\frac{1}{8} \times 7\frac{5}{8}$	24	Ogden, Utah.

Hab.—United States from Atlantic to Pacific; south to Guatemala and West Indies.

Yellow warblers were common at Ogden, as they were at all places where there was a stream of water whose banks were lined with bushes. I found the nest of this bird at Ogden—No. 24, (16294;) it was on a willow, about three feet above the ground, and contained four fresh eggs.

Myiodioctes pusillus, Bonap., (green black-cap warbler:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
227	62347	♂	Aug. 13, 1872	$4\frac{3}{4} \times 7\frac{1}{4}$	Lower Geyser Basin.
286	62348	♂	Sept. 26, 1872	$5\frac{1}{4} \times 7\frac{1}{4}$	Second Téton Lake.

Hab.—United States from Atlantic to Pacific; south to Guatemala.

We met with this beautiful warbler but twice during the summer. On the first occasion we were just entering the Lower Geyser Basin, when I observed a pair of these little birds in a grove of small pine trees; they were hopping about on the ground, and upon my approach flew up into a tree, out of which I shot the male—No. 227, (62347.)

The second and last time that I saw this species was at the Second Téton Lake, where I saw a male high up in a pine tree. I secured him also.

Family 10.—HIRUNDINIDÆ, THE SWALLOWS.

Hirundo horreorum, Barton, (barn-swallow:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
244	62295	♂	Aug. 28, 1872	7 × 12⅝	Lower Geyser Basin.
247	62296	0	Aug. 28, 1872	5¾ × 11¾	Do.

Hab.—North America, from Atlantic to Pacific.

Barn-swallows are common at most places between Fort Hall, Idaho, and Ogden, Utah. They are also numerous at Fire-Hole Basin, Wyoming Territory, where I obtained two specimens—No. 244, (62295,) and No. 247, (62296.)

Petrochelidon lunifrons, Say, (cliff-swallow:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
147	61774	♀	July 3, 1872	6 × 12⅝	Ross Fork, Idaho.

Hab.—North America, from Atlantic to Pacific.

This is another common species of swallow. We found them very plentiful in the vicinity of Great Salt Lake; thence north to Fort Hall, where they were also abundant. I obtained the nest of this species—No. 58, (16312,)—♀, No. 147, shot at Ross Fork, Idaho Territory, on the 3d of July. It was composed of mud, and was fastened to the bank of the creek, and about eight feet above the water. The nest contained two fresh eggs.

Tachycineta thalassina, Sw., (violet-green swallow:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
96	61665	♂	June 18, 1872	5½ × 12$\frac{3}{16}$	Ogden, Utah.

Hab.—Rocky Mountains to Pacific; south to Mexico; east to Saltillo, Mexico.

This bird, the most beautiful of all the swallows, is quite common at Ogden Cañon, where we obtained the only specimen collected—No. 96, (61665.) The only other place on our route at which we found this species was the Grand Cañon of the Yellowstone. There I saw a few of them, but did not succeed in obtaining any specimens.

Cotyle riparia, Boil., (bank-swallow:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
40	61664	♀	June 11, 1872	....	Salt Lake, Utah.

Hab.—United States, from Atlantic to Pacific; common at Salt Lake, and from there to Snake River.

I obtained the nest of the bank-swallow in a hole in a sand-bank by the side of Salt Lake. It contained seven fresh eggs—No. 25, (16295,) ♀, No. 40, shot.

Family 13.—LANIIDÆ, THE SHRIKES.

Collurio borealis, Baird, (great northern shrike:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
297	62270	♀	Oct. 12, 1872	$10\frac{3}{8} \times 14\frac{3}{4}$	Fort Hall, Idaho.

Hab.—Northern regions, from Atlantic to Pacific; in winter south, through most of the United States.

As the shrike or butcher-bird is confined to the cooler portions of America, it was met with by our party but once, and that was in October, at Fort Hall, Idaho Territory. There I secured one specimen, No. 297, (62270.)

Collurio excubitoroides, Baird, (white-rumped shrike:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
43	61752	♀	June 11, 1872	$8\frac{7}{8} \times 12\frac{5}{8}$	Salt Lake, Utah.
301	62271	0	Oct. 13, 1872	$8\frac{1}{4} \times 12\frac{7}{8}$	Fort Hall, Idaho.

Hab.—Missouri plains and fur countries to Pacific coast; eastward into Wisconsin, Illinois, and Michigan. (?)

Salt Lake and Fort Hall are the only localities at which I found the white-rumped shrike. At the former place, on the 11th of June, I saw a pair of them, and succeeded in shooting the female—No. 43, (61752.) It is evident, from the lateness of the season, that they breed here.

Family 15.—TANAGRIDÆ, THE TANAGERS.

Pyranga ludoviciana, Bonap., (Louisiana tanager:)

No.	Catalogue number.	Sex.	Date.	Measurements.	Locality.
1	61662	♂	May 29, 1872	....	Cheyenne, Wyo.
12	61663	♂	June 6, 1872	$7\frac{3}{8} \times 11\frac{1}{2}$	Ogden, Utah.
197	62278	♂	July 29, 1872	$7 \times 12\frac{1}{16}$	Téton Cañon, Idaho.
199	62279	♂	July 30, 1872	$7\frac{1}{8} \times 11\frac{3}{4}$	Do.
203	62280	♂	July 31, 1872	$7\frac{3}{8} \times 11\frac{3}{8}$	Do.
204	62281	♂	July 31, 1872	$7\frac{1}{2} \times 11\frac{1}{2}$	Do.
207	62282	♀	July 31, 1872	$7\frac{1}{4} \times 11\frac{1}{4}$	Do.
208	62283	♂	July 31, 1872	$7\frac{1}{2} \times 11\frac{1}{2}$	Do.
209	62284	♂	July 31, 1872	$7\frac{1}{4} \times 11\frac{1}{2}$	Do.
210	62285	♀	July 31, 1872	$7\frac{1}{4} \times 11\frac{1}{4}$	Do.
215	62286	♂	Aug. 4, 1872	$7\frac{1}{2} \times 11\frac{5}{8}$	Middle Fork, Idaho.

Hab.—From the Black Hills to the Pacific; south into Mexico.

I found a few of these beautiful birds in the bushes that border Crow Creek, near Cheyenne, and succeeded in obtaining one good specimen, No. 1, (61662.) I also saw several in the scrub-oak bushes at the foot and on the sides of the Wahsatch Range, near Ogden.

At Téton Cañon, however, these birds are quite abundant, and here I obtained eight specimens. They were generally seen on the tops of the pine trees, where the bright colors of their plumage contrasted beautifully with the dark green foliage of the pines. They are secluded in their habits, prefering their own society to that of other birds, and seldom approaching the habitations of man.

Near Ogden they were shy and suspicious, and it was difficult to get within gunshot of them, while, on the contrary, at Téton Cañon, they eyed us with curiosity only, not suspicion, for they would often follow us for some distance, lighting near by, and never trying to keep out of sight.

Family 16.—FRINGILLIDÆ, THE SPARROWS.

(Sub-family *Coccothraustinæ.*)

Carpodacus cassinii, Baird, (Cassin's purple finch:)

No.	Catalogue number.	Sex.	Date.	Measurements.	Locality.
233	62325	♀	Aug. 21, 1872	$6\frac{1}{2} \times 10\frac{3}{4}$	Yellowstone River, Wyo.
282	62326	0	Sept. 23, 1872	$6\frac{1}{2} \times 10\frac{1}{2}$	Snake River, Wyo.

Hab.—Rocky Mountains and valley of the Colorado.

These birds, the largest of the American purple finches, are quite rare. We met with them but twice, once on the Yellowstone, and once near Snake River, Wyoming Territory.

Chrysomitris tristis, Bonap., (yellow bird :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
78	....	♂	June 15, 1872	$5\frac{1}{8} \times 9\frac{7}{16}$	Ogden, Utah.
80	61667	♀	June 15, 1872	$5\frac{1}{4} \times 8\frac{7}{8}$	Do.
84	61666	♂	June 17, 1872	$5\frac{15}{16} \times 7$	Do.
295	62335	♂	Oct. 11, 1872	$5\frac{3}{8} \times 9$	Fort Hall, Idaho.
296	62336	♀	Oct. 11, 1872	$5\frac{1}{4} \times 9\frac{1}{4}$	Do.
303	62337	—	Oct. 14, 1872	$5\frac{1}{4} \times 8\frac{2}{5}$	Do.
305	62338	♂	Oct. 14, 1872	$5\frac{1}{10} \times 8\frac{3}{10}$	Do.

Hab.—North America generally.

The yellow bird, American goldfinch, or thistle-bird, is common at Ogden and Fort Hall, as it is in most localities in the United States. It seems to prefer the civilized portion of America to the densely-wooded districts, as we found none in the mountains and deep pine forests.

Chrysomitris pinus, Bonap., (pine-finch :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
179	62339	♂	July 22, 1872	$5 \times 9\frac{1}{8}$	Téton Basin, Idaho.
181	62340	♀	July 22, 1872	$5\frac{1}{8} \times 8\frac{3}{4}$	Do.
233	....	♂	Aug. 9, 1872	$4\frac{3}{4} \times 8\frac{1}{8}$	Henry's Lake, Idaho.

Hab.—North America, from Atlantic to Pacific.

Pine-finches were quite numerous about the First Cottonwood Creek, Téton Basin, where I shot two specimens, Nos. 179 (62339) and 181, (62340.) We also found them in the vicinity of Henry's Lake, where I obtained one specimen, No. 223, (——.) They were occasionally met with by our party in Téton Cañon, but I did not succeed in procuring any specimens there.

(Sub-family *Spizellinæ.*)

Passerculus alaudinus, Bonap., (lark-sparrow :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
294	62310	♂	Oct. 8, 1872	$5\frac{7}{8} \times 9\frac{1}{4}$	Snake River, Idaho.

Hab.—Coast of California and Lower Rio Grande of Texas and Mexico.

On the 8th of October I observed the only flock of these birds seen during our journey. They settled down on a small gravelly island in Snake River, and I succeeded in securing a fine specimen.

Poocaetes gramineus, var. *confinis*, Baird, (grass-finch:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	No. of nest and eggs.	Locality.
4	61674	—	June 5, 1872	$6\frac{1}{8} \times 10\frac{1}{2}$	10	Ogden, Utah.
6	61675	♀	June 5, 1872	....	7	Do.
35	61676	♀	June 8, 1872	$6\frac{3}{4} \times 10\frac{5}{8}$	....	Do.
91	61677	—	June 17, 1872	$6\frac{1}{8} \times 10$	....	Salt Lake, Utah.
151	61778	♀	July 7, 1872	$6 \times 10\frac{3}{16}$	....	Fort Hall, Idaho.
152	61777	♂	July 7, 1872	$6\frac{1}{2} \times 10\frac{3}{4}$	....	Do.
242	62308	♂	Aug, 28, 1872	$6\frac{1}{2} \times 11$	....	Lower Geyser Basin, Wyo.
257	62309	♂	Sept. 7, 1872	$6\frac{1}{4} \times 10\frac{1}{2}$	....	Shoshone Lake, Wyo.

Hab.—High central plains to the Pacific.

This bird—a mere western variety of our common grass-finch or bay-winged bunting, (*P. gramineus*)—is a very common species at Salt Lake, and in fact it was common all along our route, except in the densely-wooded regions.

I found several nests of these birds. They were placed on the ground—generally under a sage-brush—and were composed of grass, laid rudely together. They lay four or five light-colored, spotted eggs in the early part of June.

Chondestes grammaca, Bonap., (lark-finch:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	No. of nest.	Locality.
24	....	♀	June 7, 1872	....	22	Ogden, Utah.
66	61668	♂	June 14, 1872	$7 \times 11\frac{9}{16}$	....	Do.
68	61669	♀	June 14, 1872	$6\frac{13}{16} \times 10\frac{1}{2}$	....	Do.
75	61670	♂	June 15, 1872	$7\frac{3}{8} \times 11\frac{13}{16}$	....	Do.
98	61671	—	June 18, 1872	$7\frac{3}{16} \times 11\frac{7}{8}$	....	Do.
124	61776	—	June 25, 1872	....	....	Bear River, Utah.
241	62307	♂	Aug. 27, 1872	$6\frac{7}{8} \times 10\frac{3}{4}$	....	Lower Geyser Basin, Wyo.

Hab.—From Wisconsin and the prairies of Illinois (also in Michigan,) to the Pacific coast; south to Texas and Mexico.

This plain but rich-colored sparrow is quite abundant at Ogden, and from there to Snake River. It is also common at Fire-Hole Basin, Wyoming Territory, where I obtained one specimen, No. 241, (62307.) I collectedthe nest of the lark-finch on the 7th of June at Ogden. It was similar in material and situation to that of the grass-finch (*P. confinis*) just described, and contained five fresh eggs.

As the plumage of this bird is richer and deeper than that of the grass-finch, so are its eggs much more beautiful, their spots and markings being darker and more distinct.

Zonotrichia leucophrys, Sw., (white-crowned sparrow:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
225	62300	♂	Aug. 12, 1872	6$\frac{7}{8}$ × 10	Madison River, Mont.
262	62301	......	Sept. 12, 1872	7$\frac{1}{8}$ × 10	Lewis's Lake, Wyo.
283	62302	♂	Sept. 23, 1872	7 × 9$\frac{3}{4}$	Snake River, Wyo.

Hab.—United States from Atlantic to the Rocky Mountains, where they become mixed up with *Z. gambelli* Greenland, Reinhardt.

Madison River was the first place on our route where we met with this finch. There they were quite abundant, as they were at Lewis's Lake, where I obtained a fine specimen in winter plumage. Here they were very shy, and it was with great difficulty that I secured a single specimen. We also found them in considerable numbers along Snake River.

Zonotrichia gambelii, Gambel, (Gambel's finch:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
300	62299	0	Oct. 13, 1872	6$\frac{5}{8}$ × 8$\frac{7}{8}$	Fort Hall, Idaho.

Hab.—Rocky Mountains to the Pacific coast.

We met with a few flocks of these birds at Yellowstone Lake, and at Fort Hall, where I obtained one specimen, No. 300, (62299.) This species is almost exactly like the preceding, *Z. leucophrys*, the only noticeable difference being in the black stripe on the side of the crown, which, in *leucophrys*, passes down over the upper half of the lores and in front of the eye, sending back a short branch to it, which cuts off the white superciliary stripe. In *Z. gambelii* the superciliary stripe passes continuously forward to the lores, cutting off the black from the eye. In habits it resembles the white-crowned finch just described.

Junco oregonus, Sclater., (pink-sided snow-bird:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
186	62316	♀	July 24, 1872	6$\frac{3}{8}$ × 9$\frac{7}{5}$	Téton Cañon, Idaho.
245	62317	♂	Aug. 28, 1872	6$\frac{1}{2}$ × 9$\frac{5}{8}$	Lower Geyser Basin, Wyo.
265	62318	♀	Sept. 14, 1872	6$\frac{1}{2}$ × 10$\frac{1}{4}$	Snake River, Wyo.
272	62319	♂	Sept. 16, 1872	6$\frac{3}{4}$ × 10$\frac{1}{4}$	Do.
273	62320	♂	Sept. 16, 1872	6$\frac{5}{8}$ × 10$\frac{1}{4}$	Do.
276	62321	♂	Sept. 17, 1872	6$\frac{1}{4}$ × 9$\frac{5}{8}$	Do.
277	62322	♂	Sept. 17, 1872	6$\frac{1}{2}$ × 9$\frac{1}{2}$	Do.
291	62323	♂	Sept. 29, 1872	6$\frac{3}{8}$ × 10	Do.

Hab.—Pacific coast of the United States to the eastern side of the Rocky Mountains; stragglers as far east as Fort Leavenworth in winter and Great Bend of Missouri.

We first met with the pink-sided snow-bird at Téton Cañon, where I secured one specimen, No. 186, (62316.) After this they were very plentiful all along our route, until we emerged from the pine forests and once more entered the sage-brush plains. We generally found them in flocks of from fifteen to twenty, moving about from tree to tree in search of their food.

One day, while out shooting in the Lower Geyser Basin, I saw a snow-bird in a pine tree. I fired and it fell, and supposing it to be dead, I searched about on the ground, under the limb on which it had been sitting, but found no traces of it. I at last discovered a small feather on the edge of a mouse-hole, and thinking that the wounded bird might have taken refuge in this subterranean abode, I commenced digging after him with my fingers; I had not gone far before I thought I felt feathers ahead; grasping them with my thumb and finger, I commenced pulling; the bird came a little way, then, making a violent effort, escaped farther into the hole, leaving in my hand two tail-feathers.

Having no implements to dig with, except those with which nature had provided me, I was compelled to give up the chase.

Spizella socialis, Bonap., (chipping sparrow:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
153	61779	0	July 7, 1872	$5\frac{3}{8} \times 7\frac{1}{16}$	Fort Hall, Idaho.
178	62311	♀	July 20, 1872	$5\frac{5}{8} \times 8\frac{1}{8}$	Conant Creek, Idaho.
243	62312	♂	Aug. 27, 1872	$5\frac{5}{8} \times 8\frac{7}{8}$	Lower Geyser Basin, Wyo.
266	62313	♂	Sept. 14, 1872	$5\frac{7}{8} \times 9\frac{3}{8}$	Snake River, Wyo.
232	62315	♀	Aug. 22, 1872	$5\frac{1}{2} \times 9$	Yellowstone River, Wyo.
270	62314	♂	Sept. 15, 1872	$5\frac{11}{16} \times 9$	Snake River, Wyo.

Hab.—North America, from Atlantic to Pacific.

Our common chipping sparrow is too well known to need description.

Melospiza fallax, Baird, (mountain song-sparrow:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
63	61673	♀	June 14, 1872	$6\frac{9}{16} \times 8\frac{5}{16}$	Ogden, Utah.
175	62303	—	July 18, 1872	....	North Fork, Idaho.
298	62304	♀	Oct. 12, 1872	$6\frac{1}{2} \times 8\frac{1}{2}$	Fort Hall, Idaho.
299	62305	♂	Oct. 13, 1872	$6\frac{7}{8} \times 8$	Do.
304	62306	♂	Oct. 14, 1872	$6\frac{2}{5} \times 8\frac{1}{2}$	Do.

Hab.—Rocky Mountain region from Fort Thorn to the Colorado.

The mountain song-sparrow was common at Ogden, as it was at Fort Hall and on the North Fork of Snake River. I found several nests of this bird at Ogden, about the 1st of June. They were built in a clump of bushes in a marsh, about six feet above the ground, were composed of dry grass and rushes, and contained four to six eggs.

(Sub-family *Spizinæ.*)

Guiraca melanocephala, Sw., (black-headed grosbeak :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Number of nest.	Locality.
5	61685	♂	June 5, 1872	$8\frac{1}{8} \times 12\frac{11}{16}$	....	Ogden, Utah.
16	61686	—	June 6, 1872	....	....	Do.
21	61687	♂	June 7, 1872	....	....	Do.
29	61688	♂	June 8, 1872	$8 \times 12\frac{11}{16}$	....	Do.
31	61689	♂	June 8, 1872	$8\frac{1}{4} \times 12\frac{7}{8}$	....	Do.
52	61690	♂	June 12, 1872	$8\frac{3}{16} \times 12\frac{3}{8}$	....	Do.
180	62274	♀	July 22, 1872	$8\frac{1}{8} \times 12\frac{1}{2}$	63	Téton Basin, Idaho.

Hab.—High central plain from the Yellowstone to the Pacific. Table-lands of Mexico.

Black-headed grosbeaks are quite numerous among the scrub-oaks at the foot of the Wahsatch Mountains. Here I obtained six good specimens. I obtained one of their nests at the First Cottonwood Creek, Téton Basin, Idaho Territory, on the 22d of July. It was on a cottonwood sapling, about five feet above the ground, and was composed of pieces of grass and vines laid carelessly together, with their ends sticking out four or five inches; it contained two fresh eggs—No. 63, (16317,) ♀ No. 180 shot. They are peculiar in their habits: sometimes you may hunt half a day without getting more than a glimpse at them, as they flit about from bush to bush, yet their song, which at times is scarcely distinguishable from that of our common cat-bird, (*Galeoscoptes Carolinensis*,) seldom escapes your ears; at other times you cannot walk about for ten minutes without seeing several of them perched up on the top of the highest bushes near by, entertaining you with their song, without evincing the slightest symptoms of fear.

Cyanospiza amœna, Baird, (lazuli finch :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Number of nest.	Locality.
19	61691	♀	June 7, 1872	....	....	Ogden, Utah.
22	61692	♂	June 7, 1872	....	....	Do.
33	61693	♂	June 8, 1872	$6 \times 9\frac{1}{8}$	....	Do.
34	61694	♂	June 4, 1872	$5\frac{1}{2} \times 9$	....	Do.
38	61695	♂	June 9, 1872	$5\frac{3}{4} \times 9\frac{1}{16}$	....	Do.
45	61696	♂	June 11, 1872	$5\frac{1}{2} \times 9\frac{13}{16}$	....	Do.
46	61698	♂	June 11, 1872	$5\frac{1}{2} \times 9$	....	Do.
47	61697	♂	June 11, 1872	$6 \times 9\frac{1}{8}$	....	Do.
48	61699	♂	June 11, 1872	$5\frac{3}{4} \times 9\frac{1}{4}$	....	Do.
49	61700	♂	June 11, 1872	$6 \times 9\frac{3}{4}$	....	Do.
50	61701	♂	June 11, 1872	$5\frac{3}{4} \times 8\frac{15}{16}$	....	Do.
61	61702	♂	June 14, 1872	$5\frac{11}{16} \times 9$	....	Do.
65	61703	♀	June 14, 1872	$5\frac{5}{16} \times 8\frac{1}{2}$	65	Do.
71	61704	♂	June 14, 1872	$5\frac{7}{8} \times 9\frac{3}{8}$	....	Do.
72	61105	♂	June 14, 1872	$5\frac{11}{16} \times 8\frac{7}{8}$	....	Do.
73	61706	♂	June 15, 1822	$5\frac{7}{8} \times 9\frac{1}{4}$	....	Do.
74	61707	♀	June 15, 1872	$5\frac{1}{2} \times 8\frac{11}{16}$	....	Do.
86	61708	♂	June 17, 1872	$5\frac{1}{2} \times 8\frac{5}{8}$	....	Do.
114	61709	♂	June 20, 1872	$5\frac{1}{2} \times 8\frac{5}{8}$	....	Do.
116	61710	♂	June 20, 1872	$5\frac{5}{8} \times 9\frac{1}{16}$	....	Do.
117	61711	♂	June 20, 1872	$5\frac{3}{4} \times 9\frac{1}{16}$	....	Do.
118	61712	♀	June 20, 1872	$5\frac{1}{2} \times 8\frac{3}{4}$	....	Do.
183	62324	♀	July 22, 1872	$5\frac{7}{8} \times 9$	....	Téton Basin, Idaho.

Hab.—High central plains from the Rocky Mountains to the Pacific.

The lazuli finch, or blue linnet, is very common near Ogden, and in the bushes that border some of the streams in Téton Basin. There are but few of our western birds that rival or even equal this handsome little bird, either in beauty of plumage or sweetness of voice. They are greenish blue above, the head and neck being of the same color; the upper part of the breast is chestnut, separated from the throat by a faint white crescent, and the belly is white. They seem to take great delight in perching themselves up among the branches of some scrub-oaks, not far apart, trying to see who shall excel the other in pouring forth their sweet melodies.

I obtained three nests of this species at Ogden; one, No. 8, (16283,) was on a scrub-oak about three feet high, and the other two, Nos. 9 (16284,) and 35 (16285,) were on sage-bushes, (artemisia,) about two feet above the ground. The eggs, generally four in number, are laid about the first or middle of June, in a beautiful downy nest, composed of fibrous grasses and wool, lined with hair.

Pipilo megalonyx, Baird, (spurred towhee.)

No.	Catalogue-number.	Sex.	Date.	Measurements.	No. of nest.	Locality.
25	61678	♂	June 7, 1872	....	......	Ogden, Utah.
32	61679	♂	June 8, 1872	$8\frac{1}{16} \times 11\frac{1}{2}$	......	Do.
56	61680	♂	June 13, 1872	$8\frac{1}{2} \times 11\frac{3}{8}$	31	Do.
57	61681	♀	June 13, 1872	$8\frac{1}{16} \times 10\frac{3}{16}$	32	Do.
67	....	♂	June 14, 1872	$— \times 11\frac{1}{8}$	......	Do.
69	61682	♂	June 14, 1872	$8\frac{1}{2} \times 11\frac{1}{4}$	36	Do.
77	61683	♂	June 15, 1872	$8\frac{1}{4} \times 11$	......	Do.
119	61684	♂	June 21, 1872	$8\frac{13}{16} \times 11\frac{1}{4}$	......	Do.

Hab.—Southern coast of California and across through valleys of Gila and Rio Grande, west to Rocky Mountains.

Spurred towhees are very plentiful in the scrub-oaks near Ogden; we saw none elsewhere. In habits they greatly resemble the black-headed grosbeak, (*Guiraea melanocephala.*) About the middle of June they build a rude nest of dry grass and leaves; this is placed on the ground, generally at the foot of a small bush, and contains four or five light-colored eggs, spotted with reddish brown.

Pipilo chlorura, Baird, (green-tailed finch.)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
177	62292	♀	July 20, 1872	$7\frac{7}{8} \times 10\frac{1}{2}$	Conant Creek, Idaho.
182	62293	♀	July 22, 1872	$7\frac{1}{2} \times 9\frac{3}{4}$	Téton Basin, Idaho.
213	62294	♂	Aug. 3, 1872	$7\frac{3}{8} \times 10\frac{1}{4}$	Do.

Hab.—Valley of Rio Grande and Gila; Rocky Mountains north to Yellowstone Lake; south to Mexico.

We did not meet with this species in abundance at any locality on our route.

Family 17.—ALAUDIDÆ, THE LARKS.

Eremophila cornuta, Boie., (horned sky-lark.)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
39	61753	♂	June 11, 1872	$7\frac{5}{16} \times 13$	Salt Lake. Utah.

Hab.—Everywhere on the prairies and desert plains of North America Atlantic States in winter.

The horned lark is met with in greater abundance than any other bird on our great western plains. They are very tame, often letting you pass within six or eight feet of them without appearing disturbed, and then they generally run a little to one side instead of taking flight.

Family 18.—ICTERIDÆ, THE ORIOLES.

(Sub-family *Icterinæ, the Orioles proper.*)

Icterus (*Hyphantes*) *bullockii*, Cassin, (Bullock's oriole:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Number of nest.	Locality.
7	61713	♀	June 5, 1872	....	2 (16261)	Ogden, Utah.
8	61714	♀	June 5, 1872	....	3 (16262)	Do.
10	61715	♂	June 6, 1872	....	12 (16263)	Do.
11	61716	♂	June 6, 1872	....	13 (16264)	Do.
17	61717	♂	June 6, 1872	$8\frac{3}{16} \times 12\frac{1}{8}$	17 (16266)	Do.
23	61718	♂	June 7, 1872	....	19 (16267)	Do.
51	61719	♂	June 12, 1872	$7\frac{3}{4} \times 12\frac{13}{16}$	29 (16268)	Do.
53	61720	♂	June 12, 1872	$8\frac{1}{4} \times 12\frac{13}{16}$	30 (16269)	Do.
58	61721	♀	June 14, 1872	$7\frac{9}{16} \times 11\frac{3}{4}$	33 (16270)	Do.
93	61722	♂	June 18, 1872	$8 \times 12\frac{1}{2}$	48 (16278)	Do.
94	61723	♂	June 18, 1872	$8\frac{1}{4} \times 12\frac{5}{8}$	....	Do.
95	61724	♂	June 18, 1872	$7\frac{5}{8} \times 11\frac{3}{4}$	....	Do.
127	61782	♂	June 28, 1872	$8\frac{1}{4} \times 12\frac{3}{4}$	....	Devil's Creek, Idaho.
128	61783	♂	June 28, 1872	$8 \times 12\frac{5}{8}$	....	Do.
130	61784	♂	June 28, 1872	$8\frac{1}{8} \times 12\frac{5}{8}$	....	Do.
131	61785	♂ ?	June 28, 1872	$8\frac{1}{16} \times 12\frac{1}{8}$	....	Do.

Hab.—High central plains to the Pacific; rare on Upper Missouri; south into Mexico.

The western oriole, in my opinion at least, is the most beautiful of all our western birds. They are very abundant in a large marsh between Ogden and Weber Cañon; there I collected sixteen of their nests, containing over sixty eggs. They build a beautiful hanging nest, often ten and a half inches deep, and composed of fibers of grass, flax, and the inner bark of vines, and are generally lined with wool. The first lot were deep and solid, were composed chiefly of the fibers of flax and dry grass, and had a grayish appearance, while the second lot—which were built by the same birds after their first had been taken—were not very deep, had evidently been made in haste, and were principally composed of the inner bark of small bushes and vines, giving them a brownish look. They generally conceal their nests among the leaves on the top of a willow, from eight to ten feet above the ground, in such a position that it rocks to and fro whenever there is a little wind.

(Sub-family *Agelainæ, the Starlings.*)

Dolichonyx oryzivorus, (bobolink; reed-bird:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
85	61728	♂	June 17, 1872	$7\frac{1}{4} \times 12\frac{5}{16}$	Ogden, Utah.
97	61730	♀	June 18, 1872	$7 \times 11\frac{1}{4}$	Do.
101	61729	♂	June 18, 1872	$7\frac{1}{16} \times 11\frac{3}{4}$	Do.

Hab.—Eastern North America to Rocky Mountains; westward to Salt Lake and East Humboldt Mountains.

The only place on our route where we met with these birds was in the Great Salt Lake Valley; here they were quite abundant.

Agelaius phœniceus, Vieill., (red-winged blackbird:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
15	61725	♂	June 6, 1872	$9\frac{3}{16} \times 15\frac{11}{16}$	Ogden, Utah.
87	61726	♂	June 17, 1872	$9\frac{1}{4} \times 15\frac{1}{2}$	Do.

Hab.—United States, from Atlantic to Pacific.

Red-winged blackbirds were very common near Ogden, where they were breeding. This, as well as the preceding species, is too common to need description.

Xanthocephalus icterocephalus, Baird, (yellow-headed blackbird:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
135	61786	♂	June 29, 1872	$10\frac{1}{2} \times 18$	Marsh Valley, Idaho.
137	61787	♂	June 29, 1872	$10\frac{5}{8} \times 17\frac{1}{2}$	Do.
136	61783	♂	June 29, 1872	$10\frac{5}{8} \times 18\frac{1}{8}$	Do.
138	61784	♀	June 29, 1872	$8\frac{1}{2} \times 14\frac{1}{8}$	Do.

Hab.—Western America, from Texas, Illinois, Wisconsin, and North Red River to California, south into Mexico. Greenland, Reinhardt.

I saw a few yellow-headed blackbirds in a marsh near Salt Lake. The only other place where we found them was at Marsh Creek, near Carpenter's Ranch, Idaho Territory. Here I obtained four good specimens and one nest. The nest was fastened to a clump of rushes in a marsh, about five feet above the water, and was composed of dry swamp-grass. It had no lining, and presented the same appearance inside as out. It was very solid, and contained four nearly fresh eggs of a light greenish color, covered with darker spots.

Sturnella neglecta, Aud., (western lark:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	No. of nest.	Locality.
3	61733	♂	June 5, 1872	....	6 (16277)	Ogden, Utah.
13	61732	♀	June 6, 1872	....	....	Do.

Hab.—Western America, from high central plains to the Pacific; east to Pembina, Dakota.

The western lark, a mere variety of our common eastern meadow lark, (*S. magna*,) from which it is scarcely distinguishable by the casual observer, is as common west of the Rocky Mountains as the latter species is in our Eastern States. The song of the two birds is, however, entirely different. I procured three nests of this species at Ogden; they differ essentially from those of our eastern species in being rudely constructed of dry grass placed loosely in a little hole in the ground, with no aim at concealment, while our meadow-lark builds a neat covered nest perfectly concealed in a bunch of grass. The eggs closely resemble those of *S. magna*.

(Sub-family *Quiscalinæ, the Crow Blackbirds.*)

Scolecophagus cyanocephalus, Cab., (Brewer's blackbird:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
70	61731	♀	June 14, 1872	$9\frac{1}{8} \times 15$	Ogden, Utah.
121	61790	♂	June 25, 1872	....	Bear River, Utah.
123	61710	♀	June 25, 1872	....	Do.
158	62272	♂	July 14, 1872	$9\frac{7}{8} \times 15\frac{3}{4}$	Snake River, Idaho.
280	62273	♀	Sept. 20, 1872	$9\frac{13}{16} \times 14\frac{1}{2}$	Snake River, Wyo.

Hab.—High central plains to the Pacific, south to Mexico; Pembina, Dakota.

Brewer's blackbird, west of the Rocky Mountains, takes the place of our common rusty blackbird, (*S. ferrugineus*,) which it closely resembles. We met with them in abundance at nearly all points on our route, although they were not so common in the densely-wooded regions on the mountains as they were among the bushes and cottonwoods bordering the streams and rivers that run through the dry, arid plains. They breed about the middle of June, laying dark-colored eggs, blotched all over with dark brown and chocolate.

Family 19.—CORVIDÆ, THE CROWS.

(Sub-family *Garrulinæ, the Jays.*)

Pica hudsonica, Bonap., (common magpie:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
146	61780	Ad.	July 2, 1872	$14\frac{1}{2} \times 22\frac{1}{4}$	Pocotello, Idaho.

Hab.—Arctic regions of North America; United States, from the high central plains to the Pacific, north of California.

At Ogden I found an old nest of this bird, showing that they had recently lived here. They are still quite abundant in Ogden Cañon, and at many other places in the Wahsatch Range near Ogden. Port Neuf Cañon is the first place where we found magpies. Here they were very common, as they were at Pocotello, where I obtained a good specimen, No. 146 (61780.) I also saw a few at Fort Hall and on Snake River, about forty miles above the fort. We saw none after this until on our return, when we met them on Snake River, east of the Tétons. After this they were common all the way down till we arrived within about fifty miles of Ogden.

Cyanura macrolopha, Baird, (long-crested jay:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
189	62241	♂	July 26, 1872	$13\frac{3}{4} \times 18\frac{1}{2}$	Téton Cañon, Idaho.
206	62242	♀	July 22, 1872	$12\frac{5}{8} \times$ —	Do.
259	62243	♂	Sept. 7, 1872	$13\frac{1}{2} \times 19\frac{3}{4}$	Shoshone Lake, Wyo.

Hab.—Central line of Rocky Mountains to table-lands of Mexico.

This splendid bird is the Rocky Mountain representative of Steller's jay, (*C. Stelleri*,) which it differs from, principally, in having a white spot over the eye, the crest being longer and fuller, the streaks on the forehead being white instead of greenish blue, and the whole head being darker.

The long-crested jay is not an uncommon bird in the Wahsatch Mountains. They are quite numerous, however, in the Téton Range, where I obtained two specimens.

At Shoshone Lake, on the 7th of September, I saw a flock of about twenty gray jays, (*Perisoreus canadensis.*) Among them was a beautiful long-crested jay, which I succeeded in shooting. It—No. 256 (62243)—was in full plumage, and is one of the finest specimens I ever saw. When first disturbed they fly about in an angry, scolding manner, offering you a fine shot; but you must not delay long, for they soon lose their curiosity and retire into the forest, keeping themselves hid among the pines. I have often seen them early in the morning imitating the voice of the hawk-owl (*Surnia ulula*) as they flew about from tree to tree.

Cyanocitta woodhousii, Baird, (Woodhouse's jay:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
54	61754	♂ ?	June 12, 1872	$12\frac{3}{4} \times 16\frac{3}{8}$	Ogden, Utah.
120	61755	♀	June 21, 1872	$11\frac{1}{2} \times 15\frac{1}{2}$	Do.

Hab.—Central line of Rocky Mountains.

Woodhouse's jay is quite common at the foot of the Wahsatch Range, where I obtained two specimens, the only ones that were seen by any of our party during the summer. They are the Rocky Mountain representative of the California jay, (*C. californica*,) which they greatly resemble, the principal difference being in the under parts, which are much darker, and in the bill, which is longer and more slender. They are both western representatives of the Florida jay, (*C. floridana*,) which they closely resemble, the chief points of difference being in the undertail coverts, which are white in the former and blue in the latter, and in the entire under parts, which are much darker in *floridana* than in *californica*. These slight differences are no greater than those caused in many other species by the great difference in climate and longitude.

Perisoreus canadensis, Bonap., (gray jay:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
194	62244	♀	July 29, 1872	$11\frac{3}{8} \times 17\frac{3}{4}$	Téton Cañon, Idaho.
196	62245	—	July 29, 1872	$11\frac{1}{2} \times 17\frac{1}{2}$	Do.
198	62246	♂	July 30, 1872	$12\frac{3}{8} \times 18$	Do.
234	62247	♂	Aug. 22, 1872	12×17	Yellowstone River, Wyo.
263	62248	♂	Sept. 13, 1872	$12\frac{1}{8} \times 18$	Lewis's Lake, Wyo.
264	....	♀	Sept. 13, 1872	$11\frac{1}{2} \times 17\frac{1}{2}$	Do.
275	62250	♂	Sept. 16, 1872	$11\frac{1}{4} \times 18\frac{1}{4}$	Snake River, Wyo.
278	62251	—	Sept. 18, 1872	$11\frac{1}{4} \times 16\frac{1}{2}$	Do.
287	62252	♀	Sept. 27, 1872	$11\frac{3}{4} \times 17\frac{3}{8}$	Second Téton Lake, Wyo.
289	62253	♂	Sept. 27, 1872	$12 \times 18\frac{1}{4}$	Do.

Hab.—Northern America into the northern parts of United States, from Atlantic to Pacific; more south in Rocky Mountains.

We first met gray jays at the Téton Cañon, where they were quite numerous, as they were northward to the Grand Cañon of the Yellowstone, and down Snake River on the east side of the Téton Range. They were generally very tame, often alighting on a limb within ten feet of me, then, after eyeing me for a few moments, would disappear in the forest. I remember one occasion, near Yellowstone Lake, when these birds came about our camp, evidently in search of eatables, I cut off a few small pieces of elk meat and scattered them about on the ground within a few feet of me; then one of the jays, which had been watching me closely from a neighboring limb, darting down, seized a piece of the meat and flew with it into a tree near by, and, after devouring it, returned for more. I have often heard hunters and others state that they had known these jays to be so bold as to light on their shoulders!

(Section CLAMATORES, CRYING-BIRDS.)

Family 23.—TYRANNIDÆ, THE TYRANT FLY-CATCHERS.

Tyrannus carolinensis, Baird, (king-bird:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
149	61771	♂	July 5, 1872	$8\frac{1}{4} \times 14\frac{5}{16}$	Fort Hall, Idaho.
150	61770	♂	July 5, 1872	$8\frac{7}{8} \times 15\frac{3}{16}$	Do.
157	62287	♀	July 14, 1872	$8\frac{1}{8} \times 14\frac{5}{8}$	Snake River, Idaho.
166	62289	—	July 16, 1872	$8\frac{3}{4} \times 14\frac{7}{8}$	North Fork, Idaho.

Hab.—Entire continent of North America.

We found king-birds quite common at Ogden, thence northward to Snake River, where I found one of their nests, No. 60, (16314;) it was on a rose-bush, about four feet from the ground, and contained three fresh eggs. These birds must have raised one brood before this, as, two days before, I found a nest at Blackfoot River (twenty-five miles from here) that contained young birds that were nearly full-grown.

Tyrannus verticalis, Say, (Arkansas fly-catcher:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Number of nest.	Locality.
9	61751	♀	June 6, 1872	....	11 (16286)	Ogden, Utah.
14	61748	♂	June 5, 1872	....	15 (16287)	Do.
59	61749	♀	June 14, 1872	$8\frac{9}{16} \times 15\frac{1}{2}$	....	Do.
60	61750	♂	June 14, 1872	$9\frac{1}{8} \times 16\frac{5}{16}$	....	Do.
132	61781	♀	June 28, 1872	$8\frac{3}{4} \times 15\frac{1}{2}$	53 (16288)	Devil's Creek, Idaho.
134	61772	♂	June 28, 1872	$8\frac{7}{8} \times 15\frac{5}{8}$	....	Do.

Hab.—Western North America, from the high central plains to the Pacific.

Arkansas fly-catchers are numerous in the Great Salt Lake Basin, as they are among the cottonwoods and bushes that border most of the streams between Salt Lake and Fort Hall. From the 5th to the 28th of June I collected four of their nests; they were placed on willows or cottonwoods, from eight to fifteen feet above the ground; were composed of fibrous roots, pieces of dead sage-brush, (*artemisia*,) dry grass, &c., lined with wool and other soft substances. The first nest that I found is really very beautiful, as well as curious; it is composed of fibrous roots, stalks of dry grass, wool, pieces of sage-brush, with here and there a few leaves, and is lined with wool, fibrous bark, and thread, with a feather occasionally showing itself; there is much wool on the outside and all through the nest, giving it a soft, downy appearance. This beautiful structure contained four cream-colored eggs, spotted with reddish and dark brown, the spots being most numerous near the large end.

Tyrannus vociferans, Sw., (Cassin's fly-catcher:)

No.	Catalogue-number.	Sex.	Date.	Locality.
2	61747	♂	May 29, 1872	Cheyenne, Wyo.

Hab.—Pecos River, Texas, and into Mexico table-lands; north to Cheyenne, Wyoming Territory.

Cheyenne is the only place where I observed this species; there I secured one specimen.

Cassin's fly-catcher closely resembles the preceding species, (*T. verticalis*,) but is easily distinguished from it on comparison; the yellow of the breast is brighter, and the shoulders are more olivaceous; the bill and feet are larger. The most appreciable character, however, is seen in the tail. In *verticalis* the whole outer web of the external feather, including the shaft, is purely and abruptly yellowish white. In the species now under consideration, the shaft of the outer tail-feather is dark brown, its outer webs and the tips of the other feathers being light brown, with the extreme edges only being of a tolerably pure yellowish white.

Sayornis sayus, Baird, (Say's fly-catcher:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
122	61769	♂	June 25, 1872	$8 \times 13\frac{1}{2}$	Bear River, Utah T.

Hab.—Missouri and central high plains westward to the Pacific and south to Mexico.

Bear River is the only locality where this species was observed.

Contopus borealis, Baird, (olive-sided fly-catcher:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
27	61739	♂	June 8, 1872	$7\frac{13}{16} \times 13$	Ogden, Utah.
190	62289	♀	July 27, 1872	$7\frac{7}{16} \times 12\frac{1}{2}$	Téton Cañon, Idaho.
191	62290	♂	July 27, 1872	$7\frac{3}{4} \times 13\frac{1}{4}$	Do.

Hab.—Rare on either coast. Not observed in the interior of the United States, except to the north. Found in Greenland, (Reinhardt.)

But three specimens of this rare species were observed: one at Ogden, and the other two at Téton Cañon.

Contopus richardsonii, Baird, (short-legged pewee:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
28	61740	♀	June 8, 1872	$6\frac{1}{2} \times 10\frac{5}{8}$	Ogden, Utah.
193	62291	♀	July 27, 1872	$6\frac{1}{2} \times 10\frac{3}{5}$	Téton Cañon, Idaho.

Hab.—High central dry plains to the Pacific; Rio Grande Valley, southward to Mexico. Labrador, (Audubon.)

The present species is a western race of our common wood pewee, (*C. virens*,) which it is scarcely distinguishable from except on comparison. The most appreciable difference is seen in the breast, which in *Richardsonii* is nearly of a uniform olive brown, while in *virens* the middle line of the breast is paler than the sides.

Empidonax pusillus, Cab., (little fly-catcher:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	No. of nest.	Locality.
62	61741	♂	June 14, 1872	$6\frac{3}{16} \times 9\frac{1}{16}$	....	Ogden, Utah.
76	61742	♂	June 15, 1872	$5\frac{6}{8} \times 8\frac{3}{8}$	....	Do.
81	61743	♀	June 16, 1872	....	39 (16305)	Do.
82	61744	♂	June 16, 1872	$6 \times$ —	....	Do.
83	61745	—	June 17, 1872	$5\frac{3}{8} \times 9$	....	Do.
100	61746	♂	June 18, 1872	$5\frac{9}{16} \times 9\frac{1}{4}$	50 (16306)	Do.
133	61773	♂	June 28, 1872	$6 \times 9\frac{1}{8}$	....	Devil's Creek, Idaho.

Hab.—High central plains to the Pacific; fur countries; southward into Mexico.

This western race of *E. traillii* was very common in the Salt Lake Valley, where I collected seven specimens and three nests. They build a neat, compact little nest, which they place in the fork of a rose or other small bush, about five feet above the ground. It is composed of fibrous grasses, flax, wool, and other soft substances, interwoven with a few leaves of swamp-grass. It is a curious fact that this bird places all the wool and other soft, downy substances on the *outside* of its nest, lining it with the rough stalks of dry grass.

About the middle of June it lays four light cream-colored eggs, sparingly spotted with dark reddish brown near the large end.

Order 2.—STRISORES, SHRIEKING BIRDS.

Family 28.—ALCEDINIDÆ, THE KINGFISHERS.

Ceryle alcyon, Boie., (belted kingfisher:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
252	62267	♂	Aug. 30, 1872	$13\frac{3}{4} \times 22\frac{3}{4}$	Lower Geyser Basin, Wyo.

Hab.—The entire continent of North America.

Kingfishers were rare birds along our route, as this was the only specimen seen.

Family 32.—CAPRIMULGIDÆ, THE GOATSUCKERS.

Antrostomus nuttalli, Cassin, (poor-will:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
26	61734	♀	June 8, 1872	$8\frac{1}{2} \times 17\frac{7}{8}$	Ogden, Utah.
55	61735	♂	June 12, 1872	$8\frac{3}{8} \times 15$	Do.

Hab.—High central plains to the Pacific coast.

This rare bird was only found on the rocky slopes at the foot of the Wahsatch Mountains; here, on the 12th of June, I obtained their eggs; they were pure white without spots, and were laid in a slight cavity in the bare ground, without any nest. They contained full-grown embryos, and would doubtless have hatched in a few hours. The male bird, No. 55 (61735,) was shot as he left the nest, and as the feathers were worn off his belly by sitting, it is evident that both male and female take part in the incubation.

Chordeiles henryi, Cassin, (western night-hawk:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
139	61775	......	June 29, 1872	....	Marsh Creek, Idaho.
169	62254	♂	July 17, 1872	$9\frac{3}{4} \times 23\frac{7}{8}$	North Fork, Idaho.
205	62255	♂	July 31, 1872	$9\frac{1}{4} \times 23\frac{3}{8}$	Téton Cañon, Idaho.
230	6225–	Juv. ♂	Aug. 20, 1872	$6\frac{1}{2} \times 16\frac{1}{2}$	Upper Geyser Basin, Wyo.

Hab.—Rocky Mountains, from Saskatchewan to Mexico.

This Rocky Mountain race of our common night-hawk (*P. popetue*) was quite common in the Salt Lake Basin, thence north to Yellowstone Lake, where they were very numerous.

Family 34.—Trochilidæ, the Humming-birds.

Trochilus alexandri, Bourc. and Muls., (black-chinned humming-bird:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
111	61736	......	June 20, 1872	$4\frac{1}{8} \times 4\frac{5}{8}$	Ogden, Utah.
112	61738	♀	June 20, 1872	$3\frac{13}{16} \times 4\frac{3}{4}$	Do.
115	61737	♀	June 20, 1872	$3\frac{3}{4} \times 4\frac{5}{8}$	Do.

Hab.—California, Utah, Arizona, and southward.

Black-chinned humming-birds were not uncommon near Ogden, where I obtained three specimens; they were breeding there, but I was unable to discover any of their nests.

Stellula calliope, Gould, (calliope humming-bird:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
311	62371	♀	July 3, 1872	$3\frac{1}{2} \times 4\frac{1}{6}$	Fort Ellis, Mont.

Hab.—Mountains of Montana, Washington, Oregon, and California, to Mexico.

This species was only observed at Fort Ellis, Montana Territory.

Order 3.—ZYGODACTYLI, CLIMBING BIRDS.

Family 38.—Picidæ, the Woodpeckers.

Picus harrisii, Aud., (Harris's woodpecker:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
187	62260	♀	July 24, 1872	$9\frac{7}{8} \times 15\frac{5}{8}$	Téton Cañon, Idaho.

Hab.—From the Pacific coast to the eastern slope of the Rocky Mountains.

This western race of *P. villosus* was quite abundant in the Téton Cañon, thence northward, following the pine forests, to Yellowstone Lake, and the head-waters of Snake River.

Picoides arcticus, Gray, (three-toed woodpecker :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
236	62261	♂	Aug. 26, 1872	$8\frac{5}{8} \times 14\frac{1}{4}$	Lower Geyser Basin, Wyo.

Hab.—Northern portions of the United States to the Arctic regions, from the Atlantic to the Pacific.

But one specimen of this species was observed on our route.

Picoides dorsalis, Baird, (striped three-toed woodpecker :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
237	62262	0	Aug. 26, 1872	$7\frac{15}{16} \times 14\frac{5}{8}$	Lower Geyser Basin, Wyo.

Hab.—Rocky Mountain region.

One morning, while at breakfast, in the Lower Geyser Basin, I saw this and the preceding species busily engaged searching for grubs in a dead tree near camp. I took my gun and succeeded in shooting both birds. This also is the only specimen of its species seen during the summer.

Sphyropicus williamsonii, Baird, (Williamson's woodpecker :)

No.	Catalogue number.	Sex.	Date.	Measurements.	Locality.
254	62263	♂	Sept. 6, 1872	$8\frac{3}{4} \times 16\frac{1}{4}$	Head-waters of the Madison River, Wyo.

Hab.—Rocky Mountains to the Cascade Mountains.

As we were crossing the main divide of the Rocky Mountains, on the 6th of September, when the ground was covered with snow, I succeeded in shooting the only specimen seen of this rare and beautiful woodpecker.

Sphyropicus thyroideus, Baird, (brown-headed woodpecker :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
226	62259	Juv.	Aug. 13, 1872	$9 \times 15\frac{1}{8}$	Madison River, Mont.

Hab.—Wooded Rocky Mountain regions to Pacific slope.

This is another rare species, but two specimens of which were seen.

Melanerpes torquatus, Bonap., (Lewis's woodpecker:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
167	62274	♀	July 17, 1872	11 × 21½	North Fork, Idaho.
170	62275	♂	July 18, 1872	11 × 21¾	Do.
174	62276	♀	July 18, 1872	10½ × 20¾	Do.

Hab.—Western America, from Black Hills to Pacific.

North, or Henry's Fork of Snake River, is the only locality on our route where this species was met with; here, on the 17th of July, they were quite common, and very shy, and I pursued them for several hours before obtaining a specimen. On the 18th, however, they were still more numerous, and I secured two specimens without much difficulty.

Colaptes mexicanus, Sw., (red-shafted flicker:)

No.	Catalogue-number.	Sex.	Date	Measurements.	Locality.
160	62257	♂	July 16, 1872	11½ × 19⅜	North Fork, Idaho.
271	62258	♀	Sept. 16, 1872	13 × 21¼	Snake River, Wyo.

Hab.—Western North America, from Black Hills to Pacific.

This western representative of *C. auratus* was met with at North Fork, Téton Cañon, and Snake River, but was not abundant at either of these places. At Lewis's Lake, however, they were quite numerous; there, on the 13th of September, I counted twenty-seven in one flock.

Order 4.—RAPTORES, BIRDS OF PREY.

Family 40.—STRIGIDÆ, THE OWLS.

Otus wilsonianus, Lesson, (long-eared owl:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
126	61760	♀	June 28, 1872	14⅝ × 37⅛	Devil's Creek, Idaho.

Hab.—The whole of temperate North America.

I shot this specimen of the long-eared owl as it was sitting in a willow, directly under its nest, which was made of sticks about three-eighths of an inch in diameter; it was about one foot deep and two feet in diameter; the nest was empty, the young having probably flown away.

Athene hypugæa, Bonap., (prairie-owl:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
18	61637	♀	June 9, 1872	$9\frac{13}{16} \times 25\frac{9}{16}$	Ogden, Utah.
125	61761	♂	June 26, 1872	....	Malad Valley, Idaho.
143	61763	♂	July 1, 1872	....	Port Neuf River, Idaho.
148	61762	♀	July 5, 1872	$9\frac{1}{2} \times 24\frac{1}{2}$	Fort Hall, Idaho.
156	61764	Juv.	July 9, 1872	$5\frac{7}{8} \times 16\frac{7}{16}$	Do.

Hab.—Prairies and other open portions of the United States, from the Mississippi to the Pacific.

These little owls were very plentiful on the great plains and prairies, between Omaha and the Black Hills. There they live and breed in the deserted holes of the prairie-dogs, (*Cynomys ludovicianus.*) They were also quite numerous in the Salt Lake Valley and northward to Snake River; here they take up their abodes in the old holes of the badger (*Taxidea americana*, Waterh.) and coyote, (*Canis latrans*, Say.) They breed in May, laying pure-white eggs.

Surnia ulula, Bonap., (hawk-owl:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
224	62240	♂	Aug. 11, 1872	$15 \times 31\frac{1}{2}$	Madison River, Mont.

Hab.—Northern regions of both continents.

This specimen of the hawk-owl is the only one seen. I shot it in broad daylight as it flew past me and lit on a dead pine tree.

Family 41.—Falconidæ, Diurnal Birds of Prey.

(Sub-family *Falconinæ, the Falcons.*)

Tinnunculus sparverius, Vieill., (sparrow-hawk:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
161	62236	♀	July 16, 1872	$10\frac{5}{8} \times 24\frac{1}{4}$	North Fork, Idaho.
168	62237	♀	July 17, 1872	$11\frac{3}{4} \times 24\frac{1}{4}$	Do.
171	62238	Juv.	July 18, 1872	$10 \times 21\frac{3}{4}$	Do.
184	62239	♀	July 22, 1872	$11\frac{1}{8} \times 24\frac{1}{4}$	Téton Basin, Idaho.

Hab.—The entire continent of America.

Sparrow hawks were quite numerous at the North Fork, Téton Basin, and on Snake River, east of the Téton Range.

(Sub-family *Accipitrinæ, the Hawks.*)

Accipiter fuscus, Bonap., (sharp-shinned hawk :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
228	62234	♂	Aug. 20, 1872	12 × 22½	Lower Geyser Basin, Wyo.
229	62235	—	Aug. 20, 1872	13¾ × 26	Do.

Hab.—Throughout North America and Mexico.

This species was only met with in the Lower Geyser Basin, where it was quite common.

(Sub-family *Buteoninæ, the Buzzard-hawks.*)

Buteo swainsoni, Bonap., (Swainson's hawk :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
154	61765	♀	July 9, 1872	20½ × 50½	Fort Hall, Idaho.
155	61766	Pullus	July 9, 1872	11 × 21	Do.
238	62226	♀	Aug. 27, 1872	21½ × 52	Lower Geyser Basin, Wyo.
239	62227	Juv.	Aug. 27, 1872	20⅛ × 49½	Do.
251	62228	♀	Aug. 30, 1872	20¾ × 53¼	Do.
269	62229	♂	Sept. 15, 1872	20¼ × 49¾	Snake River, Wyo.
313	62230	—	July 3, 1872	19 × 49	Fort Ellis, Mont.

Hab.—Western North America; accidental in New England.

This species, though not at all numerous, was the most abundant species of hawk along our route. On the 9th of July I obtained one of their nests at Lincoln Valley, near Fort Hall, Idaho Territory. It was found on a scrub-cedar on a side hill, about nine feet above the ground, and was composed of sticks, lined with fine strips of inner bark; it was nearly flat, and measured twenty-seven inches in external diameter by ten in thickness; it contained one young bird and one egg; the egg—which contained a full-grown embryo, which was dead and partly decomposed—was white, and measured $2\frac{5}{16}$ inches in length by $1\frac{3}{4}$ in breadth.

Buteo montanus, Nuttall, (western red-tail :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
195	62231	♀	July 29, 1872	23¾ × 54	Téton Cañon, Idaho.

Hab.—Western North America.

This western representative of *B. borealis* was only met with in Téton Cañon, where I saw but one pair, the female of which I secured.

(Sub-family *Milvinæ*, *the Kites*.)

Circus hudsonius, Vieillot, (marsh-hawk:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
222	62233	Juv.	Aug. 9, 1872	$21\frac{1}{4} \times 50$	Henry's Lake, Idaho.

Hab.—All of North America and Cuba.

Marsh-hawks were quite abundant in the Salt Lake Basin, thence northward to Henry's Lake, and down Snake River.

(Sub-family *Aquilinæ*, *the Eagles*.)

Pandion carolinensis, Bon., (fish-hawk:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
220	62232	Juv.	Aug. 7, 1872	$23 \times 62\frac{1}{8}$	North Fork, Idaho.

Hab.—Throughout temperate North America.

Fish-hawks were only met with on the North Fork of Snake River; here I shot one specimen as it was soaring around its nest.

Sub-class 2.—CURSORES, SCRATCHING BIRDS.

Family 49.—TETRAONIDÆ, THE GROUSE.

Tetrao obscurus, var. *richardsonii*, Douglas, (Richardson's grouse:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
185	62216	♀	July 23, 1872	$18\frac{5}{8} \times 28\frac{1}{4}$	Téton Cañon, Idaho.
192	62217	♂	July 27, 1872	$20\frac{5}{8} \times 29\frac{1}{2}$	Do.
201	62218	♀	July 30, 1872	....	Do.
202	62219	Juv.	July 30, 1872	....	Do.
216	62220	♀	Aug. 5, 1872	....	North Fork, Idaho.
217	62221	Juv.	Aug. 5, 1872	....	Do.
218	62222	♀	Aug. 6, 1872	$18\frac{5}{8} \times 29$	Do.

Hab.—Central Rocky Mountains and northward.

This bird is easily distinguished from the *T. obscurus* by the tail, which in the latter is broadly tipped with light slate, while in *T. richardsonii* the terminal band is much narrower and more indistinct, or wanting entirely. The species was not abundant, being met with chiefly in the Téton Mountains. I obtained one of their eggs in Téton Cañon; it was light colored, sparingly spotted with brown.

Centrocercus urophasianus, Sw., (sage-cock :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
162	62223	Juv.	July 16, 1872	15¾ × --	North Fork, Idaho.
176	62225	♂	July 20, 1872	22 × 39¼	Do.
221	62224	♀	Aug. 8, 1872	21 × 35⅛	Henry's Lake, Idaho.

Hab.—Sage plains of the northwest.

We found sage-hens quite numerous in the Salt Lake Basin, thence northward to Henry's Lake, also in the Téton Basin and on Snake River, east of the Téton Range.

Pedioecetes phasianellus, Baird, (sharp-tailed grouse :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
144	61793	Juv.	July 2, 1872	6½ × 12¼	Port Neuf River, Idaho.
145	61792	Juv.	July 2, 1872	6½ × 12¼	Do.

Hab.—Northern prairies and plains, from Wisconsin to Cascades of Oregon and Washington.

We met with this species at Port Neuf River, thence north to Fort Hall and Snake River.

Bonasa umbellus, var. *umbelloides*, Baird, (gray mountain grouse :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
188	62353	♀	July 24, 1872	16 × 22	Téton Cañon, Idaho.
288	62354	Juv.	Sept. 27, 1872	12¼ × 20	First Téton Lake, Wyo.
290	62355	♂	Sept. 28, 1872	....	Do.
292	62356	Juv.	Sept. 30, 1872	14¾ × 21½	Snake River, Wyo.
293	62357	Juv.	Sept. 30, 1872	14¾ × 22¾	Do.

Hab.—Rocky Mountain region.

This western race of our eastern ruffled grouse (*B. umbellus*) was not an abundant species, though it was found throughout the pine forests from Téton Cañon to the Yellowstone.

Order 8.—GRALLÆ, WADING BIRDS.

Family 53.—Charadriidæ, the Plovers.

Ægialitis vociferus, Cassin, (killdeer :)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
89	61645	♂	June 17, 1872	9¾ × 20⅝	Salt Lake, Utah.
250	62362	♀	Aug. 28, 1872	10⅝ × 19⅛	Lower Geyser Basin, Wyo.

Hab.—North America to the Arctic regions; Mexico, South America.

The killdeer was one of the few birds that were common all along our route. They were very numerous about Salt Lake and in the Geyser Basin. At the latter place they were in perpetual fear of the marsh-hawks, (*Circus hudsonius*,) which made great havoc among them.

Family 55.—SCOLOPACIDÆ, THE SNIPES.

Gallinago wilsonii, Bonap., (English snipe:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
312	62370	♂	July 9, 1872	9 × 16	Fort Ellis, Mont.

Hab.—Entire temperate regions of North America.

Actodromus bairdii, Coues., (Baird's sand-piper:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
249	62361	♀	Aug. 28, 1872	7 × 15$\frac{5}{8}$	Lower Geyser Basin, Wyo.

Hab.—Western North America; accidental on Atlantic coast.

The Lower Geyser Basin is the only locality where these birds were seen. There I saw a flock of about thirty specimens. I fired into their midst, wounding several, only one of which, No. 249, (62361,) I secured.

Symphemia semipalmata, Harlt., (willet:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
92	61639	♀	June 17, 1872	16 × 30	Salt Lake, Utah.
110	61638	—	June 19, 1872	15$\frac{1}{8}$ × 27$\frac{3}{4}$	Do.
163	62358	—	July 16, 1872	15$\frac{3}{8}$ × 29$\frac{3}{4}$	North Fork, Idaho.

Hab.—Entire temperate regions of North America; South America.

While riding about the marshes and sloughs near Salt Lake, we were generally escorted by a troupe of twenty or thirty willets, who kept continually flying about over our heads, uttering loud, clattering notes. They would often dart down in a bee-line for our heads, and when within eight or ten feet of it, turning suddenly and gracefully to one side, they would rise again to repeat the performance.

Gambetta melanoleuca, Bonap., (tell-tale:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
235	62360	—	Aug. 23, 1872	14$\frac{3}{4}$ × 25	Yellowstone Lake, Wyo.

Hab.—Entire temperate regions of North America; Mexico.

The tell-tale, or stone-snipe, was very abundant on the shores of Yellowstone Lake.

Tringoides macularius, Gray, (spotted sand-piper:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
173	62359	♂	July 18, 1872	$8\frac{1}{2} \times 13\frac{1}{2}$	North Fork, Idaho.

Hab.—Entire temperate North America; Europe.

Numenius longirostris, Wilson, (long-billed curlew:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
107	61640	—	June 19, 1872	$22\frac{7}{8} \times 40$	Salt Lake, Utah.

Hab.—The entire temperate regions of North America.

On the 24th of June I saw a flock of fifty curlews near Bear River. It was a rainy day, and they were running about among the sage-brush, (artemisia.) Upon my near approach they took to wing, and after circling about for a few minutes settled down again. They were quite common at Salt Lake, and north to the North Fork of Snake River.

Family 56.—PHALAROPODIDÆ, THE PHALAROPES.

Phalaropus wilsonii, Sab., (Wilson's phalarope:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
105	61647	♀	June 19, 1872	$9\frac{3}{8} \times 17\frac{1}{2}$	Salt Lake, Utah.
140	61795	♂	June 30, 1872	$9 \times 15\frac{1}{2}$	Marsh Creek, Idaho.

Hab.—Entire temperate regions of North America; New Mexico, (Dr. Henry.)

Family 57.—RECURVIROSTRIDÆ, THE AVOSETS AND STILTS.

Recurvirostra americana, Gm., (American avoset:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
104	61641	♀	June 19, 1872	$17\frac{1}{4} \times 29\frac{1}{2}$	Salt Lake, Utah.
103	61642	——	June 19, 1872	$18\frac{3}{16} \times 30\frac{3}{4}$	Do.

Hab.—All of temperate North America; Florida, (Mr. Würdemann.)

Avosets were quite numerous about Salt Lake, thence northward to the North Fork, opposite the Crater Buttes. In habits they resemble the willet, (*Symphemia semipalmata.*)

Himantopus nigricollis, Vieill, (black-necked stilt:)

No.	Catalogue-number.	Sex.	Date.	Measure-ments.	Locality.
103	61644	♀	June 19, 1872	$14\frac{1}{4} \times 26\frac{7}{8}$	Salt Lake, Utah.
106	61643	♀	June 19, 1872	$14\frac{3}{8} \times 27$	Do.

Hab.—United States generally.

We procured the eggs of this species on the 17th of June at Salt Lake. They were four in number, and were laid on a pile of drift-wood, in the edge of a little bay of the lake. The eggs measure $1\frac{5}{8}$ inches in length by $1\frac{3}{16}$ in breadth, and are of a light yellowish brown color, spotted and blotched with dark brown and black, the spots being most numerous near the large end.

Family 58.—Gruidæ, the Cranes.

Grus canadensis, Temm, (sand-hill crane:)

No.	Catalogue-number.	Sex.	Date.	Measure-ments.	Locality.
219	62369	♀	Aug. 6, 1872	47×88	North Fork, Idaho.

Hab.—Whole of western regions of United States; Florida.

Sand-hill cranes were first met with on North or Henry's Fork, thence north to Yellowstone Lake, and south to Snake River, below Jackson's Lake. They were quite numerous in all this region, but as they were very shy it was difficult to obtain a shot at them.

Family 67.—Rallidæ, the Rails.

Porzana carolina, Vieill, (common rail:)

No.	Catalogue-number.	Sex.	Date.	Measure-ments.	Locality.
79	61646	♂	June 15, 1872	$9 \times 13\frac{1}{2}$	Ogden, Utah.

Hab.—Entire temperate regions of North America.

Rails were quite common in a marsh at the foot of the Wahsatch Range. Here I secured one specimen, No. 79, (61646,) and two nests, Nos. 37 (16303) and 38, (16304.) The nests are large and bulky, and were placed in a clump of flags in a swamp. They are composed of marsh-grass, and contain twelve drab-colored eggs, spotted with chocolate and reddish brown.

Sub-class 3.—NATATORES, THE SWIMMERS.

Order 9.—LAMELLIROSTRES, ANSERINE BIRDS.

Family 69.—ANATIDÆ.

(Sub-family *Cygninæ, the Swans.*)

Cygnus buccinator, Rich., (trumpeter-swan:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
284	62367	♂	Sept. 23, 1872	....	Snake River, Wyo.
285	62368	♂	Sept. 23, 1872	....	Do.

Hab.—Western America, from the Mississippi Valley to the Pacific.
These large and beautiful birds were only met with on Snake River, in the vicinity of Jackson's Lake.

(Sub-family *Anatinæ, the River-ducks.*)

Anas boschas, Linn., (mallard:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
164	62364	Juv.	July 16, 1872	$11\frac{1}{2} \times 6\frac{1}{2}$	North Fork, Idaho.
165	62365	Juv.	July 16, 1872	$16\frac{3}{4} \times 11\frac{3}{4}$	Do.

Hab.—Entire continent of North America and greater part of Old World.

Dafila acuta, Jenyns, (sprig-tail; pin-tail:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
260	62366	♀	Sept. 7, 1872	$23\frac{1}{2} \times 27$	Shoshone Lake, Wyo.

Hab.—Whole of North America and Europe.

Querquedula cyanopterus, Cassin, (red-breasted teal:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
109	61648	......	June 19, 1872	$16\frac{3}{4} \times 25\frac{7}{8}$	Salt Lake, Utah.
....	61649	......	1872	....	

Hab.—Rocky Mountains to Pacific; accidental in Louisiana.
I found the nest—No. 55, (16321)—of this species on the 29th of June,

at Marsh Creek, Idaho Territory. It was in the swamp-grass, was lined with down, and contained nine eggs.

Chaulelasmus streperus, Gray, (gadwall:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
159	62363	♀	July 15, 1872	$19\frac{5}{8} \times 33\frac{1}{2}$	Market Lake, Idaho.

Hab.—North America generally, and Europe.

On the 29th of June I found the nest of this bird at Marsh Creek. It was lined with down, and contained three fresh eggs.

Order 11.—LONGIPENNES, LONG-WINGED SWIMMERS.

Family 76.—LARIDÆ, THE GULLS.

(Sub-family *Sterninæ, the Terns.*)

Sterna fosteri, Nuttall, (Foster's tern:)

No.	Catalogue-number.	Sex.	Date.	Measurements.	Locality.
141	61767	♀	June 30, 1872	....	Marsh Creek, Idaho.
142	61768	♂	June 30, 1872	....	Do.

Hab.—North America generally.

OÖLOGY.

Sub-class I.—INSESSORES, THE PERCHERS.

Order I.—PASSERES.

(Section OSCINES, SINGERS.)

Family 1.—TURDIDÆ, THE THRUSHES.

Turdus swainsonii, Cab., (olive-backed thrush:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
62	16316	July 21, 1872	2	Téton Basin, Idaho.....	Eggs fresh.

This nest was found on a dead cotton-wood sapling, among the branches of a pine-tree, on the side of a cañon; it was about five feet above the ground, and was composed of dry grass, lined with finer stalks of the same. Its measurements were as follows: Depth, outside, 5.50 inches; inside, 2 inches: diameter, outside, 3.75 inches; inside, 3 inches.

Turdus audubonii, Baird, (Audubon's thrush:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
67	16320	July 16, 1872	3	Fort Ellis, Mont	Eggs fresh.

This nest was situated in a small pine-tree about eight feet from the ground, in the pine regions of the mountains. Nest bulky, deeply saucer-shaped, measuring 6 inches in external diameter by 3 in depth; cavity, 3 inches broad by about 1.75 deep. Composed of green moss and lined with fine grass-leaves. Eggs, three in number, broadly ovate, obtuse; measurement, .85 inch in length by .72 in breadth; their color is a rather deep greenish blue, exactly like those of *T. migratorius*.

Galeoscoptes carolinensis, Gray, (cat-bird:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
52	16310	June 18, 1872	5	Ogden, Utah	Eggs nearly fresh.

See page —.

Oreoscoptes montanus, Baird, (mountain mocking-bird:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
26	16296	June 10, 1872	4	Salt Lake, Utah	Eggs fresh.

See page —.

Family 9.—SYLVICOLIDÆ, THE WOOD-WARBLERS.

Geothlypis trichis, Cab., (Maryland yellow-throat:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
44	16308	June 17, 1872	4	Ogden, Utah	Eggs fresh.

See page —.

Dendroica æstiva, Baird, (yellow warbler:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
24	16294	June 8, 1872	4	Ogden, Utah	Eggs fresh.

See page —.

Family 10.—HIRUNDINIDÆ, THE SWALLOWS.

Hirundo lunifrons, Say., (cliff swallow :)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
58	16312	July 3, 1872	2	Ross Fork, Idaho	Eggs fresh.

See page —.

Cotyle riparia, Boil., (bank swallow :)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
25	16295	June 10, 1872	7	Salt Lake, Utah	Eggs fresh.

See page —.

Family 16.—FRINGILLIDÆ, THE SPARROWS.

Pooecetes gramineus, var. *confinis*, Baird, (grass finch :)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
10	16281	June 5, 1872	4	Ogden, Utah	Eggs contained large embryos.
23	16282	June 8, 1872	4	......do	Do.

See page —.

Coturniculus passerinus, Bonap., (yellow-winged sparrow :)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
7	16280	June 5, 1872	4	Ogden, Utah	Eggs fresh.

I found this nest on the ground, by the side of a sage-bush. It was very light, being carelessly constructed of fibrous roots and grasses, lined with finer pieces of the same. It measured 4.35 inches in external diameter, and contained four white eggs, spotted with reddish brown.

Chondestes grammaca, Bonap., (lark-finch :)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
22	16292	June 7, 1872	5	Ogden, Utah	Eggs fresh.
65	16293	June 16, 1872	....	......do	

See page —.

Spizella breweri, Cass, (Brewer's sparrow:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
61	16315	July 21, 1871	3	Conant Creek, Idaho.	Nearly fresh.

I found but one nest of Brewer's chipping sparrow. It was placed on a sage-brush about one foot above the ground, and was composed entirely of the stalks of dry grass, lined with finer pieces of the same. Its external diameter measures 2.80 inches by 2.30 in depth; inside, 2 inches broad by 1.60 deep. The eggs are greenish blue, spotted with chocolate brown, the spots being most numerous at and forming a ring around the large end.

Melospiza fallax, Baird, (mountain song sparrow:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
34	16301	June 13, 1872	4	Ogden, Utah	Eggs contained large embryos.

See page —.

Passerella schistacea, Baird, (slate-colored sparrow:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
16	16290	June 6, 1872	6	Ogden, Utah..........	Eggs fresh.

This nest was found on a bush in a marsh, about six feet above the ground. It was composed of dry swamp-grass, covered on the outside with dead leaves, with here and there a little green moss. It was cup-shaped, very compact, and was lined with fine stalks of dry grass and hair. It measured about 4.25 inches in external diameter by 2.75 deep. It was 1.90 inches deep inside by 2.30 broad. The eggs were light greenish blue, spotted and blotched all over with dark brown.

Guiraca melanocephala, Sw., (black-headed grosbeak:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
63	16317	July 22, 1872	2	Téton Basin, Idaho...	Eggs fresh.

See page —.

Cyanospiza amœna, Baird, (lazuli finch:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
8	16283	June 5, 1872	3	Ogden, Utah..........	Eggs fresh.
9	16284	June 5, 1872	4	......do	Do.
35	16285	June 14, 1872	4	......do	Eggs contained small embryos.

See page —.

Pipilo megalonyx, Baird, (spurred towkee:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
31	16299	June 13, 1872	4	Ogden, Utah..........	Eggs nearly fresh.
32	16300	June 13, 1872	5	......do..............	Eggs fresh.
36	16302	June 14, 1872	4	......do..............	Do.

See page —.

Family 18.—Icteridæ, the Orioles.

(Sub-family *Agelaunæ, the Starlings.*)

Xanthrocephalus icterocephalus, Baird, (yellow-headed black-bird.)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
57	16311	June 30, 1872	3	Marsh Valley, Idaho ...	

See page —.

Sturnella neglacta, Aud., (western lark:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
6	16277	June 5, 1872	3	Ogden, Utah...........	Eggs contained large embryos.
21	16278	June 7, 1872	6	......do...............	Do.
43	16379	June 15, 1872	5	......do...............	Do.

See page —.

(Sub-family *Icterinæ.*)

Icterus bullockii, Bonap., (western oriole:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
2	16261	June 5, 1872	6	Ogden, Utah...........	Eggs nearly fresh.
3	16262	June 5, 1872	6	........do.............	Do.
12	16263	June 6, 1872	4	........do.............	Eggs fresh.
13	16264	June 6, 1872	5	........do.............	Eggs nearly fresh.
14	16265	June 6, 1872	4	........do.............	Eggs fresh.
17	16266	June 6, 1872	4	........do.............	Do.
19	16267	June 7, 1872	6	........do.............	Eggs nearly fresh.
29	16268	June 12, 1872	5	........do.............	Eggs fresh.
30	16269	June 12, 1872	6	........do.............	Eggs contained large embryos.
33	16270	June 13, 1872	5	........do.............	Eggs fresh.
40	16271	June 15, 1872	5	........do.............	Do.
41	16272	June 15, 1872	5	........do.............	Do.
45	16273	June 17, 1872	3	........do.............	Do.
46	16274	June 17, 1872	1	........do.............	Do.
47	16275	June 17, 1872	3	........do.............	Do.
48	16276	June 17, 1872	2	........do.............	Eggs contained small embryos.

See page —.

(Sub-family *Quiscalinæ, the Crow black-birds.*)

Scolecophagus cyanocephalus, Cab., (Brewer's black-bird:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
66	16319	June 15, 1872	....	Ogden, Utah...........	Eggs nearly fresh.

See page —.

(Section *Clamatores, crying birds.*)

Family 23.—Tyrannidæ, the Tyrant Fly-catchers.

Tyrannis carolinensis, Baird, (king-bird:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
60	16314	July 14, 1872	3	Snake River, Idaho	Eggs fresh.

See page —.

Tyrannus verticalis, Say, (Arkansas fly-catcher:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
11	16286	June 5, 1872	4	Ogden, Utah...........	Eggs fresh.
15	16287	June 6, 1872	1	......do	Do.
53	16288	June 28, 1872	2	Devil's Creek, Idaho ...	Do.
54	16289	June 28, 1871	4	......do	Eggs nearly ready to hatch.

See page —.

Empidonax pusillus, Cab., (little fly-catcher:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
39	16305	June 15, 1872	3	Ogden, Utah...........	Eggs fresh.
50	16306	June 17, 1872	4	......do	Do.
41	16307	June 17, 1872	4	......do	Do.

See page —.

Order II.—STRISORES.

Family 32.—Caprimulgidæ, the Goat-suckers.

Antrostomus nuttalli, Cassin, (poor will:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
28	16298	June 12, 1872	2	Ogden, Utah	Eggs contained full-grown embryos.

See page —.

Order IV.—RAPTORES, THE BIRDS OF PREY.

Family 40.—STRIGIDÆ, THE OWLS.

Athene hypugæa, Bonap., (prairie-owl:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
27	16297	June 10, 1872	....	Salt Lake, Utah........	

See page —.

Family 41.—FALCONIDÆ.

(Sub-family *Buteoninæ, the Buzzard-hawks.*)

Buteo swainsonii, Bonap., (Swainson's hawk:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
59	16313	July 9, 1872	1	Fort Hall, Idaho	Egg decayed.

See page —.

Order V.—PULLASTRÆ.

Family 43.—COLUMBIDÆ, THE PIGEONS AND DOVES.

Zenaidura carolinensis, Bonap., (common dove:)

No.	Catalogue-number:	Date.	Eggs in nest.	Locality.	Remarks.
1	16256	June 5, 1872	2	Ogden, Utah	Eggs fresh.
4	16257	June 5, 1872	2	......do	Do.
5	16258	June 5, 1872	2	......do	Do.
18	16291	June 7, 1872	2	......do	Eggs contained large embryos.
20	12259	June 7, 1872	2	......do	Eggs fresh.
42	12260	June 15, 1872	2	......do	Do.

Mourning or ground doves were very numerous in the Salt Lake Valley, where I collected twelve of their eggs. They lay two white eggs, either in a slight excavation in the ground lined with a few pieces of straw or dry grass laid loosely together, or in a neat nest of fibrous roots, which is placed on a bush from two to five feet above the ground.

Sub-class II.—CURSORES.

Order VI.—GALLINÆ.

Family 49.—TETRAONIDÆ, THE GROUSE.

Tetrao richardsonii, Baird, (Richardson's grouse:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
64	16318	July —, 1872	1	Téton Cañon, Idaho....	Egg stale.

See page —.

Order VIII.—GRALLÆ.

Family 57.—RECURVIROSTRIDÆ, THE AVOSETS AND STILTS.

Himantopus nigricollis, Vieill, (black-necked stilt:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
49	16309	June 17, 1872	4	Salt Lake, Utah	Eggs fresh.

See page —.

Family 67.—RALLIDÆ, THE RAILS.

Porzana carolina, Vieill, (common rail:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
37	16303	June 15, 1872	12	Ogden, Utah...........	Eggs contained large embryos.
38	16304	June 15, 1872	8	......do	One young bird in nest.

See page —.

Sub-class III.—NATATORES, THE SWIMMERS.

Order IX.—LAMELLIROSTRES.

Family 69.—ANATIDÆ.

(Sub-family *Anatinæ, the River-ducks.*)

Querquedula cyanopterus, Cassin, (red-breasted teal:)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
55	16321	June 29, 1872	9	Marsh Creek, Idaho....	Eggs contained large embryos.

See page —.

Chaulelasmeus streperus, Gray, (gadwall :)

No.	Catalogue-number.	Date.	Eggs in nest.	Locality.	Remarks.
56	16322	June 29, 1872	3	Marsh Creek, Idaho....	Eggs fresh.

See page —.

List of birds found in Téton Basin and Cañon, Idaho Territory, July, 1872.

[This list is, of course, very imperfect, owing to the short time we spent in the basin ; yet it will serve to give some idea of the birds found in that region.]

Oreoscoptes montanus, Baird. Mountain mocking-bird.
Turdus migratorius, Linn. Common robin.
Sialia arctica, Swainson. Rocky Mountain blue-bird.
Regulus calendula, Licht. Ruby-crowned wren.
Parus montanus, Gambel. Mountain titmouse.
Vireo gilvus var. *swainsoni*, Baird. Western warbling greenlet.
Pyranga ludoviciana, Bonap. Louisiana tanager.
Carpodacus cassinii, Baird. Cassin's purple finch.
Chrysomitris pinus, Bonap. Pine-finch.
Pooecetes gramineus, var. *confinis*, Bd. Grass-finch.
Junco oregonus, Sclat. Pink-sided snow-bird.
Pipilo chlorura, Baird. Green-tailed finch.
Eremophila cornuta, Boie. Horned sky-lark.
Sturnella neglecta, Aud. Western meadow-lark.
Cyanura macrolopha, Baird. Long-crested jay.
Perisoreus canadensis, Bonap. Gray jay.
Corvus carnivorous, Bartram. American raven.
Tyrannus carolinensis, Baird. King-bird.
Contopus borealis, Baird. Olive-sided fly-catcher.
Contopus richardsonii, Baird. Short-legged pewee.
Empidonax pusillus, Cab. Little fly-catcher.
Ceryle alcyon, Boie. Belted king-fisher.
Chordeiles henryii, Cassin. Western night-hawk.
Picus harrisii, Aud. Harris's woodpecker.
Buteo montanus, Nuttall. Western red-tail.
Tetrao obscurus, var. *richarsonii*. Richardson's grouse.
Centrocercus urophasianus, Sw. Sage-cock.
Bonasa umbellus, var. *umbelloides*, Baird. Gray mountain grouse.

List of birds found in Fire-Hole Basin, Wyoming Territory, August, 1872.

[This list, like the preceding, and for the same reason, is very imperfect, and will admit of many additions.]

Turdus migratorius, Linn. Common robin.
Sialia arctica, Sw. Rocky Mountain blue-bird.
Regulus calendula, Licht. Ruby-crowned wren.

Parus montanus, Gambel. Mountain titmouse.
Myiodioctes pusillus, Bonap. Green black-cap warbler.
Hirundo horreorum, Barton. Barn swallow.
Pooecetes gramineus, var. *confinis*, Baird. Grass-finch.
Chondestes grammaca, Bonap. Lark-finch.
Junco oregonus, Sclat. Pink-sided snow-bird.
Carpodacus cassinii, Baird. Cassin's purple finch.
Chrysomitris pinus, (?) Bonap. Pine-finch.
Scolecophagus cyanocephalus. Brewer's blackbird.
Cyanura macrolopha, Baird. Long-crested jay.
Perisoreus canadensis, Bonap. Gray jay.
Picicorvus columbianus, Bonap. Clark's crow.
Corvus carnivorus, Bartram. American raven.
Tyrannus carolinensis, Baird. King-bird.
Empidonax pusillus, Cab. Little fly-catcher.
Ceryle alcyon, Boie. Belted king-fisher.
Chordeiles henryii, Cassin. Western night-hawk.
Picus harrisii, Audubon. Harris's woodpecker.
Picoides arcticus, Gray. Three-toed woodpecker.
Picoides dorsalis, Baird. Striped three-toed woodpecker.
Accipiter fuscus, Bonap. Sharp-shinned hawk.
Buteo swainsonii, Bonap. Swainson's hawk.
Circus hudsonius, Vieillot. Marsh harrier.
Spizella socialis, Bonap. Chipping sparrow.
Sitta aculeata, Cassin. Slender-billed nuthatch.
Grus canadensis, Temm. Sand-hill crane.
Ægialitis vociferus, Cassin. Killdeer.
Ætodromus bairdii, Coues. Baird's sand-piper.
Bernicla canadensis, Boie. Canada goose.
Pelecanus erythrorhynchus, Gm. American pelican.

List of the birds found in Utah Territory.

(NOTE.—The following list embraces all the species known to have been taken within the limits of the Territory of Utah. For some of them I am indebted to Mr. Allen, Mr. Henshaw, and Mr. Ridgway.)

1. Turdus pallasi.
2. Turdus swainsonii.
3. Turdus audubonii.
4. Planesticus migratorius.
5. Galeoscoptes carolinensis.
6. Oreoscoptes montanus.
7. Cinclus mexicanus.
8. Sialia arctica.
9. Regulus calendula.
10. Parus montanus.
11. Parus septentrionalis.
12. Campylorhynchus brunneicapillus.
13. Catherpes mexicanus.
14. Salpinetes obsoletus.
15. Cistothorus palustris.
16. Troglodytes parkmanni.
17. Anthus ludovicianus.
18. Geothlypis trichas.
19. Geothlypis macgillivrayi.
20. Icteria longicauda.
21. Helminthophaga ruficapilla.
22. Helminthophaga celata.
23. Dendroica audubonii.
24. Dendroica blackburniæ.
25. Dendroica æstiva.
26. Myiodioctes pusillus.
27. Setophaga ruticilla.
28. Hirundo horreorum.
29. Petrochelidon lunifrons.
30. Tachycineta bicolor.
31. Tachycineta thalassina.
32. Cotyle riparia.
33. Stelgidopteryx serripennis.

34. Vireo swainsonii.
35. Vireo olivaceus.
36. Vireo plumbeus.
37. Ampelis cedrorum.
38. Collurio excubitoroides.
39. Pyranga ludoviciana.
40. Carpodacus cassinii.
41. Carpodacus frontalis.
42. Chrysomitris tristis.
43. Chrysomitris psaltria.
44. Chrysomitris pinus.
45. Leucosticte tephreotes.
46. Passerculus alaudinus.
47. Pooecetes gramineus, var. confinis.
48. Coturniculus passerinus.
49. Chondestes grammaca.
50. Zonotrichia leucophrys.
51. Zonotrichia gambelii.
52. Junco oregonus.
53. Junco caniceps.
54. Poospiza bilineata.
55. Poospiza belli.
56. Spizella socialis.
57. Spizella breweri.
58. Melospiza fallax.
59. Melospiza lincolnii.
60. Passerella schistacea.
61. Calamospiza bicolor.
62. Calamospiza melanocephala.
63. Cyanospiza amœna.
64. Pipilo megalonyx.
65. Pipilo chlorura.
66. Passer domesticus, (introduced.)
67. Eremophila cornuta.
68. Dolichonyx oryzivorus.
69. Molothrus pecoris.
70. Agelaius phœniceus.
71. Xanthrocephalus icterocephalus.
72. Sturnella neglecta.
73. Icterus bullockii.
74. Scolecophagus cyanocephalus.
75. Corvus carnivorus.
76. Corvus americanus.
77. Picicorvus columbianus.
78. Gymnokitta cyanocephala.
79. Pica hudsonica.
80. Cyanura macrolopha.
81. Cyanocitta woodhousii.
82. Perisoreus canadensis.
83. Tyrannus carolinensis.
84. Tyrannus verticalis.
85. Sayornis sayus.
86. Contopus borealis.
87. Contopus virens, var. richardsonii.
88. Empidonax pusillus.
89. Empidonax difficilis.
90. Empidonax hammondii.
91. Empidonax obscurus.
92. Ceryle alcyon.
93. Antrostomus nuttalli.
94. Chordeiles henryi.
95. Trochilus alexandri.
96. Selasphorus platycercus.
97. Picus harrisii.
98. Sphyropicus nuchalis.
99. Sphyropicus williamsonii.
100. Sphyropicus thyroideus.
101. Melanerpes torquatus.
102. Colaptes mexicanus.
103. Otus wilsonianus.
104. Athene hypugæa.
105. Falco peregrinus.
106. Hypotriorchis columbarius.
107. Tinnunculus sparverius.
108. Accipiter fuscus.
109. Buteo swainsoni.
110. Buteo montanus.
111. Archibuteo sancti-johannis.
112. Circus hudsonius.
113. Aquila canadensis.
114. Haliætus leucocephalus.
115. Cathartes aura.
116. Zenaidura carolinensis.
117. Tetrao obscurus.
118. Centrocercus urophasianus.
119. Pediœcetes phasianellus.
120. Bonasa umbellus, var. umbelloides.
121. Ortyx virginianus. (Introduced.)
122. Lophortyx californicus. (Introduced.)
123. Lophortyx gambelii.
124. Ægialitis vociferus.
125. Ægialitis nivosus.
126. Gallinago Wilsonii.
127. Macrorhamphus griseus.
128. Pelidna alpina, var americana.
129. Actodromus minutilla.
130. Gambetta melanoleuca.
131. Gambetta flavipes.
132. Tringoides macularius.
133. Actiturus bartramius.
134. Numenius longirostris.
135. Symphemia semipalmata.
136. Phalaropus wilsonii.
137. Recurvirostra americana.

138. Himantopus nigricollis.
139. Grus canadensis.
140. Ibis ordii.
141. Ibis alba.
142. Ardea herodias.
143. Botaurus lentiginosus.
144. Nyctiardea grisea, var. nævia.
145. Rallus crepitans.
146. Porzana carolina.
147. Porzana jamaicensis.
148. Fulica americana.
149. Cygnus americanus.
150. Anser hyperboreus.
151. Anser gambelii.
152. Bernicla canadensis.
153. Anas boschas.
154. Dafila acuta.
155. Nettion carolinensis.
156. Querquedula cyanoptera.
157. Spatula clypeata.
158. Chaulelasmus streperus.
159. Mareca americana.
160. Aix sponsa.
161. Fulix marila.
162. Fulix affinis.
163. Aythya americana.
164. Bucephala albeola.
165. Erismatura rubida.
166. Mergus americanus.
167. Pelecanus erythrorhynch us.
168. Graculus dilophus.
169. Larus californicus.
170. Larus delawarensis.
171. Chroicocephalus philadelphia.
172. Xema sabinii.
173. Sterna fosteri.
174. Colymbus torquatus.
175. Podiceps cornutus.
176. Podilymbus podiceps.

COLEOPTERA.

By Geo. H. Horn, M. D., Philadelphia.

The species collected during the expedition of 1872 are very few in number, and add scarcely anything to our knowledge of distribution, and an unusually small number of new forms. They are distributed as follows:

YELLOWSTONE LAKE.

Cincindela 12-guttata, Dej.
Carabus tædatus, Fab.
Agabus, n. sp.
Colymbetes binotatus, Harr.
Gyrinus picipes, Aubé.
affinis, Aubé.
Silpha lapponica, Hbst.
Canthon simplex, Lec.
Diplotaxis brevicollis, Lec.
Melanophila longipes, Say.
Anclastes druryi, Kby.
Adelocera profusa, Cand.
Cœlocnemis dilaticollis, Mann.
Iphthimus serratus, Mann.
Tragosoma harrisii, Lec.
Argaleus nitens, Lec.
Criocephalus protractus, Lec.
agrestis, Kby.
Haltica bimarginata, Say.

TÉTON BASIN.

Cicindela montana, Lec.
Amara polita, Lec.
gibba, Lec.
Harpalus oblitus, Lec.
Diplotaxis tristes, Kby.
Silis, n. sp.
Eleodes humeralis, Lec.
Cantharis sphæricollis, Say.

SNAKE RIVER.

Platynus deplanatus, Mén.
Nothopus zabroides, Lec.
Harpalus oblitus, Lec.
Amphizoa lecontei, Matth.
Colymbetes seminiger, Lec.
n. sp.
Dytiscus confluens, Say.
Acmæodera mixta, Lec.
Eleodes tricostata, Say.
Cantharis nuttali, Say.
cyanipennis, Lec.
Epicauta puncticollis, Mann.
maculata, Say.
Chrysomela philadelphica, Linn.

The most interesting of all the species collected is *Amphizoa lecontei* Matthews, described in July, 1872, by Rev. A. Matthews, in a pamphlet issued by E. Janson, of London, entitled "Cistula Entomologica," p. 121. It differs from our well-known *A. insolens*, Lec., by the dorsum of the elytra being depressed along the middle from near the base to the apex, so that each elytron along its middle appears subcostate. Another species has been described by the same author, (p. 119,) but I cannot see any character by which it can be separated from the long series of *A. insolens* before me. It has been named *Amphizoa Josephi*. The two sexes of *Amphizoa* do not differ greatly; the antennæ of the male are very obsoletely subserrate, and the female has a somewhat broader form of body.

Of the three new species little need be said here. Two are water-beetles, and the family is now in process of revision. The Telephoride, *Silis*, will be described, with many other new forms, in a forthcoming review of the entire group.

It is rather remarkable that no representatives of the families *Histeridæ*, *Coccinellidæ*, and *Curculionidæ* appear, and very few *Tenebrionidæ*, although the region has on other occasions yielded many representatives of all these families.

NOTES ON ORTHOPTERA.

By Cyrus Thomas, Ph. D.

Although the collection of *Orthoptera* made last season was not so large as some former collections made by the survey, yet it was one of considerable interest, as it contained a few new species, and assisted in determining the range of other species already known. The collection was chiefly made by Messrs. Carrington and Brown; a few were collected by Dr. Curtis. One very important bottle of specimens was collected by Dr. Hayden personally, while temporarily separated from the main party in Southern Montana; in this I found a new species of *Platyphama*, the first of this genus found in the United States, though a few species have been obtained from Mexico. It also contained a new species of *Chrysochraon*, somewhat peculiar in having the sides of the pronotum irregularly waved and slightly converging in front.

As the descriptions of the new species are given in my "Synopsis of the Acrididæ of North America," which is now in course of publication, I will not repeat them here, but will only add such notes in regard to colors, habits, localities, &c., as are not fully given in that work; and in doing this I shall not attempt to arrange them systematically.

I have not as yet made a thorough examination of the collection, yet I have gone over it sufficiently to satisfy myself that there are no new species except those already mentioned. Although this is the case, the collection is not without interest, as it brings to view forms which were not seen in the broad intervening space between Southern Wyoming and the borders of Montana. It also reveals the interesting fact that *Œdipoda atrox*, Scudd., hitherto found only in California, re-appears in the Yellowstone Basin. In the same basin we again meet with *Decticus trilineatus*, Thos., which has not been seen west of the dividing range of the Rocky Mountains. The ubiquitous *Caloptenus spretus* is seen in nearly every bottle of the collection from Ogden northward.

The following species were found in the Yellowstone Basin, probably all from the limits of the National Park: *Caloptenus spretus*, *Platyphama montana*, *Pezotettix obesa*, *Stenobothrus curtipennis*, *Œdipoda atrox*, *Œ. undulata*, *Decticus trilineatus*.

It is somewhat singular that but two or three crickets are found in the entire collection.

The collection which I made during my excursion to the northwest was comparatively small, as I did not attempt to collect any except those species or varieties which appeared to be new, or where there existed some doubt in my mind as to the coloring, in which case notes were made at the time while the specimens were fresh. As before stated, I give these notes without any attempt to arrange the species systematically.

In addition to the collections mentioned, I also received, specimens from Jefferson County, Alabama, collected by Dr. G. T. Deason; from East Tennessee, through Theophilus Rogan, esq.; and from Mississippi, I suppose through Mr. D. L. Phares; also from the Agricultural Department a very valuable collection made by Professor Glover, in Florida, some years ago.

In the collection from Mississippi I find a very large, fine specimen of

Œdipoda discoidea, Serv. In that from East Tennessee I had the pleasure of finding the first specimen of *Pyrgomorpha* I have seen; the species is described in my Synopsis. In Professor Glover's collection I found a new species of *Tryxalis*, the first, so far as I am aware, that has been found in the United States; also *Stenacris chlorizans*, Walk. I at first overlooked Walker's description, and placed it among the cylindrical *Opomala* as a new species. If this genus as established by Walker be retained, it will be necessary to remove other species from *Opomala* and place them here; and the position of the eyes will then be the only distinguishing feature of *Mesops*.

Œdipoda phœnicoptera, Germ.

I met with this species (June 21) in Southern Dakota, between Yankton and Springfield, (Bon Homme County.) The wings, though usually of the bright red common to this species, are frequently yellowish, with but a faint reddish tinge. These specimens vary slightly from the usual type in the form and size of the spots of the elytra, the variation being toward *Œ. corallipes*, Hald.

Œ. discoidea, Serv.; *Œ. rugosa*, Scudd.; *Œ. corallipes*, Hald.; *Œ. Haldemannii*, Scudd.; *Œ. paradoxa*, Thos.

My investigations the past season have increased my doubt in respect to the distinction of these species. I have now in my collection specimens from Mississippi, Washington City, Illinois, Nebraska, Kansas, Dakota, Colorado, Wyoming, and Utah, and although there are slight variations in the markings of the elytra, the rugosity of the thorax, and the color of the disk of the wings, yet these variations fade so insensibly from one into the other that there is no possibility of fixing the line of distinction. Locality appears to have something to do with these variations, but does not govern them entirely. For example, a specimen before me, from Mississippi, has the disk or basal portion of the wing an orange-red, while another, by the side of it, from Nebraska, has it lemon-yellow with splotches of orange-red. The former is evidently the *discoidea* of Serville, and the latter stands about midway between *rugosa* and *corallipes*. When we examine them closely, the following differences are seen: taking the first as the standard, (both females,) the latter has the pronotum slightly shortened, and more wrinkled and rugose, being slightly tuberculate, the posterior femora a little less dilated, and the contour as a general thing more full and rounded; the spots on the elytra are a little larger, though very similar in form and position. When we remember that the former is from a locality of rank vegetation and moist atmosphere, while the latter is from a locality just the opposite, will not this account for the differences in the pronotum? If these stood alone, I might suppose they were different species; but pinned close beside is a specimen (a female) from Southern Illinois, with the base of the wings a clear bright lemon-yellow; the pronotum, though a little more shortened, yet in other respects is much like the specimen from Mississippi, the spots on the elytra enlarged, the small ones apparently absorbed into the larger, the spaces also comparatively large, yet the specimen is smaller than either of the others. The specimens from Washington correspond very closely with the last, (from Illinois,) but are rather smaller, and the pronotum is slightly more rugose on the disk. Now, if we pass to the western plains, we find the *Haldemannii* of Scudder and *corallipes*, Hald., which are absolutely so closely allied that they scarcely constitute different varieties, it being an impossibility to distinguish alcoholic specimens except in extreme cases. These are of larger size than the *rugosa*, the wings yellow at base, and the inside of the posterior femora generally a bright coral-red, the pronotum somewhat more wrinkled and rugose than the Nebraska specimen, (which has, as I should have stated, the posterior femora orange-yellow inside and the tibiæ yellowish, tinged with red;) the spots on the elytra are more broken up. In Utah, we meet with another variety which resembles very closely the *corallipes* except that the wings are pale-red at base and the inside of the posterior femora yellow.

In consideration of all these facts, we are certainly justified in thinking it highly probable that these are but varieties of the same species, the differences being attributable to the differences of climate and food, those in the moister climate, where the vegetation is ranker and where they are less exposed to the sun, being darker and "plumper" than those found on the more arid plains of the West.

Œ. kiowa, Thos.

Female.—The central foveola of the vertex is not exactly quadrilateral, but somewhat hexagonal. Parts of the mouth, pectus, and venter yellowish-white. Face, dirty brown; lateral carinæ distinct, reaching the corners of the face; cheeks, dusky or dark brown; from the upper margin of each eye a pale stripe runs back to the pronotum; the posterior part of the occiput fades, backward, from dusky to yellow; pronotum dusky with paler spots. The angles (or longitudinal corners when folded) of the elytra are marked with a narrow yellow stripe; the upper (posterior) narrow field dusky; rest as described in report of 1871. Posterior tibiæ bright blue, with an indistinct, pale ring below the knee; apex black. Tarsi pale yellow. Wings pellucid with a few fuscous dots near the apex; nerves and nervules of the apical portion dusky; rest pale or white.

Dimensions.—Length, .87 inch; elytra, .86 inch; posterior femora, .52 inch; posterior tibiæ, .46 inch; pronotum, .20 inch.

Taken at Lincoln, Nebraska, August 3.

Œ. tenebrosa, Scudd.

Var. With disk of the pronotum pale, cinereous, *Tomonotus pseudonietanus*, Thos.

Antennæ fuscous, and considerably flattened toward the extremity. The pale portions of the mouth and face are slightly tinged with pale rufous. The disk or basal portion of the wings a very bright brick-red. Posterior femora with three distinct white bands; posterior tibiæ black, with a white ring below the knee.

Taken at Lincoln, Nebraska, August 3.

Œ. verruculata, Kirb.

In the southwestern part of Minnesota, (August 19,) I noticed quite a number of individuals of this species sticking to the weeds along the roadside. Supposing them to be alive, I stopped to collect some, when, to my surprise, I found they were all dead; again and again I repeated the experiment, but with the same result. All these appeared to be females; their colors as bright as though living.

Stenobothrus maculipennis ? Scudd.

Female.—Face dull, rusty yellow; cheeks and sides of the head brown, darkest immediately back of the upper part of the eye, where it forms an ill-defined stripe which runs back to the pronotum. Occiput and disk of the pronotum pale brown.

The black or dark-brown stripe running back from the eye continues along the upper portion of the side of the pronotum, passing over the lateral carinæ upon the disk of the posterior lobe; the lateral carinæ yellowish. The elytra have a pale stripe along the lower (or anterior) field, near the margin; a narrow stripe along the middle field is marked with black or dark fuscous spots, four or five in number; the portion above this and the apical third semi-transparent, distinctly tinged with reddish purple. Wings transparent but tinged, especially the front and apical portions, with reddish purple; the nerves and nervules of the front portion dusky. Posterior femora pale yellow; a narrow dusky stripe along the upper carina (or rib) of the disk; two pale dusky spots on the inside of the upper carina. The posterior tibia has the lower two-thirds of the under surface dusky, the rest pale yellow; spines white at the immediate base, rest black. Antennæ pale rufous.

The pronotum expands but moderately on the posterior lobe, the lateral carinæ curving regularly inward, (though moderately,) the closest approximation being in advance of the middle; posterior margin obtusely rounded; no entering angle on the posterior lateral margin, though it slightly (very slightly) curves inward from the humerus to the lower angle.

The sub-anal plate of the male is slightly elongate, fleshy, entire, and rounded at the tip.

Dimensions.—♀ Length, .75 inch; elytra, .60 inch; posterior femora, .46 inch; posterior tibiæ, .38 inch; pronotum, .13 inch. ♂ Length, .64 inch; elytra, .52 inch; posterior femora, .40 inch; posterior tibiæ, 36 inch.

Abundant in the vicinity of Omaha, Nebraska, August 1. This independent description, taken from living specimens, is given here, that it may be used as a means of comparison with specimens from other localities, as there is so much difficulty in distinguishing some of Mr. Scudder's closely allied species, if in fact they are distinct, which is a matter of some doubt.

Caloptenus occidentalis? Thos.

In the Minnesota portion of Red River Valley, at Glyndon, on the Northern Pacific road, and near Morris, on the Saint Paul and Pacific road, I found a small variety of this genus quite abundant, which, though differing slightly from *occidentalis*, appears to belong to that species.

Foveola of the vertex elongate, rounded in front; frontal costa solid above the ocellus and slightly sulcate below it, with a row of punctures each side. The pronotum has the lateral carinæ tolerably well defined and almost right-angled, especially in the male. Elytra and wings about as long as the abdomen in the female. Posterior femora reach the tip of the abdomen. Antennæ extend to the posterior extremity of the pronotum. Prosternal spine broadly transverse at the base. The cerci of the male are short and tapering, turning up very slightly; the tip of the sub-anal plate is entire, not notched.

Color of the living insect.—The face is sometimes almost milk-white, with a few luteous or purplish dots sprinkled over it; the cheeks are pale, but a black stripe, quite narrow, runs down the sulcus below the eye; the usual black stripe behind the eye, extending upon the pronotum, is present, but is very variable. The lateral and posterior margins of the pronotum are bordered by a broad pale, purplish band; a very narrow white stripe extends down the side of the thorax from the base of the elytra to the insertion of the posterior legs. The elytra are almost uniform in color; sometimes a few dim dots can be seen along the middle field, yet many specimens appear to have them unspotted; the general color is a dark ashy brown, wings transparent, tinged with blue; this bluish cast is very evanescent, almost wholly disappearing from a specimen kept for ten hours, though not immersed in any liquid. The external face of the posterior femora is crossed by three oblique dark and two intermediate white bands; the dark bands cross over to the upper margin of the inner face; inner face and under side yellow. The posterior tibiæ pale greenish blue, generally with a dark ring near the base; spines black. Tarsi dark above, white beneath. Abdomen dark, mottled above; the posterior margins of the segments bluish white; venter yellowish white.

Length about .8 or .9 of an inch. July 5–11.

C. bivittatus, Say.

This species is very variable, both in color and size, yet it is easily recognized in almost any of its numerous variations, and it is only the more particular investigation that causes the entomologist to doubt the identity. I herewith give some notes in regard to the varieties met with the past summer in the Northwest.

Omaha, August 1.—*Female,* living specimen. Stripes on the pronotum very distinct, rather broad, reddish yellow, the intermediate space a velvety black, (or dark fuscous.) The general color of the sides of the insect, a purplish red; the face, and the external face of the posterior femora, the same color; the upper, external carina of the posterior femora, shining black; posterior tibiæ deep blue, fading at the apex to pale rufous; tarsi rufous. Elytra slaty brown, with a few dusky spots near the base on the disk. Wings transparent, but tinged with red; nerves and nervules along the front margin dusky; rest colorless. The posterior femora have two black spots on the upper margin of the internal face; the spines of the posterior tibiæ, black. These specimens were found abundant on a tall weed much like hemp, in company with *C. differentialis* and *Acridium emarginatum.* In some specimens the dark stripe along the posterior femora occupies the upper half of the disk; then there is above this a yellow line, between the upper lateral and dorsal carinæ, and then a dark stripe along the upper margin of the inner face. The general color is sometimes a dark ashy green, which prevails on the head, sides, and beneath. The cerci of the males are broad, extending back a short distance, then bend suddenly upward, leaving a rounded protrusion on the lower edge. Sub-anal plate obtuse and entire at the tip.

In Platte bottoms I noticed quite a number of individuals of this species in the long rank grass, with the general color a bright yellow, while others were ashy green, yet the two varieties were frequently seen pairing. This yellow variety was also seen at Sioux Falls, Dakota, August 25.

C. differentialis, Thos.

The individuals of this species found at Omaha, August 1, in company with the previous species, had the antennæ red; general color of the head and thorax, pale olive; abdomen and pectus, bright yellow.

Dimensions.—♂ Length, 1.2 inches; elytra, 1 inch; posterior fermora, .63 inch; posterior tibiæ, .58 inch; pronotum, .24 to .26 inch.

At North Platte I noticed quite a number of the dark variety of this species, with bright yellow stripes. This variety has the posterior femora marked with black bands, and the general color is quite dark, almost a black. These were found congregated on a large weed growing profusely in the Platte bottoms, and were often seen pairing with other varieties.

Acridium emarginatum, Uhl.

Male.—Taken at Omaha, August 1. Face greenish yellow; a row of distinct black punctures down each margin of the frontal costa, and a row across the upper part of the clypeus. Palpi and antennæ bright yellow. The dorsal stripe on the head and pronotum bright yellow, extending forward over the vertex and down the front nearly to the central ocellus; its extension on the suture of the elytra yellowish white; it is bordered each side by a broad, dark greenish brown stripe, which fades on the sides into reddish brown on the elytra, and paler greenish brown on the pronotum, these latter colors occupying the entire sides. The pronotum has scattered over it golden dotes. Wings transparent, pale greenish yellow at base, the front margin and apical half tinged with pale reddish brown; nerves and nervules corresponding in color with the parts. Abdomen with a dark stripe along the dorsal carina, sides purplish green, each segment having a ring of black dots on the posterior margin. The cerci very broad, somewhat notched at the apex, pale purplish; sub-anal plate with a broad, square notch at the apex. The elytra have no spots whatever on them. Anterior and middle legs greenish externally, striped internally with black. Posterior femora pale dull green or olive externally, with a row of black dots along each margin of the disk; internal face fuliginous or purplish; a row of black dots along the upper margin. Posterior tibiæ, with the posterior and inner face black, exterior face greenish purple, becoming black above; spines white at base, black at tips. Pulvilli remarkably large, oblong-ovate.

Dimensions.—Length, 1.36 inches; elytra, 1.22 inches; pronotum, .32 inch; posterior femora, .75 inch; posterior tibiæ, .73 inch.

This and the two preceding species appear to reside chiefly on high, rank weeds, not being properly ground-locusts; though in this respect *C. bivittatus* varies more than the other two, as it appears to adapt itself to almost any situation.

Opomala bivittata, Serv.

I met with this species at Lincoln, Nebraska, also at Manhattan, in Kansas.

Female.—Head and thorax rufous, except the stripes, which are reddish brown. Elytra semi-transparent, light brown or brownish, slightly tinged with rufous on the upper half, near the base; a short, narrow, white stripe near the base, along the lower (front) margin. Wings pellucid, with a faint greenish-yellow tinge; nerves and nervules mostly dark. Four anterior legs rufous; posterior femora rufous above and on the disk, yellow beneath; posterior tibiæ yellow. Venter and pectus yellowish.

Dimensions.—Length, 1.5 inches; elytra, 1.13 inches; pronotum, .25 inch; posterior femora, .90 inch; posterior tibiæ, 1.1 inches. August 3.

Ommatolampis viridis, Thos.
Syn. *Caloptenus viridis*, Thos.

Lincoln, Nebraska, August 5.—Among the orthoptera met with at this place, I noticed this species quite abundant in the luxuriant green grass. I am now tolerably well satisfied that it belongs to *Ommatolampis* of Burmeister, and have, therefore, placed it in that genus, and herewith give a full description from living specimens, the males and females exhibiting scarcely any differences in size or color.

The vertex, on close examination, appears to be somewhat hexagonal, as in *Acridium*, with a slight central depression; frontal costa sulcate; sides nearly parallel and punctured; lateral carinæ nearly or quite parallel; eyes as heretofore described. Posterior lobe of the pronotum punctured. Pectus covered with minute hairs. Elytra same length as abdomen. Posterior femora reach the tip of the abdomen.

Color.—Bright pea-green throughout, except the following markings: Antennæ rufous except the basal joint, which is green. A small, dusky spot between the eyes, a dark spot beneath the eyes, which is bordered in front by a white stripe. A narrow white stripe runs along the upper margin of each eye, and extends backward along the lateral carina of the pronotum. A median dusky stripe runs along the disk of the pronotum, the central portion pale and sometimes almost white; a black stripe extends along the sides of the anterior lobes of the pronotum, which is bordered by white; the lateral margins have a minute white line along them, sometimes interrupted by black punctures. There is an oblique white line on the side of the mesothorax, running to the base of the middle leg; a similar but larger one on the metathorax, running to the base of the posterior legs. These lines are generally shaded in front with black. Elytra semi-transparent, almost uniform green, there being sometimes a pale ashy-brown shade on the upper (posterior) portion. Wings pellucid; when living, the front margin is slightly tinged with bluish green, and the posterior half with very pale rufous; but these shades are often very dim and evanescent. The posterior femora are green, except a rufous band above the knee; the upper and lower carinæ (or ribs) of the disk have generally a thread-like line of white along them, and the upper is sometimes bordered above with a pale rufous line. Posterior tibiæ green; spines tipped with black; tarsi green; the pulvilli rufous.

The cross incisions of the pronotum were not dark in these specimens, as mentioned in my original description, which was taken chiefly from alcoholic specimens.

Dimensions.—Length, 1 to 1.10 inches; elytra, .76 inch; posterior femora, .63 inch; posterior tibiæ, .58 inch; pronotum, .25 inch.

ODONATA FROM THE YELLOWSTONE.

By Dr. H. Hagen.

LESTES.

L. disjuncta, Selys.
Known before from Brit. America. (A few specimens.)

L. congener, Hag. Syn. N. Amer. Neurop., 67, 5. (A male.)

AGRION.

Two species, but not well enough preserved for description; probably described species.

GOMPHUS.

G. (*Herpetogomphus*) *vipirinus ?* Selys.
The species is described by Baron De Selys Longchamps, from Mexico. The specimen is not so preserved as to be sure of the identity; at least it belongs to no other known species. (One fragment.)

G. colubrinus ? Selys. Hag. Syn. N. Amer. Neurop., 101, 7.
Known from Hudson Bay, Brit. America. One male, in poor condition, if not belonging to this species is new but nearly related.

ÆSCHNA.

A. constricta, Say. Hag. Syn. N. Amer. Neurop., 123, 8.
Common, at least represented by many specimens; a species common everywhere east of the Mississippi from Canada to Maryland, and hitherto west to Wisconsin.

A. eremita, Scudd. Proc. Bost. Nat. Hist. Soc., x, 213.
Taken in abundance at Hermit Lake, White Mountains, N. H., by Mr. Scudder, and also common in Saskatchewan and Fort Resolution, Great Slave Lake; taken by Mr. Kennicott and Mr. Scudder. (One female.)

A. multicolor, Hag. Syn. N. Amer. Neurop., 121, 4.
Known before only from the Pecos River, W. Texas; Cordova, Mexico, and the Upper Missouri; a decidedly western species. (Few specimens.)

A. propinqua, Scudd. Proc. Brit. Nat. Hist. Soc., x, 214.
Fragments of one male and female, not sufficient to identify decidedly; probably this species. Known before from N. England.

LIBELLULA.

L. nodisticta, Hag. Syn. N. Amer. Neurop., 151, 3.
Formerly only known by a young male collected in Mexico by Mr. Saussure. (Male and female.)

L. forensis, Hag. Syn. N. Amer. Neurop., 154, 9.
Formerly only known by a male from California, in the Berlin Museum. (Male and female.)

L. saturata, Uhler. Hag. Syn. N. Amer. Neurop., 152, 4.
Known before from California, Cape San Lucas, and San Diego, and from Mexico, Cordova, Tampico; a decidedly western species. (One fragment.)

L. flavida, Hag. Syn. N. Amer. Neurop., 156, 15.
Known before from Pecos River, W. Texas. (One fragment.)

MESOTHEMIS.

M. simplicicollis, Hag. Syn. N. Amer. Neurop., 170, 1.
Common throughout from Massachusetts and Illinois to Mexico, Florida, and Cuba. (One female.)

M. longipennis, Burm. Hag. Syn. N. Amer. Neurop., 173, 7.
Common everywhere as the foregoing species. (Male and female.)

M. corrupta, Hag. Syn. N. Amer. Neurop., 171, 3.
Known from Illinois, W. Texas, Mexico. (One female.)

M. composita, nov. sp.
Milk-white, with a yellowish tinge on the head, front, mouth parts; three transverse shining black lines behind the eyes; lobe of the prothorax small, rounded, yellowish white; thorax yellowish white, a little bluish; two large not well-defined brown bands on the mesothorax; two oblique black lines on each side, and a third one between them not depassing the stigma; abdomen thickest at the base, black, each segment with an elongated milk-white spot on each side, and another similar one on the second and third segments; venter covered with a whitish powder, the second and third segments with a large elongated milk-white spot; appendices black, short, cylindrical; the tubercle between them white; valvar opening with a rounded excision; feet black, femora white behind; wings hyaline, a small yellow spot at the base; neuration black; the costa milk-white; the pterostigma large, oblong, black; fourteen antecubitales; two postcubitales; three series of areoles after the triangle; membranula white.
Long. corp., 47 mill.; exp. alar, 76 mill.
The species is related to *M. corrupta*. (One female.)

DIPLAX.

D. assimilata, Hag. Syn. N. Amer. Neurop., 174, 1.
Known from the northern and middle parts of the United States. (One fragment.)

D. scotica, Donov. Hag. Syn. N. Amer. Neurop., 179, 9.
Common in Europe, N. Asia, and collected at N. Red River by Mr. Kennicott. (A few specimens.)

D. vicina, Hag. Syn. N. Amer. Neurop., 175, 4.
Common in the north of the United States. (Several specimens.)

D., spec. nov.
Nearly related to *D. rubicundula* Say, but different by the genital parts. (Only two males, imperfect.)

Species not belonging to Odonata.

HETÆRINA.

H. Californica, Hag. Syn. N. Amer. Neurop., 59, 2.

The fragments of three males are not to be separated from the type in my collection. (Some fragments.)

POLYSTŒCHOTES.

P. punctatus, Hag. Syn. N. Amer. Neurop., 206, 1.

Very common everywhere in the whole United States. (Numerous specimens.)

STATHMOPHORUS.

Spec.—Only a male related to *St. Argus*, Harr., perhaps distinct. The male of *St. Argus* is still unknown.

PTERONARCYS.

Pt. Californica, Hag. Syn. N. Amer. Neurop., 16, 5.

A female; a decidedly western species.

MYRMELEON.

M. diversus, nov. sp.

Brown, covered with grayish powder; head pale yellowish near the mouth and the eyes; two black spots on the clypeus; front largely shining black, brown mat behind the antennæ; on each side of the occiput a yellow spot, and near the middle a yellow band, attenuated and interrupted in the middle; antennæ short, black, annulated finely with yellow, the tips enlarged brownish; palpi yellow, the last joint black; last joint of the labial palpi longer, ovoid, black, cylindrical at the truncated tip; prothorax quadrangular, a little narrower and rounded before, dull yellowish, with two interrupted brown lines in the middle, and one on each side, not reaching the anterior part; thorax and abdomen brown, a final yellowish triangular spot on the segments; legs yellowish; femora behind in the middle, tibiæ inside, and basal joint on tip black; spurs as long as the first joint; wings hyaline, veins yellow, spotted with black on the radius, and most of the small furcations; stigma small, whitish. The species belongs to the genus *Myrmeleon*, and is related to the *M. formicarium*. I believe a specimen in very bad condition, from the Pecos River, W. Texas, belongs here. (Two specimens.)

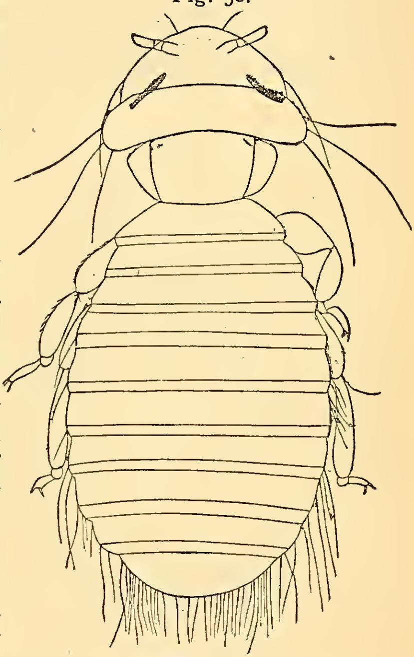
DESCRIPTIONS OF NEW SPECIES OF MALLOPHAGA COLLECTED BY C. H. MERRIAM WHILE IN THE GOVERNMENT GEOLOGICAL SURVEY OF THE ROCKY MOUNTAINS, PROFESSOR F. V. HAYDEN, UNITED STATES GEOLOGIST.

By A. S. Packard, Jr., M. D.

Menopon picicola, n. sp. (Fig. 58.)

Body slightly more than twice as long as broad. Head lunate, being much shorter than wide, well rounded in front, with a lobe on each side. Antennæ short and slender, terminal joint nearly twice as long as penultimate. Head with three long hairs from posterior division, and two oblique dark spots in the middle. Prothorax with a median square area half as wide as head, with two rings on each side, making the entire segment three-fourths as wide as head. Abdomen regularly oval, two-thirds as wide as long, terminal segment large and broad. Segments convex, with a slight ridge crossing behind the middle of each segment. Two or three long hairs project from hind edge of each segment, and numerous finer hairs. Legs moderately long, tibiæ long, a third longer than femora; tarsi with second joint long and slender, ending in two large claws. Pale horn color.

Fig. 58.



MENOPON PICICOLA.

Length, .08 inch. Ten specimens.

From *Picoides arcticus* and *P. dorsalis*, (Nos. 236 and 237.) August 26, 1872, at Lower Geyser Basin, Wyoming Territory. This is more closely allied to *M. citrinellæ*, Denny,* than any other species I am acquainted with, but differs in the shorter, broader head. The form of the prothorax is very different, being transversely oval instead of squarish, as in *M. citrinellæ*.

Goniodes Merriamanus, n. sp. (Fig 59; *a*, male antennæ.)

Head about as broad as long, full, convex, broad, and regularly rounded in front of insertion of antennæ. Deeply excavated in middle, receiving basal two-thirds of basal joint of antennæ; on posterior edge of the notch a prominence, and still posteriorly a large prominence, giving a square appearance to head posteriorly, which at hinder edge suddenly contracts where it is articulated to prothorax. Head about two-thirds as wide as abdomen. Prothorax about half as wide as head. Abdomen ovate or pear-shaped, being broadest just before the end. It

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*Monographia Anoplurorum Britanniæ. London, 1842.

is whitish, corneous on the edges. Antennæ recurved, four-jointed, basal very large, second as long as first is thick, third and fourth slender, subequal; fourth as long as second is thick. Legs stout, second pair with stout spines on inner side of tibiæ; tarsal joints very indistinct, short, with a long curved claw.

Length, .10 inch. One specimen.

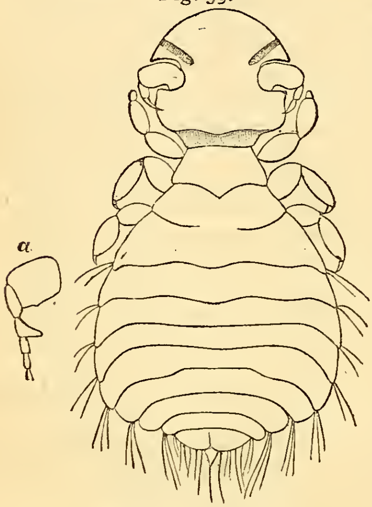
From *Tetrao Richardsoni*, (No. 219.) Collected August 5, 1872, at North Fork of Snake River, Idaho.

It is very different from *G. tetraonis* Denny, and closely allied to *G. Colchici* Denny, especially in the pyriform shape of the abdomen. The head in one species is rather longer and more produced in front of the antennæ, the prothorax is rather longer and broader, and the mesothorax wider and shorter in proportion.

Goniodes mephitidis, n. sp. (Fig. 60.)

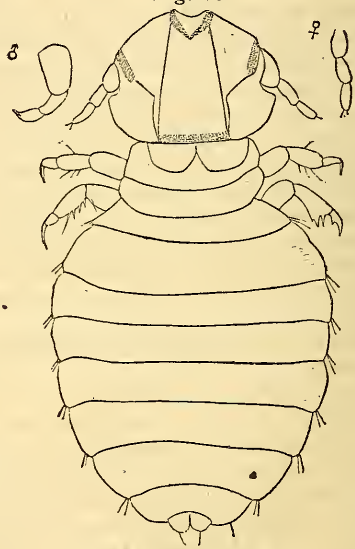
Head short, about as long as broad, well rounded in front, with a narrow curved sinus in the middle; widest behind the middle, with well-

Fig. 59.



GONIODES MERRIAMANUS.

Fig. 60.



GONIODES MEPHITIDIS.

marked lateral projections. Two dark spots on each side of the sinus; side of head in front of the projections lined with black. A transverse black line across hind edge of head, ending on each side in two black points, and sending obscure prolongations anteriorly. Antennæ four-jointed; basal joint very large, three outer ones filiform, third considerably longer than second, fourth minute, short. Prothorax corneous, slightly narrower but distinct from mesothoracic segments, the sides of which are produced hook-like beyond it. Abdomen large, orbicular, but little longer than broad, white. Legs white, hind tibiæ dilated distally, with several long spines on the inner side, one especially large; several long hairs on the outer side. The tarsal joint ends in a curved slender claw as long as itself, seen with the naked eye; head and thorax appear pale testaceous; abdomen white.

Length, .06 inch. Seven specimens.

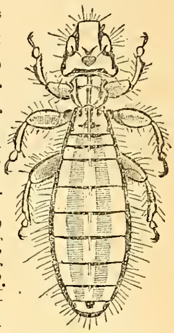
From a skunk (*Mephitis*) collected August 13, 1872, at Fire-Hole Basin, Wyoming Territory.

It differs from any species figured by Denny in the notch in front of head, and short, broad lunate mesothoracic segment, and long oval form of abdomen.

Nirmus buteonivorus, n. sp. (Fig. 61.)

A very large species, long and slender; head long, oblong, subtrapezoidal, half as wide in front as at base; front truncate, with prominent rounded lateral wings on each side of head, behind insertion of antennæ, more prominent than usual. Antennæ just reach as far as the front edge of head; four-jointed; two basal joints of much the same size and length, two outer much smaller, fourth slenderer, and a third longer than third. A large, round inflated swelling on under side, just behind the mouth, and behind the single-jointed minute labial palpi, apparently forming a sucker to draw mouth near to skin of host. Mental region behind flattened, rather narrow. Prothorax small, rounded square, incised on each side; a transverse impressed line crossing the anterior third, and, with the longitudinal line, dividing the surface into four square spaces, the two anterior half as long as two posterior. Abdomen, including meso and metathorax, regularly ovallanceolate, two and a half times as long as wide, with fine long hairs along edge. Legs rather large and long, with tarsi on three hinder pair of legs, basal joints much swollen and enlarged, with a white swollen disk-like undersurface for holding on to skin of host; second joint remarkably long and slender. Edge of head white, and whole body black, front edge of head white, hind edge black, a dark scutellate spot just behind the middle of the head; two round black spots under base of head; two black spots projecting inward at front edge of mesothorax; a brown stripe across hind edge of each abdominal segment, interrupted on anterior four rings by median line of the body. Joints of legs edged with black brown.

Fig. 61.



NIRMUS BUTEONIVORUS.

Specimens vary much in extent and intensity of dark lines and spots, as usual.

Length .40 inch. Twelve specimens.

From *Buteo Swainsonii*, (No. 239.) Collected August 27, 1872, at Lower Geyser Basin, Wyoming Territory.

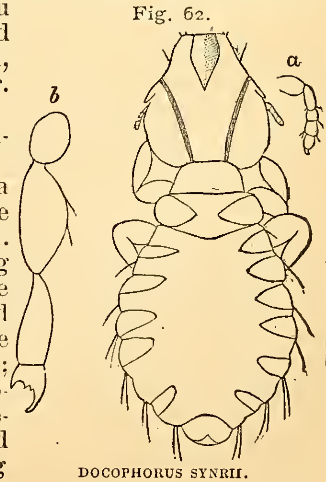
Differs remarkably in form and size from any figured by Denny.

I have in describing this species used, for comparison, a specimen of this genus from Goose Lake, Siskiyou County, Cal., (J. Holleman,) in which the head is triangular, and the tarsal joints not dilated, and second joint is much shorter and thicker. Its host not indicated.

Docophorus syrnii, n. sp. (Fig. 62; *a*, antenna; *b*, hind leg.

Head a little longer than broad, being a little longer than usual; two-thirds as wide as abdomen. Mouth cavity deeply excavated. Trabeculæ small, acutely pointed, projecting slightly beyond the head. Two oblique chitinous bands diverge from base of head to upper side of base of trabeculæ; antennæ slender, of the usual form; five-jointed; fourth joint much shorter than fifth. Prothorax trapezoidal, half as wide as head; mesothorax wide, projecting considerably beyond the succeeding segment; edge more bulging

Fig. 62.



DOCOPHORUS SYRNII.

than others. Abdomen regularly oval, but little broader than long, with the usual triangular pale horny pieces on each side of segments, with a few long hairs, especially toward end of body.

Length, .09 inch. Four specimens.

Lives on *Syrnium nebulosum*, (♂ No. 55, private collection.) Collected November 24, 1872, at Locust Grove, New York, by C. H. Merriam.

Of the species figured by Denny, it approaches nearest in the form and shape of the head to *D. testudinarius*, (Children,) Back's Narrative, &c. It is allied in form to *D. ostralegi* Denny, but the prothorax is shorter; and to *D. icterodes* Nitzsch but the head is much broader. From *D. communis* Nitzsch, it differs considerably, the head being shorter and broader, and the trabeculæ much smaller, judging from Denny's figures.

DESCRIPTION OF NEW PARASITIC WORMS FOUND IN THE BRAIN AND OTHER PARTS OF BIRDS.

BY A. S. PACKARD, JR., M. D.

Among the zoological specimens collected by Mr. C. H. Merriam, in explorations under Professor Hayden in the summer of 1872, were specimens of an apparently undescribed worm found "under the eyes" of a hawk. In describing this worm, we had occasion to compare it with an undescribed species of the same genus of worm in the museum of the Peabody Academy of Science, and found by Mr. Walker in the brain of the night-hawk,

Indeed, one of the most obscure subjects in zoology is the history and development of animal parasites, and especially those which take up their abode in the brain of different animals. Professor Wyman has described, in the "Proceedings of the Boston Society of Natural History" for October 7, 1868,* a species of round worm in the brain of seventeen out of nineteen specimens of the Anhinga, or snake-bird, shot in Florida, thus proving that "their presence in the cranial cavity might be called the normal condition of this bird." He remarks that "parasites have occasionally been found infesting the brain or its membranes in man and animals, but far less frequently than in the other regions of the body. The number of species thus far observed is quite small, and are chiefly referable to the genera *Tænia*, *Filaria*, *Trichina*, and *Diplostomum*, and confined almost wholly to man and domesticated animals, such as the sheep, reindeer, dromedary, horse, and ox; and, among wild animals, to the chamois, roebuck, and a few others. That they have not been more frequently seen in the wild species is, without doubt, due to the fact that the brains of these have been so seldom examined for the purpose of detecting them." These worms, "which correspond very nearly, if not identical, with the *Eustrongylus papillosus*, Diesing," were found in every instance coiled up on the back of the cerebellum, their number varying from two to eight. The male is only half as thick as the female, and the end of its body is always more closely coiled than in the female.

This worm is viviparous, the young hatching in the oviduct. Their earlier stages are unknown, but the analogy of the Gordiaceous and other worms leads to the supposition that the parasite of the brain of the Anhinga is one of the migratory kinds, and that a part of its life, at least, is passed in a locality quite different from that in which it was detected. The manner in which the transfer of the embryo is effected, outwardly to some other animal, or the water, and then back to another Anhinga, is wholly unknown.

Eustrongylus buteonis, n. sp.

This thread-worm seems to agree generically with the species of *Eustronyglus*, said by Professor Wyman to "correspond very nearly, if not identical, with the *Eustronyglus papillosus* Diesing, found in the brain of the Anhinga bird of Florida. Our species is, however, much shorter and thicker.

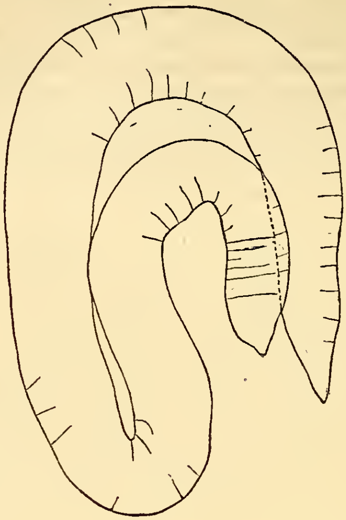
*An abstract, with figures, of this interesting paper may also be found in the "American Naturalist," vol. 2, p. 41, 1869.

Male.—(Fig. 63, *a*, magnified ten times.) Body cylindrical, rather short and thick; head cylindrical, pointed, conical, much slenderer than

Fig. 63a.

EUSTRORGYLUS BUTEONIS.

Fig. 63b.



EUSTRONGYLUS BUTEONIS.

Fig. 64.

EUSTRONGYLUS CHORDEILIS.

the other end. I can perceive no papillæ around the end of the head. End of the body rather more incurved than in the female, bluntly conical; penis forming a single spiculum, a little curved, and inclosed in a bivalved sheath, one valve being truncate and the other pointed, and reaching nearer the end of the penis than the truncate valve.

Length .40 inch. Two individuals.

Female.—(Fig. 63, *b*, magnified ten times.) Over twice as large as the male; the body short and thick; the head subacutely conical, with no papillæ that I can see; end of the body obtuse; extreme tip slightly mucronate.

Length one inch. Two individuals.

Four specimens, taken from "under the eyes of *Buteo Swainsoni*, (No. 269,) collected September 15, 1872, at Snake River, Wyoming Territory," by C. H. Merriam.

Eustrongylus chordeilis, n. sp. (Fig. 64, magnified ten times.)

An outline figure of a worm, generically identical with *E. buteonis*, is introduced in order to bring out more clearly the specific characters of the latter species. Two females were taken by Mr. C. A. Walker "from the brain of the night-hawk, (*Chordeilis Virginianus*,) shot in June, at Campton, New Hampshire, and presented to the museum of the Peabody Academy of Science, at Salem, Massachusetts. It is a much slenderer form than *E. buteonis*, but much shorter and thicker than the species described and figured by Professor Wyman. Both ends of the body are much alike, the anal end being much more pointed than in *E. buteonis*, and the anterior end of the body less tapering.

Length .70 inch.

NOTE.—We would invite the special attention of the members of the survey and other traveling and collecting parties to the preservation in alcohol of the parasites of birds, mammals, snakes, lizards, and frogs. Search for them in the brain, under the skin, and in the intestines, lungs, and liver of all these animals. Also look for various bot-fly larvæ under the skin of the buffalo, deer, elk, squirrels, and all sorts of mammals.

The beaver in Europe is tenanted by a singular flattened parasite, somewhat flea-like, the discovery of which is to be looked for in this country. Moreover, hair-worms (Gordius), and the intestinal worms of the Indians are much desired.

DESCRIPTION OF NEW INSECTS.

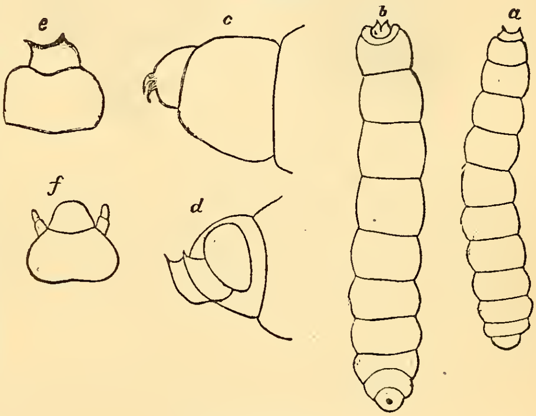
By A. S. Packard, Jr., M. D.

DIPTEROUS LARVA FOUND IN THE GIZZARD OF PICOIDES ARCTICUS.

Fig. 65, *a*, dorsal, *b*, ventral view of larva; *c*, end of body; *d*, side view of end of body; *e*, dorsal view of end of body; *f*, head, greatly magnified.

Body white, cylindrical, a little flattened, with twelve segments exclusive of head, the segments moderately convex. Head very minute, sunken in the small prothoracic segment, (which is much smaller than the second or mesothoracic segment;) subtriangular in form, a little longer than broad; a transverse suture just in front of insertion of antennæ indicates the posterior edge of the clypeus. Antennæ cylindrical, two-jointed, the second joint longer than basal, and rather slenderer, its tip reaching as far as the end of the head.

Fig. 65.



DIPTEROUS LARVA.

Terminal segment of the body much smaller and narrower than the penultimate, bearing two large, stout, upcurved corneous hooks, with adjoining bases; nine stigmata, one on prothorax and one on first eight abdominal segments, round minute, corneous, the ninth round, with a round area on one side.

Length .35 inch; 135 specimens taken "from the gizzard of *Picoides arcticus*, (No. 236,) Lower Geyser Basin, August 26, 1872, by C. H. Merriam." Some of these larvæ were half grown. Most of them were perfectly preserved; a few had been partially digested. With them were associated a part of the body of a *Cerambycid* larva, and a portion of the elytra of a Scolytus-like beetle, so that they must have come from under the bark of some tree.

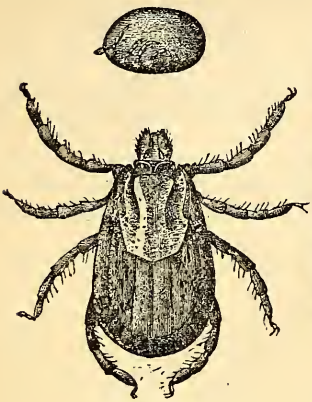
This larva, remarkable for its large size, its minute head, and terminal upcurved hooks, like those of many coleopterous larvæ living under bark, seems to be related to the young of the *Cecidomyiadæ*, or perhaps a closely allied group, from the two-jointed antennæ, the general form of the minute head, and the presence of nine stigmata. Several Cecidomyia larvæ have a pair of anal appendages, though not so marked as in the present form.

ARACHNIDA.

Ixodes bovis Riley. (Packard, in First Report Peabody Academy of Science, 1869, Fig. 66, fully gorged individual, natural size, and another empty, enlarged; Fig. 67, mouth-parts much enlarged.)

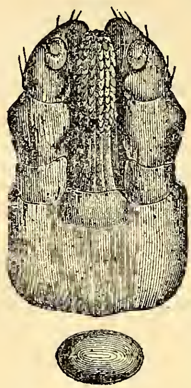
A reddish coriaceous flattened species, with the body oblong oval, contracted just behind the middle; head short and broad, not spined behind, with two deep, round pits; palpi and beak together unusually short; palpi long and slender; labium short and broad, densely spined beneath; above, the mandibles are smooth, with terminal hooks; thoracic shield distinct, one-third longer than wide, smooth and polished, convex, with the lyrate mesial convexity very distinct. The whole body is sparsely covered with minute hairs. Legs long and slender, pale testaceous red; coxæ not spined.

Fig. 66.



IXODES BOVIS.

Fig. 67.



IXODES, MOUTH-PARTS.

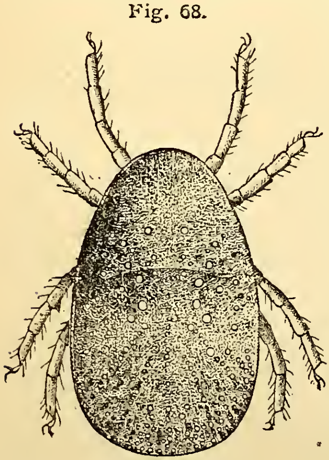
Length of body, .15 of an inch; width, .09 of an inch.

This species, which occurs in great abundance at times on cattle in the West, and Texas and Central America, was also detected by Mr. Merriam on a porcupine, (*Erethizon epixanthus*,) August 10, 1872, at Henry's Lake, Idaho Territory; and on *Lepus Bairdii*, (No. 47,) collected September 15, 1872, at Snake River, Wyoming Territory.

Argas Americana, n. sp. (Fig. 68.)

Though our specimens are from Texas, (Belfrage,) yet this interesting genus, which has not been known before to inhabit America, is associated with *Ixodes bovis*, having been received in a lot of *Ixodes* taken from cattle.

Fig. 68.



ARGAS AMERICANA.

Body very flat and thin, oval, with the head and mouth-parts concealed by the overreaching dorsal portion of the body, which is bent upward around the margin, though the edge is not revolute. Body above covered with very numerous little round pits, large in the middle and becoming smaller on the edge. There are two large, conspicuous oval pits on middle of the anterior third of body; just in front of the middle a transverse curved row of six smaller pits, three on each side. Behind are six prominent pits, three on each side. On posterior third of the body are rows of these punctures radiating outward. The edge of the body is roughly granulated. Margin of body beneath pitted as above. Smooth between the legs and on the head. Palpi long and slender when stretched out, not reaching the edge of body. Legs large and stout, hind pair just reaching edge of body. Claws long and curved, as usual.

Length, .26 inch; breadth, .15 inch.

It is nearly allied in form to *Argas Persicus*, (see Plate 33, Fig. 6, D., Insectes Aptères, Walkenaer et Gervais,) but differs in the edge of body being more finely granulated, and in the pits posteriorly being arranged in radiating lines. The Persian Argas is extremely troublesome to travelers in the East, and the American species is noticed here as it was found among a number of *Ixodes bovis* taken by Mr. G. W. Belfrage from cattle in Texas.

INSECTS INHABITING GREAT SALT LAKE AND OTHER SALINE OR ALKALINE LAKES IN THE WEST.

By A. S. Packard, Jr., M. D.

The subject of brine-inhabiting insects is one of very considerable interest, both in a physiological and zoö-geographical point of view, as well as from its bearings on questions relating to the earlier geological history of the American continent.

Professor A. E. Verrill has found the larvæ of *Chironomus oceanicus*, Pack., living at the enormous depth of 120 feet in the sea at Eastport, Maine. We have also found the same insect between tide-marks, in Maine and Massachusetts, and have, in company with Professors Moebius and Kupffer, dredged a very similar species at the depth of three or four fathoms, in the bay of Kiel, on the shores of the Baltic Sea. Thus an air-breathing insect, whose congeners live in fresh-water pools, is capable of living at considerable depth in the sea

Now, exceedingly few insects which pass their life in fresh water are found living in the sea; on the other hand, we know of many more marine genera of shrimps, &c., (crustacea,) which live in fresh water; such are species of Palæmon and allies, and Gammarus; several species of the former genus are found living in bodies of fresh water, both in the Southern States and in Italy. All the fresh-water forms of life have probably come from salt-water ancestors, as, in the early geological ages there were no large bodies of fresh-water; and as in the present day, both in the great lakes of America (Lakes Superior and Michigan) and the deep lakes of Sweden, which were formerly arms of the sea, we find marine crustacea in the water, at the bottom, while the surface-water contains fresh-water forms.

As extremely interesting in this connection, I will translate, from an able memoir of Professor F. Plateau,* some conclusions from his extended studies of the action of the sea on fresh-water insects and crustacea, and of fresh water on marine crustacea.

ARTICULATES LIVING IN FRESH WATER.

1. Sea-water has but a very feeble influence, or none, on aquatic Coleoptera (beetles) or Hemiptera, (bugs,) in the perfect state; this influence is perhaps a little greater for the larvæ.

2. Sea-water injures such fresh-water articulates as have a thin skin, or branchiæ, and these effects are, in general, the more marked as the extent of the thin skin is greater.

3. The fresh-water articulates which can live with impunity in sea-water, are those in which there is no absorption of salt water by the skin; those which die in a comparatively short time, have absorbed chloride of sodium and magnesium.

4. The injurious salts contained in sea water, are the chlorides of sodium and of magnesium; the influence of sulphates may be regarded as nothing.

5. The difference in density which exists between fresh and salt water does not explain the death of fresh-water articulates in salt water.

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* Recherches Physico-Chemiques sur les Articulés Aquatiques. Bruxelles, 1870.

6. When fresh-water articulates pass by a very slow transition from fresh into salt water, and when, during this transition, reproduction has taken place, the new generation resists much longer the action of salt-water than the ordinary individuals of the species.

MARINE CRUSTACEA.

7. The most common crustacea of our shores die in fresh water, after a time, varying with each species, but not passing beyond nine hours.

8. Marine crustacea plunged in fresh water lose the salts (especially the chloride of sodium) with which their tissues are impregnated.

9. In the greater number of cases the presence of chloride of sodium is a part of the indispensable conditions of the existence of marine crustacea. This salt seems to be the sole necessity.

10. Small individuals, and those which, having just moulted, have the teguments thin, resist less than the others the influence of liquids of exceptionable composition.

11. The difference between the densities of sea and fresh water cannot be considered as the cause of the death of marine crustacea in fresh water.

12. (Applicable to the two groups.) The principle of endosmose explains the absorption of salt by the thin tegument or branchial surfaces of fresh-water articulates placed in sea-water; the diffusion of gases and dialysis, operating with more energy for the chlorides of sodium and magnesium than for the sulphate of magnesium, showing in virtue of which cause that the chlorides alone of sea-water are absorbed. Finally, dialysis explains how marine crustacea, when placed in fresh water, lose in this liquid the salts with which they were impregnated.

So much has been said about the absence of life in the Great Salt Lake, that an erroneous impression may prevail as to the life of that, and similar though smaller lakes. With a view of imparting what knowledge we now have as to this subject, in order to earnestly call the attention of those who live near the shores of Great Salt Lake, and travelers and collectors to this subject, I will give a brief account of what is known regarding articulate life in these saline waters.

In 1852 Mr. T. R. Peale prepared for Stansbury's "Report on the Valley of the Great Salt Lake of Utah," p. 379, an account of the insect-life of the lake. He states that in a mass of exuviæ of insects brought from the shores of the Great Salt Lake, there was an abundance of the larvæ and exuviæ of the pupæ of Chironomus, and fragments of other tipulidæ.

Afterward Mr. S. A. Briggs, of Chicago, noticed and figured in "Science Gossip," (London,) a creature whose zoological position he did not know. It was the larva of a species of Ephydra.

This pupæ-case was afterward described by me under the name *Ephydra gracilis*.* The specimens were collected by Mr. Sereno Watson. Other specimens of the larvæ, as well as pupæ and adult flies, were collected by Mr. S. A. Garman, and also by Mr. J. A. Allen, and are in the Museum of Comparative Zoology at Cambridge, and will be described hereafter. The Ephydra sometimes occurs in large quantities.

I have also received from Mr. Garman two specimens of *Corixa* taken by him from the lake.

Undoubtedly other insects will be found in Salt Lake, and we trust some one of the readers of this article will make a careful examination

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*American Journal of Science and Arts, Febuary, 1871.

of the shores of the lake, and carefully preserve and forward to the office of the survey every trace of life he may find.

In proof of this supposition, I may state that the late lamented Professor Torrey, in 1870, made an exceedingly interesting collection of insects in the brine of Clear Lake, California. This collection comprised two aquatic beetles, (*Laccophilus decipiens*, Lec., and *Berosus punctatissimus*,) and the early stages of three flies, *i. e.*, a species of *Tanypus*, *Stratiomys*, and *Ephydra Californica* Pack.

This last species lives in the "excessively salt, but also strongly alkaline" Lake Mono, in California. The late Mr. Horace Mann, jr., remarked that the Indians about Mono Lake eat the pupæ-cases of Ephydra in large quantities.

Two hemipterous insects also inhabit Clear Lake, *i. e.*, a Gerris-like form, *Hydrotrechus robustus* Uhler, and *Corixa decolor* Uhler.

The genus Ephydra is also an inhabitant of salt-vats and of the shores of the ocean. The larvæ live on decaying organic matter.

We now come to that strange crustacean or shrimp-like creature, the *Artemia*, an animal found in different parts of the world in salt-vats, saline pools and lakes. The family to which it belongs is, *par excellence*, a fresh-water group, and though the respiratory surface of the false gills presents an enormous extent, and one judging by the principles advanced by Plateau, as quoted above, (section 2,) would think this to be the last animal to be readily adapted to a saline life, yet it flourishes in immense numbers in the densest and strongest brine.

The brine crustacean of Salt Lake was first described by Professor A. E. Verrill, in the American Journal of Science and Arts, November, 1869, under the name of *Artemia fertilis*. It was collected at Salt Lake by Messrs. Sereno Watson, D. C. Eaton, and S. A. Briggs. The former alludes to its occurrence in vast numbers.

Mr. S. W. Garman, who has specially observed this creature while alive in the lake, writes the following notice of its habits to the American Naturalist for December, 1872. "A peculiarity of the little crustacean (*Artemia fertiliso*, Verrill) living in the waters of Salt Lake, which ought to be noticed, is that of its congregating in masses of strange appearance in the water. When the masses are small they sometimes stretch out so as to have the form of a serpent. All other times they represent rings, globes, and various irregular figures. A gentle breeze does not affect the water filled by Artemiæ, so that while the water on all sides of these dense congregations is slightly ruffled, that which they occupy remains as if covered by oil, thus indicating the figure of the mass. My attention was called to them by seeing on the surface the figure of a great serpent in one place and in another what appeared to be a small stream of comparatively still water flowing out through the lake. Though I waded out to and through these immense bodies, I could not positively ascertain that the individuals were traveling in a common direction; the time was too short to determine this, yet I think it is the fact."

It is apparent that a study of the habits of this animal is much to be desired, and collections of the eggs, young, and both sexes *in large quantities* and preserved in *strong alcohol*, are greatly needed for the further elucidation of its mode of life and structure.

We have shown that the animal life of the great Salt Lake is, we had almost said, abundant, and the idea of Professor Baird, if carried out, of stocking this lake with fish, is not an impracticable one so far as natural food for such fish is concerned.

OTHER FRESH-WATER CRUSTACEA ALLIED TO ARTEMIA.

There are certain other remarkable crustacea found living in pools which are apt to dry up late in the summer, which are allied to the Artemia, and are locally abundant in the far West. This notice is inserted to call the attention of travellers and collectors, as well as members of the survey, to them.

First, the shelled crustacea, or *Limnadia* and *Estheria*. These are singular crustacea, which are protected by a valve-like expansion of the back, so that the body is inclosed by two shells, and the creature bears a most remarkable likeness to the bivalves of pools and streams, (*Cyclas.*) In Texas a species of *Limnadi* (*L. Texana* Pack.) is quite common, according to Mr. Belfrage, in Western Texas in the early spring. It occurs in muddy pools made after rains, and wholly disappears with the first drying of the pools. "As far as I have seen, they are only found in the woody bottom-lands and always near creeks." It may also be looked for in Colorado, Kansas, and Montana, and probably Arizona.

With these bivalved crustacea occur usually in great numbers, when found at all, Artemia-like animals, the Branchipus, specimens of which are most desirable to compare with the brine crustacean. But the most interesting of all these phyllopod crustaceans is the *Apus*, an animal found abundantly at times in pools in Kansas, and Texas, and Mexico, and the plains of the Rocky Mountains. In collecting the Apus, large numbers of the young and old are desired, preserved in strong alcohol, and the exact date and locality should be inserted in the bottle, written on a piece of firm paper, in pencil or ink.

These animals are about an inch long; a round shield, bearing simple and compound eyes, protects the front part of the body, while the hinder portion is long and narrow, consisting of many segments, bearing beneath leaf-like gills. The body ends in two long feelers, much like those arising from the head. They have been found by Von Siebold to be parthenogenous, *i. e.*, the females produce young from eggs without union with the other sex.

North America is richer than any other quarter of the globe in species, though it is a remarkable fact that none are known to exist east of the Mississippi River.

BOTANY.

BY JOHN M. COULTER.

WASHINGTON, D. C., *April* 15, 1873.

SIR: I have the honor of presenting to you my report upon the botanical specimens collected this last summer.

I have separated the botany of the region I traversed into three divisions, sufficiently distinct, in my opinion, to form as many separate floras, and have given their different conditions of soil and climate.

I have included in my notes upon the mountain-flora a short table of timber-lines, showing the variation in the height of the timber-line, depending on the latitude and the presence of elevated plateaus or large bodies of water. The latitude is given with each peak, but the other conditions are so well known it was thought unnecessary to include them.

I have also added three tables comparing the flora of the western slope of the Rocky Mountains, between latitudes 43° and 46°, with that of the eastern slope. The tables were compiled from the collections of 1871 and of this last season, and are necessarily imperfect, though they will serve to give some idea of the distribution of phenogamous vegetation on both slopes of the dividing-ridge.

Of grasses, about sixty species were obtained; of mosses, fifty-three species; of lichens, sixty-six species, including varieties, of which one is probably new to science, and two new to the continent. Among the few Fungi collected, two new species have been described by Charles H. Peck, esq. There probably will be in the whole collection nearly 1,200 species of plants.

I wish here to express my thanks for the many favors I have received from botanists. To Professor Thomas C. Porter were intrusted all the doubtful specimens and new species of Phenogamia, and I am under the greatest obligation to him for his prompt attention and ready response, as well as for the great interest he has always shown in my work. He very kindly consented to make a re-examination of my whole collection of Phenogamia, except the *Coniferæ*, and to correct the mistakes of inexperience.

Through the kindness of Dr. George Vasey, I have had access to all the collections at the Agricultural Department, which proved of infinite service. I would thank him also for the interest he took in my work, and for the valuable assistance he repeatedly rendered me.

Thanks are due also to Henry Willey, esq., Charles H. Peck, Leo Lesquereux, S. T. Olney, George Thurber, and others for the determination of those species to which they have devoted special attention.

The study of western flora is an immense field open now to all lovers of botany, and many rich harvests are waiting to be reaped by the industrious collector. Hoping that under your auspices in the future, as in the past, much information may be added to our comparatively meager knowledge of western botany,

I am, very respectfully, your obedient servant,

JOHN M. COULTER.

Dr. F. V. HAYDEN,
United States Geologist.

The plants catalogued in the present volume were all collected during the season of 1872. I was attached to the party under command of Captain Stevenson, and remained with it through the whole summer, Up to the Fire Hole Basin, Philo J. Beveridge acted as my assistant. and proved himself an active, earnest worker. Most of the collection was pressed by him, and the care he always took has made handsome specimens.

In the party under the immediate direction of Dr. Hayden, Mr. Walter Platt took charge of the botanical collections, and rendered good service in the region he traversed. Although the plants common to the mountain ranges and valleys along the Yellowstone are not essentially different from those found along Snake River, yet it is interesting to note the fact of their existence on both the eastern and western water-sheds. A slight difference can be traced, but by no means sufficiently great to justify making two distinct floras, one of the eastern, the other of the western slope.

Collections were commenced in the last of May at Ogden, Utah, where our permanent camp was located until the last of June. During this time a fine opportunity was afforded for studying the local flora of the plain bordering on Great Salt Lake, as well as that part of the Wahsatch range of mountains, near which Ogden is situated. The flora of this great basin has been so thoroughly examined and described by Sereno Watson in his final report that very little can be said in addition. Several trips were made to the shores of Great Salt Lake, and collections were obtained of the flora of that peculiar region. During our stay of a month over three hundred species were collected, representing fully the June vegetation of that locality. Representatives were obtained from four different conditions of soil and temperature, viz, the borders of Salt Lake and its neighboring alkaline marshes; the common sandy sage-brush plain, somewhat enriched here by the irrigation universally practiced in Utah; the alluvial deposits along Ogden and Weber Rivers; and the mountains of the Wahsatch Range. On the latter very few alpine plants were discovered, for a sub-alpine flora clothes almost entirely the highest peaks,

From Ogden collections were made in the latter part of June along the stage-route to Fort Hall; in July from Fort Hall to the Téton Basin and western slopes of the Téton Range; in August, up Henry's Fork to Henry's Lake, across the "Tyghee" Pass and into the Fire-Hole Basins. After this date the flowering season had about passed, and only a few species not before collected were noticed. Collections were made in September and the first of October down the South Fork of Snake River, principally of plants in an advanced state of fruitage. On October 11 we closed our collections at Fort Hall, having been about five months in the field.

I would divide the plants collected into three separate and distinct floras, viz:

I. The flora of the plains from Ogden, Utah, to the Téton Basin.

II. The flora of the Téton Range and Mountains along the Yellowstone.

III. The flora of the Geyser Basins.

Although a few flowers are common to all these divisions, as can be seen in the following catalogue, yet the main features are very distinct.

I. The Flora of the plains is exactly what has been so often seen and described on all the vast "sage-brush" deserts of the West. It is peculiar to this dry, sandy region, yet much more luxuriant than one would imagine from the nature of the soil. At the same time it becomes extremely monotonous, as a few species exhaust the number, and you can observe but an endless display of individuals. As justly remarked by C. C. Parry, in his "Botany of the Mexican Boundary," "the peculiarities of the scenery of a country depend upon its vegetable productions." Thus one who has ever traveled across these sand deserts will not fail to picture them in his memory, connected with the universally prevalent gray or dull olive color of the herbage. Hence, owing to the immense number of individuals represented by only a few species, the scenery of the country has an unpleasant sameness. The extensive plains exhibit a monotonous succession of the same forms, and the botanist, knowing exactly what to expect, loses the zeal he would possess in a more varied region. Occasionally, where a stream has made a richer soil, there is a change from desert to valley flora, and the more brilliant hues of the vegetation, from the delicately tinted petals to the rich green leaves, is a wonderful rest to the eyes and awakens new zeal.

On all these plains an entire absence of trees is noted, except a few of stunted growth along the larger streams; while the mountain-ranges are sparingly timbered with *Coniferæ* from base to summit, intermixed along some of the foot-hills with "bitter cottonwood." Upon the plains around Ogden a variation in the flora is noted as we near Great Salt Lake. The higher types seem unable to exist in the strongly alkaline soil, and give place to the *Chenopodiaceæ*. This family is well represented here, as is common along all bodies of salt water, not so much by the number of species as by the immense display of individuals. Small *Polygonums* and *Euphorbias* also mat the ground in places, but are by no means so abundant as the Chenopods, chiefly represented by the genus *Obione*. Wherever the soil is largely charged with alkali the "grease-wood" (*Sarcobatus vermiculatus*) is very abundant. In almost the same situations were always found the *Halostachys occidentalis*, *Salicornia herbacea*, and *Eurotia lanata*, as well as numerous other chenopodiaceous plants.

Farther back, toward the mountains, the higher types appear again, and with a greater richness of color than seems possible in such soil. Of course the Artemesias are common everywhere, and especially *A. tridentata*, completely covering the plains and far up the mountain slopes. Among the shrubby Artemisias can be seen the beautiful *Calochortus Nuttallii*, the "Sego" of the Mormons, numerous *Phloxes* and *Gilias*, brilliant-flowered *Cacti*, several species of *Eriogonum*, chiefly *E. ovalifolium*, *E. heracleoides*, and *E. umbellatum*, several species of *Œnothera*, *Astragalus*, *Phacelia*, and many others equally important that might be mentioned. Along the water-courses may be seen two bright *Mimuli*, *M. Lewisii* and *M. luteus*, several labiate plants, two species of rose, *R. fraxinifolia* and *R. blanda*, many *Ranunculaceæ*, the two brilliant *Capparidaceæ*, *Cleome aurea* and *Cleome integrifolia*, several *Onagraceæ*, &c.

All of these orders are far surpassed by the *Compositæ*, both in the great variety of species and the immense display of individuals. Sereno Watson estimates that they comprise one-seventh of western collections, and he by no means overestimates them.

II. The flora of the mountain-ranges. The plants collected from the Wahsatch Mountains, near Ogden, are, for the most part, sub-alpine, and almost identical with those collected at equal altitudes on the Téton Range, and seem to be identical with those common to every range in the Northwest. But the Tétons rise so much higher, and are exposed constantly to such severe cold from snow and winds, that, above 10,000 feet, I gathered a flora such as I saw nowhere else on the trip. Apparently delicate plants were seen blooming through the snow, and vegetation, though limited in species, seems abundant until within three hundred feet of the summit of Mount Hayden, where all plant-life ceases, except a few lichens clinging to a bare rock, which is swept continually by fierce winds. A fine field was presented here for the collection of truly alpine plants, and no opportunity was lost for obtaining anything peculiar to this great elevation, unusually exposed, as it is, to tempests. All the alpine plants are noted in the catalogue, and the elevations given at which they were collected. The Téton Range is heavily timbered with *Coniferæ*, chiefly *Pinus ponderosa*, to an altitude of 11,000 feet, this being the average timber-line of the whole range. The maximum growth is at an altitude between 8,000 and 10,000 feet. A marked difference is observed, however, between the western and eastern slopes, the latter being much more densely timbered than the former, and the trees much larger and less twisted and gnarled. This seems to result from the fact that on the eastern side the Tétons rise almost sheer out of the plains, presenting an enormous perpendicular wall, behind which the trees of the eastern slope are completely sheltered; while, on the west, the peaks are rounded down into the plains by the foot-hills, and this whole, broad, sloping side is exposed to every blast from the north and west.

One noticeable feature in the tree-life on the mountains is the abruptness with which it terminates at the average height of 11,000 feet. Tall, straight *Coniferæ* are seen growing to the very edge of this line, and one step takes us from a forest to a bleak, open waste, where not a tree can live, except a few stunted and twisted forms that have been bent out of all shape by the superincumbent mass of snow that rests upon them during the winter. These stunted forms, sometimes even with their tops matted close to the ground, are always found growing behind some wall of rock or steep bank, where the winter snows accumulate in immense drifts and completely cover and protect them during the blighting winters of that high altitude. According to Parry "the so-called timber-line marks the extreme point of *minimum* winter temperature, below which no exposed phænogamous vegetation can exist." All life above this limit is buried by the deep winter snows, and thus protected; hence in this truly alpine region many plants are found that are common at much lower altitudes. The flowering season is necessarily short, and we were fortunate in being upon the Tétons in the very midst of it, during the last part of July.

I have said that all phænogamous life ceases within 300 feet of the summit of Mount Hayden, which is about 13,800 feet above the level of the sea. This is owing to the great sharpness of the peak not allowing the snow to rest upon it, but to accumulate in great banks upon its lower slopes. Hence there is no protection for plants during the long winters above this bank, and we pass suddenly from a bright, varied alpine vegetation to bleak, lichen-covered rocks, just as, 2,000 feet below, we passed suddenly from forest growth to a low, matted vegetation. It is noticeable that the timber-line becomes lower as we advance farther north in almost a fixed proportion to the latitude. The altitude of this line was accurately measured by Mr. Henry Gannett upon every mountain he ascended, and I insert below a table containing the altitude of this line upon several peaks, together with their approximate latitudes. We were unfortunate in obtaining no accurate measurement upon the Tétons, and hence the altitude of the timber-line upon this isolated range is but approximate.

The timber-lines in Colorado are mostly from Parry's measurements.

I include also a few peaks on other continents, for the sake of comparison, the latitudes of which are approximate, as their positions are well known. The table is arranged according to the latitudes, commencing at the northernmost point and running south.

Name.	Latitude.		Elevation.
	°	′	
Timber-line on Bridger's Peak, Montana	45	47	9,002
Timber-line on Mount Delano, Montana	45	32	8,784
Timber-line on Ward's Peak, Montana	45	30	9,156
Timber-line on Mount Blackmore, Montana	45	26	9,550
Timber-line on second cañon of Madison River, Montana	45	00	9,754
Timber-line on Electric Peak, Wyoming	44	58	9,442
Timber-line on mount near Henry's Lake, Idaho	44	55	9,368
Timber-line on Mount Washburn, Wyoming	44	48	9,900
Timber-line on Mount Washington, New Hampshire	44	00	5,000 to 5,200
Timber-line on Cascade Range, Oregon	44	av.	7,000
Timber-line on Mount Hayden, Téton Range	43	44	11,000
Timber-line on Wind River Mountains	43	00	10,160
Timber-line on Mount Shasta, California	41	15	8,000
Timber-line on Gilbert's Peak, in the Uintas	40	50	11,100
Timber-line on Long's Peak, Colorado	40	20	10,800
Timber-line on Audubon's Peak, Colorado	40	00	11,325
Timber-line on Mount Engelmann, Colorado			11,518
Timber-line on Berthoud's Pass, Colorado	39	50	11,816
Timber-line on Gray's Peak, Colorado	39	45	11,643
Timber-line on Pike's Peak, Colorado	38	53	12,040
Timber-line in Colorado in general			11,600 to 12,000
Timber-line on San Francisco Mount, Arizona	35	30	11,547
FOREIGN PEAKS.			
Timber-line on Alps	47 to 44	00	6,500
Timber-line on Ætna	37	48	6,600
Timber-line on Himalayas	28 to 30	00	11,800
Timber-line on Teneriffe	27	45	7,300
Timber-line on Andes, in South America			11,000 to 12,000
Timber-line on Andes, in Mexico			12,800

It will be seen that there is a very regular increase in the elevation of the timber-line as the latitude decreases, subject of course to variations when in the neighborhood of high table-lands or seas. As we approach the sea the timber-line rapidly sinks, until it is rarely over 7,000 feet in elevation, while, upon the mountain-peaks that rise above elevated plateaus, it reaches an elevation of nearly 13,000 feet.

This immense extent of high land of course raises the temperature, and, by allowing the height of the timber-line to depend upon the *mean annual temperature* of the place, the difference between the height of the line near table-lands and seas is accounted for.

The Wahsatch Range, near Ogden, is almost entirely destitute of trees, their place being supplied by tangled shrubs. Occasionally a small, stunted pine is met with, and the common juniper, (*J. occidentalis.*) The most common shrub is the *Ceanothus velutinus*, forming patches so tangled as to be almost impassable to the climber. The *Cercocarpus ledifolius*, or "mountain mahogany," was also noted in considerable abundance to the height of 7,500 feet.

III. The flora of the Fire-Hole Basin is distinct, from the fact that it is a region so covered with hot springs and geysers, giving in the geyserite, scattered everywhere, an unnatural soil, and creating an artificial warmth. The geyserite is a bleak, barren waste, supporting only plants peculiar to itself, and seeming to kill everything of a different nature. A great number of the hot springs have made deposits until they have almost closed themselves up. On top of this a soil has collected, the spring underneath keeps it warm, and the luxuriant growth of a regular hot-bed is the result. The plants that grow in such situations are not all of them different in species from those that grow in the valleys near by, but they spring up much ranker and attain two or three times their usual size. To some plants of common species the soil gives such a discolored appearance as to make them at first scarcely recognizable. For instance, take the Gentians that are represented here so profusely. *G. detonsa*, *G. affinis*, and *G. Amarella* were repeatedly met with disguised by perfectly *black* stems and veins, leaves unusually dark, and petals with the black appearance common to dried specimens. This was the case only in the immediate neighborhood of the hot springs. Elsewhere they retained their original coloring, though growing much ranker than I ever saw them.

The plants growing on the geyserite are chiefly of the composite family, represented by the genera *Solidago*, *Senecio*, *Chænactis*, *Linosyris*, *Antennaria*, and *Achillea*. In some of the hot springs in both Upper and Lower Geyser Basins an *Alga* was discovered growing, but it came East in such a condition that its species could not be determined. Also in the Lower Basin were found some orange-colored confervoid specimens, concerning which Charles H. Peck, esq., to whom they were sent, remarks, "I believe they have been described under the name *Conferva aurantiaca*, but it is now generally regarded as the primary state of some plant of higher order, moss or fern."

In all this western region the botanist notices the absence of one great group of plants. The Ferns are almost unrepresented here, owing to the great dryness of the climate. Being fond of dark, damp places, they are seldom found in this elevated region, where the air is dry and pure. Occasionally, in some dark and unusually damp cañon, a few stunted forms were found, and then in no great abundance. Two localities only were noted where Ferns were found in any size and abundance: once in the new Geyser Basin, discovered on Shoshone Lake, being there the hot-bed growth before mentioned; and next under the shadow of the Tétons, on the eastern slope, where a mountain-stream had made a rich deposit, and no sunlight could come on account of the immense growth of *Coniferæ*. But seven genera were found, including ten species, viz, one *Pteris*, two *Pellæas*, one *Cryptogramme*, two *Aspidiums*, one *Cystopteris*, one *Botrychium*, and two *Woodsias*. Of these the *Cystopteris fragilis* was by far the most abundant. *Botrychium lunarioides*, var. *obliquum*, was found only in the Geyser Basin.

Mosses were very abundant, both along the cold streams of dark cañons and also upon the bare rocks of the mountain tops. A considerable collection was made, numbering fifty-two species. Some were easily determined by comparing with dried and labeled specimens, but the doubtful ones were sent to Leo Lesquereux, esq., Columbus, Ohio, who has done them full justice. It will be noticed that some were unable to be determined on account of having no fruit, especially specimens of the genus *Bryum*. The order used in cataloguing them is that of the "*Musci Boreali-Americani*" of Sullivant and Lesquereux.

Lichens were common on the volcanic rock of the Téton Range. Some of the peaks seemed perfectly covered with them, hardly a square inch being seen that did not bear some brilliantly-colored specimen. They seemed to grow in greater abundance and more brilliancy of color on basaltic rock than on granite. Specimens were obtained mostly late in the season, and rather a large collection was secured. They were sent to Henry Willey, esq., New Bedford, Massachusetts, and he deserves great credit for the prompt and accurate manner in which he worked them up. The number of species collected, including their several varieties, is sixty-seven, all of which are mounted and labeled.

Fungi occurred in considerable abundance, but as no conveniences for preserving them were provided, but a small collection could be made. They were sent to Charles H. Peck, Albany, New York, who has done more than could be expected with the very indifferent material sent to him. The fleshy fungi are hard subjects to deal with in the field, and several expedients were resorted to for preserving them. An attempt was made to preserve them by pressing sections, but it was found impossible to keep them from gluing themselves to the paper suitable for pressing flowers, and thus ruining specimens. The very few that I did succeed in bringing home in this manner could not be determined. The list of fungi therefore is rather small, although containing two new species. This is a group that has never been thoroughly examined in the West, and I have no doubt that a close scientific investigation would disclose hundreds of species new to science. A wide and an interesting field is here laid open to the mycologist.

For the convenience of those interested in comparing the flora of the eastern and western slopes, I add here three tables compiled from the collections made in 1871 and 1872. Having but the work of two seasons as material, the tables are, to a certain extent, necessarily imperfect, and future collections will make many corrections, but they will serve to show the general distinctions. None of the plants peculiar to the Great Salt Lake Basin are included. No attempt was made to include the Cryptogamia, as they are not sufficiently known. It will be remembered that collections were made on the Rocky Mountain slopes between latitude 43° and 46°.

PHÆNOGAMIA FOUND ON BOTH SLOPES.

Clematis verticillaris.
 Douglasii.
 ligusticifolia.
Anemone multifida.
Thalictrum Fendleri.
Ranunculus aquatilis,
 var. trichophyllus.
 var. stagnalis.
 Cymbalaria.
 repens.
 nivalis,
 var. Eschscholtzii.
 Flammula,
 var. reptans.
Caltha leptosepala.
Trollius laxus.
Aquilegia cœrulea.
 flavescens.
Delphinium Menziesii.
 elatum,
 var. (?) occidentale.
Aconitum nasutum.
Actæa spicata.
Berberis Aquifolium.

Nuphar advena.
Arabis Drummondii,
 var. alpina.
Cardamine paucisecta.
Erysimum asperum.
 cheiranthoides.
Sisymbrium canescens.
 junceum.
Smelowskia calycina.
Stanleya viridiflora.
Physaria didymocarpa.
Draba alpina.
 nemorosa,
 var. lutea.
Viola Nuttallii.
Silene acaulis.
 Menziesii.
Lychnis Drummondii.
Stellaria longipes.
Arenaria lateriflora.
 congesta.
 arctica.
Claytonia Caroliniana,
 var. lanceolata.

Claytonia Chamissonis.
Talinum pygmæum.
Sphæralcea acerifolia.
Linum perenne.
Geranium Richardsonii.
    Fremontii.
Lupinus polyphyllus.
    cæspitosus.
    leucophyllus.
    laxiflorus.
    ornatus.
Trifolium longipes.
    Haydeni.
Glycyrrhiza lepidota.
Hedysarum boreale.
Astragalus hypoglottis.
    campestris.
Oxytropis Lamberti.
Thermopsis fabacea.
Spiræa betulæfolia.
Geum triflorum.
    strictum.
Ivesia Gordoni.
Potentilla fruticosa.
    millegrana.
    Anserina.
    diversifolia.
    glandulosa.
    Norvegica.
Rubus Nutkanus.
    strigosus.
Amelanchier Canadensis,
    var. alnifolia.
Ribes bracteosum.
    viscosissimum.
    lacustre.
Saxifraga nivalis.
    bronchialis.
    oppositifolia.
    hieracifolia.
    punctata.
    Jamesii.
Tellima parviflora.
Mitella pentandra.
Heuchera parvifolia.
Parnassia fimbriata.
Epilobium paniculatum.
    tetragonum.
Gayophytum diffusum.
    racemosum.
Œnothera triloba.
    heterantha.
    biennis.
Mentzelia lævicaulis.
Bupleurum ranunculoides.
Carum Gairdneri.
Osmorrhiza nuda.
Sium angustifolium.
Myrrhis occidentalis.
Cymopterus fœniculaceus.
Heracleum lanatus.
Cornus pubescens.
Symphoricarpus montanus.
    occidentalis.
Lonicera involucrata.
Galium boreale.
    Aparine.
    trifidum.
Valeriana edulis.
Machæranthera canescens.
Aster integrifolius.
    glacialis.
    adscendens.
    salsuginosus.
    multiflorus.
    elegans.
    Haydeni.
Erigeron Bellidiastrum.
    glabellum.
    corymbosum.
    macranthum.
Townsendia scapigera.
Solidago gigantea.
    Virga-aurea,
    var. multiradiata.
Linosyris viscidiflora.
Aplopappus acaulis.
Grindelia squarrosa.
Chrysopsis villosa.
Iva axillaris.
Helianthus lenticularis.
Helianthella uniflora.
Heliomeris multiflora.
Chænactis Douglasii.
Bahia leucophylla.
Actinella grandiflora.
Amida hirsuta.
Achillea Millefolium.
Artemisia Ludoviciana.
    discolor.
    tridentata.
    dracunculoides.
Gnaphalium luteo-album,
    var. Sprengelii.
Antennaria alpina.
    margaritacea.
    Carpathica,
    var. pulcherrima.
    dioica.
    racemosa.
Senecio Andinus.
    lugens.
    aureus.
    triangularis.
    hydrophilus.
Arnica cordifolia.
    Chamissonis.
Arnica augustifolia.
Tetradymia canescens.
Cirsium foliolosum.
    Drummondii.
Stephanomeria exigua.
Hieracium Scouleri.
Crepis occidentalis.
    acuminata.
Macrorrhyncus troximoides.
    glaucus.
Mulgedium pulchellum.
Porterella carnulosa.
Campanula rotundifolia,
    var. linifolia.
Arctostaphylos Uva-Ursi.
Ledum glandulosum.
Bryanthus empetriformis.
Pyrola chlorantha.
    rotundifolia,
    var. incarnata.
    secunda.
Moneses uniflora.
Chimaphila umbellata.

Pterospora Andromedea.
Monotropa Hypopitys.
Dodecatheon Meadia.
Androsace septentrionalis.
Lysimachia ciliata.
Aphyllon fasciculatum.
Collinsia parviflora.
Pentstemon confertus,
var. cœruleo-purpureus.
deustus.
Mimulus Lewisii.
luteus.
Veronica alpina.
serpyllifolia.
Americana.
Castilleia pallida.
Pedicularis Grœnlandica.
racemosa.
bracteosa.
Orthocarpus luteus.
Eunanus Fremontii.
Verbena bracteosa.
Mentha Canadensis,
var. glabrata.
Dracocephalum parviflorum.
Brunella vulgaris.
Stachys palustris.
Mertensia Sibirica.
alpina.
Echinospermum deflexum,
var. floribundum.
Eritrichium villosum,
var. aretioides.
leiocarpum.
crassisepalum.
Phacelia circinata.
sericea.
Phlox longifolia.
Collomia linearis.
Gilia congesta,
var. crebrifolia.
pungens,
var. squarrosa.
Polemonium confertum.
cœruleum.
Frasera speciosa.
Gentiana affinis.
detonsa.
Apocynum cannabinum.
Chenopodium album.
hybridum.
Blitum capitatum.
Monolepis chenopodiodes.
Obione canescens.
Amarantus albus.
Eriogonum ovalifolium.
umbellatum.
heracleoides.
microthecum.
Oxyria digyna.
Rumex salicifolius.
Polygonum amphibium,
var. terrestre.
tenue.
Bistorta,
var. oblongifolium.
Shepherdia Canadensis.
Comandra pallida.
Arceuthobium Americanum.
Euphorbia serpyllifolia.
Betula occidentalis.
glandulosa.
Alnus incana.
Salix arctica.
longifolia.
cordata.
Populus tremuloides.
balsamifera,
var. angustifolia.
Pinus flexilis.
contorta,
var. latifolia.
Abies Douglasii.
Engelmanni.
Juniperus occidentalis.
Lemna trisulca.
Sparganium simplex.
Potamogeton perfoliatus,
var. lanceolatus.
Habenaria hyperborea.
dilatata.
Spiranthes Romanzoffiana.
Iris tenax.
Sisyrinchium Bermudiana.
Zygadenus Nuttallii.
glaucus.
Streptopus amplexifolius.
Smilacina racemosa.
stellata.
Calochortus Nuttallii.
eurycarpus.
Lloydia serotina.
Milla grandiflora.
Allium brevistylum.
stellatum.

PHÆNOGAMIA FOUND ONLY ON THE EASTERN SLOPE.

Ranunculus Nelsonii.
Nasturtium obtusum.
Cardamine hirsuta.
Arabis hirsuta.
Drummondii.
perfoliata.
Thelypodium integrifolium.
Vesicaria alpina.
Draba glacialis.
nemorosa.
Lepidium intermedium.
Viola Canadensis.
canina,
var. sylvestris.
Cleome integrifolia.
Silene Douglasii.
antirrhina.
Arenaria Fendleri.
Stellaria crassifolia.
borealis.
Cerastium arvense.
vulgatum,
var. Behringianum.
nutans.
Sagina Linnæi.
Paronychia sessiliflora.
Spraguea umbellata.
Claytonia linearis.
Lewisia rediviva.
Malvastrum Munroanum.

Malvastrum coccineum.
Geranium Carolinianum.
Rhus aromatica,
var. trilobata.
Acer glabrum.
Astragalus diphysus.
Canadensis,
var. Mortoni.
Kentrophyta.
alpinus.
tegetarius.
caryocarpus.
oroboides,
var. Americanus.
frigidus.
bisulcatus.
pauciflorus.
Oxytropis multiceps.
Lathyrus palustris.
Spiræa cæspitosa.
Cercocarpus ledifolius.
Sibbaldia procumbens.
Chamærhodos erecta.
Potentilla pulcherrima.
Pennsylvanica,
var. strigosa.
fissa.
Nuttallii.
Cratægus sanguinea.
Ribes hirtellum.
oxycanthoides.
prostratum.
cereum.
Saxifraga cæspitosa.
Heuchera cylindrica.
Parnassia parviflora.
palustris.
Sedum stenopetalum.
rhodanthum.
Epilobium augustifolium.
suffruticosum.
alpinum.
Œnothera albicaulis.
marginata,
var. purpurea.
Gaura coccinea.
Mentzelia ornatus.
Cymopterus alpinus.
Thaspium trifoliatum.
Cornus Canadensis.
Linnæa borealis.
Galium triflorum.
Liatris punctata.
Aster Engelmanni.
falcatus.
Townsendia grandiflora.
spathulata.
Erigeron acre.
compositum.
cæspitosum.
canescens.
Diplopappus alpinus.
Solidago nemoralis.
Linosyris Howardii.
Aplopappus lanceolatus.
inuloides.
cæspitosus.
Rudbeckia laciniata.
Helianthus Nuttallii.
Helianthus petiolaris.
Hymenopappus tenuifolius.
Helenium autumnale.
Artemisia trifida.
cana.
vulgaris.
biennis.
frigida.
Richardsoniana.
Arnica longifolia.
Senecio canus.
Fremontii.
Cirsium undulatum.
discolor.
Echinais carlinoides,
var. nutans.
Calais nutans.
Hieracium albiflorum.
Lygodesmia spinosa.
juncea.
Crepis runcinata.
Andersonii.
Taraxacum Dens-leonis.
Gaillardia aristata.
Mulgeduim leucophæum.
Vaccinium Myrtillus.
Kalmia glauca,
var. microphylla.
Plantago eriopoda.
Primula farinosa.
Androsace filiformis.
Phelipæa Ludoviciana.
Pentstemon glaucus,
var. stenosepalus.
Menziesii.
cristatus.
attenuatus.
Limosella aquatica.
Synthyris pinnatifida.
Castilleia affinis,
var. minor.
Veronica scutellata.
Verbena hastata.
Lycopus Virginicus.
Monarda fistulosa.
Lophanthus urticæfolius.
Eritrichium glomeratum.
Echinospermum Redowski,
var. occidentale.
Myosotis sylvatica,
var. alpestris.
Hydrophyllum capitatum.
Phacelia Menziesii.
Franklinii.
Nemophila parviflora.
Phlox Douglasii,
var. diffusa.
Gilia pusilla.
liniflora.
Polemonium cœruleum,
var. foliosissimum.
Gentiana Amarella,
var. stricta.
Apocynum androsæmifolium..
Acerates decumbens.
Oxybaphus augustifolius.
Abronia fragrans.
Blitum polymorphum.
Suæda depressa.

Salicornia herbacea.
Eriogonum ovalifolium,
var. tenuis.
Polygonum viviparum.
Euphorbia glyptosperma.
dictyosperma.
Euphorbia montana.
Urtica gracilis.
Alnus viridis.
Pinus monophylla.
Abies Menziesii.
Juniperus communis.
Lemna minor.
Potamogeton rufescens.
pectinatus.
Triglochin maritimum.
Xerophyllum tenax.
Prosartes trachycarpa.
Fritillaria pudica.
atropurpurea.
Erythronium grandiflorum.
Allium Schœnoprasum.
bisceptrum.

PHÆNOGAMIA FOUND ONLY ON THE WESTERN SLOPE.

Clematis ligusticifolia,
var. breviflora.
alpina,
var. Ochotensis.
Ranunculus affinis.
adoneus.
Delphinium scopulorum.
Pæonia Brownii.
Dicentra uniflora.
Nasturtium curvisiliqua.
palustre,
var. hispidum.
Cardamine oligosperma.
Arabis retrofracta.
Vesicaria arctica.
Draba stellata.
aurea.
Lepidium montanum.
Barbarea vulgaris.
Viola cucullata.
Cleome aurea.
Arenaria verna.
pungens.
Hypericum Scouleri.
Lupinus pusillus.
parviflorus.
Trifolium Kingii.
Hedysarum Mackenzii.
Astragalus pictus.
Geyeri.
Oxytropis nana.
Spiræa dumosa.
betulæfolia,
var. rosea.
Millefolium.
Geum macrophyllum.
Potentilla arguta.
diversifolia,
var. multisecta.
Fragaria vesca.
Virginiana.
Rosa blanda.
fraxinifolia.
Purshia tridentata.
Dryas octopetala.
Tellima tenella.
Mitella trifida.
Sedum Rhodiola.
Œnothera marginata.
scapoidea.
Andina.
Gaura parviflora.
Lythrum alatum.
Angelica Breweri.
Sium lineare.
Cicuta maculata.
Conioselinum Canadense.
Lonicera Utahensis.
Valeriana dioica,
var. sylvatica.
Eupatorium purpureum.
Aster pulchellus.
Sayi.
Townsendia strigosa.
Erigeron filifolium.
grandiflorum.
Solidago Guiradonis,
var. spectabilis.
elongata.
Linosyris Howardii,
var. Nevadensis.
Aplopappus suffruticosus.
uniflorus.
Balsamorrhiza Hookeri.
sagittata.
Rudbeckia occidentalis.
Helianthella multicaulis.
Layia glandulosa.
Gnaphalium microcephalum.
Antennaria Carpathica.
Arnica latifolia.
Senecio Fendleri.
subnudus.
Stephanomeria paniculata.
Malacothrix sonchoides.
Crepis nana.
Vaccinium ovalifolium.
Myrtilloides.
uliginosum.
Pyrola aphylla.
picta.
Kalmia glauca.
Plantago Patagonica,
var. gnaphalioides.
Glaux maritima.
Aphyllon uniflorum.
Phelipæa erianthera.
Utricularia vulgaris.
Pentstemon acuminatus.
glaucus.
glaber.
confertus.
cyananthus.
Menziesii,
var. Lewisii.
Mimulus moschatus.
floribundus.
luteus,
var. alpinus.

Veronica Anagallis.
peregrina.
Synthyris alpina.
Castilleia flava.
parviflora.
Pedicularis Sudetica.
Orthocarpus Tolmiei.
Cordylanthus ramosus.
Scutellaria galericulata.
Physostegia parviflora.
Mertensia brevistyla.
Lithospermum pilosum.
Eritrichium augustifolium.
Californicum.
Coldenia Nuttallii.
Piptocalyx circumscissus.
Hydrophyllum capitatum,
var. alpinum.
Phacelia Ivesiana.
Nama demissa.
Phlox canescens.
cæspitosa.
Collomia linearis,
var. subulata.
Gilia aggregata.
intertexta.
leptomeria.
floccosa.
pusilla,
var. Californica.
Nicotiana attenuata.
Gentiana simplex.
Amarella.
calycosa.
Asclepias speciosa.
Chenopodium album,
var. leptophyllum.
Obione argentea.
Eurotia lanata.
Grayia polygaloides.
Eriogonum Kingii.
cernuum,
var. tenue.
flavum.
cæspitosum.
Rumex maritimus.
paucifolius.
venosus.
Polygonum Bistorta,
var. linearifolium.
Ceratophyllum demersum.
Urtica dioica,
var. occidentalis.
Parietaria Pennsylvanica.
Salix reticulata.
arctica,
var. Brownii.
glauca.
Salix cordata,
var. angustata.
amygdaloides.
Pinus ponderosa.
Abies grandis.
amabilis.
Juniperus Virginiana.
Typha latifolia.
Sagittaria variabilis.
Habenaria fœtida.
Goodyera Menziesii.
Corallorhiza multiflora.
Veratrum album.
Camassia esculenta.
Alluim acuminatum.
cernuum.

RANUNCULACEÆ.

Clematis ligusticifolia, Nutt.—Port Neuf Cañon, Idaho Territory, July.

Clematis ligusticifolia, Nutt., var. *breviflora*, T. & G.—Blackfoot River, Idaho Territory, July; near Brigham City, Utah Territory, June.

Clematis verticillaris, D. C., (*C. Columbiana*, T. & G., *Atragene Americana*, Sims.)—Téton Mountains, elevation 11,000 feet, July.

Clematis Douglasii, Hook., (*C. Wyethii*, Nutt.)—Téton Mountains, elevation 10,000 feet, July; Snake River Valley; Fort Ellis, Montana Territory.

Clematis alpina, Mill., var. *Ochotensis*, Gray.—Téton Mountains, elevation 10,000 feet, July.

Anemone multifida, D. C.—Mountains near Clark's Fork, Wyoming Territory, elevation 9,000 feet, August; Snake River Valley, July; Fort Ellis, Montana Territory. At this last locality both red and white flowers were collected.

Anemone multifida, D. C., var.? "Dwarf, 6–8′; divisions of the leaves lance-ovate, becoming glabrous; petals 5 to 6, deep red; heads of carpels globose; carpels woolly below, smooth above; style recurved." Professor Porter.—Téton Range at 10,000 feet altitude, July 24.

Thalictrum Fendleri, Engelm.—Red Mountain, elevation 9,600 feet, September; Téton Range, elevation 10,000 feet, July; Fort Ellis, Montana Territory; Henry's Fork of Snake River.

Myosurus aristatus, Benth., (Lond. Jour. Bot., 6, 458.)—Black Buttes, June.

Ranunculus aquatilis, L. var. *trichophyllus*, Chaix.—Near Ogden, Utah Territory, June; Heart Lake, September; Snake River Valley, August.

Ranunculus aquatilis, L., var. *stagnalis*, D. C.—Divide between Marsh and Malade Valleys, June.

Ranunculus Flammula, L., var. *reptans*, Gray.—Henry's Fork of Snake River, August; Téton Basin, July; Trail Creek Mountains, September.

Ranunculus Cymbalaria, Pursh.—Near Ogden, Utah Territory, May; Fort Ellis, Montana Territory, July; Henry's Lake, Idaho Territory, August.

Ranunculus affinis, R. Br.—Téton Mountains, elevation 10,000 feet, July.

Ranunculus nivàlis, R. Br., var. *Eschscholtzii*, S. Watson.—Upper Téton Cañon, July.

Ranunculus repens, L.—Near Ogden, Utah Territory, June; Henry's Fork of Snake River, August; Téton River, July.

Ranunculus macranthus, Scheele, (*R. repens*, var. *macranthus*, Gray.)—Ogden Cañon, Utah Territory, June.

Ranunculus adoneus, Gray, (En. Hall and Harbour's Plants, p. 56.)—Henry's Lake, Idaho Territory, August.

Ranunculus Nelsonii, Gray, (Proc. Am. Acad., May, 1872, p. 351.)—Yellowstone Lake, 1871.

Caltha leptosepala, D. C.—Téton Mountains, elevation 11,500 feet, July.

Trollius laxus, Salisb.—Téton Mountains, elevation 12,000 feet, July; Trail River Mountains, September.

Aquilegia cœrulea, James.—Téton Mountains, elevation 8 to 10,000 feet. Flowers were noted of four distinct colors with all their intermediate shades, viz, white, blue, pink, and buff; July.

Aquilegia flavescens, S. Watson, (Clarence King's Rep., vol. v, p. 10.)—Ogden Cañon, Utah Territory, June; Yellowstone Lake, August; Trail River Mountains, September; mountains near Henry's Lake.

Delphinium elatum, L., var. (?) *occidentale*, S. Watson.—Téton Foot-hills, July.

Delphinium Menziesii, D. C.—Near Ogden, Utah Territory, May; Téton Mountains, elevation 10,000 feet, July.

Delphinium scopulorum, Gray, (Plantæ Wrightianæ, 2, p. 9.)—Téton Foot-hills, August 3.

Aconitum nasutum, Fisch.—Yellowstone Lake, August; Upper Geyser Basin, September; Téton Cañon, July.

Actæa spicata, L., var. *arguta*, Torr.—Upper Téton Cañon, July.

Pæonia Brownii, Dougl.—Snake River Valley, July. Every specimen found had but two carpels instead of 3–5. The seeds are eaten by the Boisé Indians as beans.

BERBERIDACEÆ.

Berberis Aquifolium, Pursh.—Plains and foot-hills near Ogden, Utah Territory, June; Lower Fire-Hole Basin, August, in fruit.

NYMPHACEÆ.

Nuphar advena, Ait.—Henry's Fork of Snake River, July; Lower Falls of the Yellowstone, August 4.

PAPAVERACEÆ.

Argemone Mexicana, L., var. *hispida*, Torr.—Near Brigham City, Utah Territory, June 25.

FUMARIACEÆ.

Dicentra uniflora, Kellogg ined., (by Professor Thomas C. Porter.) Dwarf, 3–5′; scape 1-flowered, furnished with one or two linear bracts; flowers 6–7″ long, apparently purple; sepals oblong, obtuse, 3–4″ long, deep purple; outer petals contracted in the middle, the lower half with short rounded spurs, the upper hooded part oblong and widely recurved, spreading; inner petals abruptly expanded above the claw into sharp triangular wings, not crested. Summit of a mountain near Ogden, Utah Territory, and in the Téton Range at 10,000 feet altitude. Mr. Coulter says, "It grows on the mountain tops where the snow has just melted, or even rarely in the snow itself. No leaves or any trace of them were found, although the plant was collected both in June and August. I had described this plant as a new species, and named it *D. nivalis*, when I learned from Dr. Gray that it had been discovered in the Sierra Nevada, as early as 1870, by Mr. Kellogg, who was about publishing it as *D. uniflora*.

CRUCIFERÆ.

Nasturtium officinale, Br.—Weber River, Utah Territory, June. Doubtless introduced.

Nasturtium curvisiliqua, Nutt. MSS.—Henry's Lake, Idaho Territory, August.

Nasturtium obtusum, Nutt.—Growing in the spray of the lower falls of the Yellowstone, August.

Nasturtium palustre, D. C., var. *hispidum*, Gray.—Great Salt Lake, June.

Barbarea vulgaris, R. Br.—Snake River Valley, August.

Arabis Drummondii, Gray.—Near Ogden, Utah Territory, June.

Arabis Drummondii, Gray, var. *alpina*, S. Watson.—Mountains near Henry's Lake, Idaho Territory, August.

Arabis retrofracta, Graham.—Near Ogden, Utah Territory, June; Téton Basin, July 21; Shoshone Lake, September; Red Mountain, elevation 10,000 feet; a very dwarf form.

Streptanthus cordatus, Nutt.—Near Ogden, Utah Territory, June.

Cardamine hirsuta, L.—Yellowstone Lake, August.

Cardamine paucisecta, Benth.—Téton Cañon, July.

Cardamine oligosperma, Nutt.—Téton Mountains, elevation 10,000 feet, July.

Vesicaria arctica, Richards.—Téton Mountains, elevation 10,000 feet, July.

Physaria didymocarpa, Gray.—Téton Mountains, elevation 12,000 feet, July.

Draba aurea, Vahl.—Téton Mountains, elevation 12,000 feet, July.

Draba alpina, L.—Mountains near Henry's Lake, Idaho Territory, August.

Draba alpina, L., var., S. Watson, (near *D. glacialis*, var. γ, Hook.)—Téton Mountains, elevation 12,000 feet, July.

Draba glacialis, Adams, (*D. alpina*, var. (?) S. Watson.)—Mountains near Ogden, Utah Territory, elevation 9,500 feet, June.

Draba stellata, Jacq., (Watson in Clarence King's Rep., vol. v, p. 21.)—Téton Mountains, elevation 11,000 feet, July.

Sisymbrium junceum, Bieb.—A form (?)—Snake River Valley, July.

Sisymbrium canescens, Nutt.—Weber River, Utah Territory, June; very variable. "Ah-tsàh of the Pah-Utes." Watson.

Smelowskia calycina, E. Meyer.—Téton Mountains, elevation 12,000 feet, July; mountains along Clark's Fork, Wyoming Territory, elevation 9,000 feet.

Erysimum cheiranthoides, L.—Snake River Valley, July.

Erysimum asperum, D. C.—Near Ogden, Utah Territory, May; Téton Mountains, elevation 10,000 feet, July.

Stanleya viridiflora, Nutt.—Port Neuf Cañon, Idaho Territory, July; Snake River Valley.

Thelypodium Nuttallii, S. Watson, (*Streptanthus sagittatus*, Nutt.)—Near Ogden, Utah Territory, June; divide between Marsh and Malade Valleys; Yellowstone Lake, August.

Brassica Sinapistrum, Boissier.—Fort Hall, Idaho, July. Doubtless introduced.

Lepidium sativum, L.—Flowers rose-colored. Weber River, Utah Territory, June. Probably introduced.

Lepidium montanum, Nutt.—Malade Valley, Utah Territory, June; Snake River Valley, July. Very abundant. A dwarf form was found near Fort Hall, Idaho.

Thlaspi cochleariforme, D. C., (*T. alpestre*, L., Watson in Clarence King's Rep., vol. v, p. 31.)—Mountains near Ogden, Utah Territory, elevation 9,000 feet, June.

Raphanus sativus, L.—Plains near Ogden, Utah Territory, June. Just beginning to run wild.

VIOLACEÆ.

Viola canina, L., var. *sylvestris*, Regel.—Upper Geyser Basin, September.

Viola Canadensis, L.—Union Pass, Gallatin River, September.

Viola Nuttallii, Pursh.—Little Cottonwood Cañon, Utah Territory, June; Clark's Fork, Wyoming Territory, elevation 9,000 feet; Trail Creek Mountains, September; Téton Range, elevation 10,000 feet, July.

Viola Nuttallii, Pursh. var. *venosa*, S. Watson. (Clarence King's Rep., vol. v, p. 35.)—Mountains near Ogden, Utah Territory, June.

CAPPARIDACEÆ.

Cleome integrifolia, T. & G.—Great Salt Lake, June.

Cleome aurea, Nutt.—Ogden Cañon, Utah Territory, June; Snake River Valley, July. Very abundant.

CARYOPHYLLACEÆ.

Saponaria vaccaria, L., (*Vaccaria vulgaris*, Host.)—Near Ogden, Utah Territory, June; Fort Ellis, Montana, July.

Silene acaulis, L.—Téton Mountains, elevation 12,000 feet, July 29.

Silene Douglasii, Hook.—Yellowstone Lake, August.

Silene Douglasii, Hook, var. (?) (S. Watson, in Clarence King's Rep., vol. v, p. 36.)—Fort Ellis, Montana Territory.

Silene Menziesii, Hook.—Wooded cañon of Téton River, July.

Lychnis Drummondii, S. Watson, (*Silene Drummondii*, Hook.)—Upper Cañon of the Madison, August; Yellowstone Lake; Heart Lake, September; Snake River Valley, July.

Cerastium nutans, Raf.—Gallatin Cañon, Montana Territory, September.

Cerastium vulgatum, L. var. *Behringianum*, Gray.—Mountains near Clark's Fork, Wyoming Territory; elevation 9,000 feet, August.

Cerastium arvense, L.—Lower Fire-Hole Basin, August.

Cerastium arvense, L. var.—Yellowstone Lake, August.

Stellaria longipes, Goldie.—Ogden Cañon, Utah Territory, June; Henry's Fork of Snake River, July.

Arenaria congesta, Nutt.—Shoshone Lake, September; Téton Basin, July; Snake River Valley, August.

Arenaria pungens, Nutt.—Téton Mountains; elevation 11,000 feet, July.

Arenaria verna, L.—Trail Creek Mountains, September; Téton Mountains, elevation 12,000 feet.

Arenaria arctica, Stev.—Red Mountain; elevation 10,000 feet, September.

Arenaria lateriflora, L.—Trail River Mountains, September; Téton Mountains, elevation 11,500 feet, July; Snake River Valley, August.

Sagina Linnæi, Prest.—Lower Fire-Hole Basin, August.

PORTULACACEÆ.

Talinum pygmæum, Gray.—Tower Falls, August; Red Mountain; elevation 10,000 feet, September.

Claytonia Caroliniana, Michx., var. *lanceolata*, S. Watson. (*C. lanceolata*, Pursh.)—Mountains near Ogden, Utah Territory, June; Upper Téton Cañon, elevation 10,000 feet, July.

Claytonia linearis, Hook.—Mountains along Clark's Fork, elevation 9,000 feet, August.

Claytonia perfoliata, Don.—Mountains near Ogden, Utah Territory, elevation 10,000 feet, June. A quantity of good specimens were collected, but were unaccountably lost.

Claytonia Chamissonis, Esch. and Ledeb.—Henry's Lake, Idaho Territory, August; Yellowstone Lake; Spray flower of the lower falls of the Yellowstone, August; Snake River Valley, July; Little Cottonwood Cañon, Utah Territory, June 21.

Spraguea umbellata, Torr.—Tower Falls, August 2; Upper Geyser Basin near hot springs.

Lewisia rediviva, Ph.—Fort Ellis, Montana.

HYPERICACEÆ.

Hypericum Scouleri, Hook.—Swamp near Ogden, Utah Territory, June 18; Snake River Valley, July.

MALVACEÆ.

Sidalcea malvæflora, Gray. (*Sidia*, D. C.)—Ogden Cañon, Utah Territory, June 15; Malade Valley, Utah.

Malvastrum coccineum, Gray.—Near Ogden, Utah Territory, May 31.

Malvastrum Munroanum, Gray.—Divide between Marsh and Malade Valleys, June 29.

Sphæralcea acerifolia, Nutt.—Ogden Cañon, Utah Territory, June; Téton Basin, July; Jackson's Lake, September.

Malva rotundifolia, L.—Near Ogden, Utah Territory, June; doubtless introduced.

LINACEÆ.

Linum perenne, L.—Ogden Cañon, Utah Territory, June; Téton Mountains, elevation 10,000 feet, July; Trail Creek Mountains, September; near Jackson's Lake, in fruit.

Linum Kingii, Watson, var. *sedoides*, Porter.—Uintah Mountains, Wyoming Territory, August; *Dr. Joseph Leidy*.

GERANIACEÆ.

Geranium Richardsonii, Fisch. & Mey.—Near Ogden, Utah Territory, May; North Fork of Snake River, July.

Geranium Carolinianum, L.—Near Ogden, Utah Territory, June.

Geranium Fremontii, Torr. var.—Two forms, probably varieties of *G. Fremontii*, were found near Henry's Lake, Idaho.

CELASTRINEÆ.

Pachystima myrsinites, Raf. (*Oreophila myrtifolia*, Nutt.)—Near Ogden, Utah Territory, June.

RHAMNACEÆ.

Ceanothus velutinus, Dougl.—Mountains near Ogden, Utah Territory, June.

SAPINDACEÆ.

Acer glabrum, Torr. (*A. tripartitum*, Nutt.)—Near Ogden, Utah Territory, June; mountains along Clark's Fork, Wyoming Territory, elevation 8,000 feet.

ANACARDIACEÆ.

The following two species were noted, but as specimens have been brought in before, and they are unpleasant subjects to handle, they were not collected.

Rhus toxicodendron, L.—Near Ogden, Utah Territory, June.

Rhus glabra, L.—Near Ogden, Utah Territory, June; Fort Hall, Idaho Territory, July.

LEGUMINOSÆ.

Lupinus pusillus, Pursh.—Blackfoot River, Idaho, July 13.

Lupinus parviflorus, Nutt.—Divide between Marsh and Malade Valleys, June; Téton Basin, July.

Lupinus sericeus, Pursh.—Ogden Cañon, Utah Territory, June.

Lupinus cæspitosus, Nutt.—Henry's Fork of Snake River, July.

Lupinus ornatus, Dougl.—Téton Basin, July; Henry's Fork of Snake River, August.

Lupinus polyphyllus, Lindl.—Upper Téton Cañon, July 28; near Brigham City, Utah, June.

Lupinus leucophyllus, Lindl.—Port Neuf Cañon, Idaho, July; Téton Basin, August.

Lupinus laxiflorus, Dougl.—Trail Creek Mountains, September.

Medicago sativa, L.—Near Ogden, Utah, June; Fort Hall, Idaho. Doubtless escaped.

Trifolium longipes, Nutt.—Plains near Ogden, Utah, June; Téton Basin, July.

Trifolium Parryi, Gray.—Brigham Cañon, Utah, June. "Ripe legume stiped, stipe elongated, equaling in length the erect teeth of the calyx." Professor Porter.

Trifolium variegatum, Nutt.—Near Ogden, Utah, June; Little Cottonwood Cañon, Utah, June.

Trifolium Haydeni, Porter. (Hayden's report for 1871.)—Mountains near Henry's Lake, Idaho, August.

Psoralea lanceolata, Pursh.—Plains near Ogden, Utah, June.

Astragalus Canadensis, L.—Port Neuf Cañon, Idaho, July.

Astragalus Canadensis, L. var. *Mortoni*, S. Watson.—Port Neuf Cañon, Idaho, July.

Astragalus hypoglottis, L.—Snake River Valley, July; near Fort Ellis, Montana, July.

Astragalus Utahensis, T. and G. (Gray's Rev. l. c., 213.)—Ogden, Utah July.

Astragalus Geyeri, Gray.—Blackfoot River, Idaho, July.

Astragalus tegetarius, S. Watson.—Near Fort Ellis, Montana, July; Snake River Valley, August.

Astragalus campestris, Gray.—Near Fort Ellis, Montana, July; Téton Basin; mountains near Henry's Lake, Idaho, August; Grand Cañon of the Yellowstone; Clark's Fork, Wyoming. Very variable in the breadth of the leaves.

Astragalus junceus, Gray, (*A. diversifolius*, Gray.)—Near Ogden, Utah, June; Snake River Valley, July.

Astragalus alpinus, L.—Yellowstone Lake, August.

Astragalus pictus, Gray.—Snake River Plains, July. Occurs in great abundance.

Oxytropis nana, Nutt.—In fruit. Henry's Fork of Snake River, July.

Oxytropis Lamberti, Pursh.—In fruit. Snake River Valley, July.

Glycyrrhiza lepidota, Nutt.—Sand Creek, Idaho, October.

Hedysarum Mackenzii, Rich.—Near Ogden, Utah, June.

Hedysarum boreale, Nutt.—Bear River, Utah, June; Trail Creek Mountains, September; Téton Mountains, elevation, 10,000 feet, July; Yellowstone Lake, August; remarkably glabrous.

Vicia Americana, Muhl.—Swamp near Ogden, Utah, June; Divide between Marsh and Malade Valleys, near Brigham City, Utah.

Lathyrus polyphyllus, Nutt.—Plains near Ogden, Utah, June.

Lathyrus palustris, L.—Near Ogden, Utah, May.

Lathyrus palustris, L., Form.—Near Blackfoot River, Idaho, July.

Lathyrus palustris, L., var. *myrtifolius*, Gray.—Near Ogden, Utah, June. The specimen was collected, but unfortunately lost.

Pisum arvense, L. Accidental.—Port Neuf Cañon, Idaho.

Thermopsis fabacea, D. C.—Divide between Marsh and Malade Valleys, June.

ROSACEÆ.

Prunus demissa, Walp.—Divide between Marsh and Malade Valleys, June.

Spiræa dumosa, Nutt.— (*S. ariæfolia*, var. *discolor*, T. and G.)—Twin Buttes, on Henry's Fork of Snake River, July.

Spiræa opulifolia, L.—Ogden Cañon, Utah, June.

Spiræa opulifolia, L. var. *pauciflora*, Hook.—Mountains near Ogden, Utah, June.

Spiræa betulæfolia, Pallas.—Téton Mountains, elevation 11,000 feet, July.

Spiræa betulæfolia, Pallas, var. *rosea*, Gray.—Shoshone Lake, September; mountains near Henry's Lake, Idaho, August.

Spiræa Millefolium, Torr. (P. R. R. Rep., vol. iv, p. 83, t. 5.) Snake

River Valley, Idaho, *John M. Coulter;* Ophir, Southern Utah, *E. S. Blackwell.*

Rubus Nutkanus, Moç.—Ogden Cañon, Utah, June; Téton Mountains, elevation 10,000 feet, July.

Rubus strigosus, Michx.—Madison River, August; Yellowstone Lake; Téton Basin, July.

Purshia tridentata, D. C.—Divide between Marsh and Malade Valleys, June.

Cercocarpus ledifolius, Nutt. "Mountain mahogany."—Mountains near Ogden, Utah, June.

Drydas octopetala, L.—Téton Mountains, elevation 12,000 feet, July.

Geum strictum, Ait.—Near Fort Ellis, Montana, July.

Geum macrophyllum, Willd.—Divide between Marsh and Malade Valleys, June; Téton River, July.

Geum triflorum, Pursh.—Mountains near Henry's Lake, August; mountains along the Yellowstone, elevation 8–10,000 feet; Téton Basin, July.

Fragaria Virginiana, Ehrh.—Mountains near Henry's Lake, Idaho, August; Téton Basin, July.

Fragaria vesca, L.—Ogden Cañon, Utah, June; Téton Basin, July.

Potentilla Norvegica, L., a form approaching *P. rivularis.*—From Ross Fork to Fort Hall, Idaho, July.

Potentilla Norvegica, L.—Malade Valley, Utah, June 27.

Potentilla millegrana, Engelm.—Port Neuf Cañon, Idaho, July; foothills of the Téton Range, August.

Potentilla diversifolia, Lehm.—Yellowstone Lake, August.

Potentilla diversifolia, Lehm., var. *multisecta*, S. Watson. (Clarence King's Rep., vol. v, p. 86.)—Téton Mountains, elevation 11,500 feet, July.

Potentilla pulcherrima, Lehm.—Near Ogden, Utah, June.

Potentilla gracilis, Dougl.—Divide between Marsh and Malade Valleys, June; Fort Ellis, Montana.

Potentilla gracilis, Dougl., var. *flabelliformis*, Nutt.—Henry's Fork of Snake River, July.

Potentilla Anserina, L.—Near Ogden, Utah, May.

Potentilla fruticosa, L.—Malade Valley, Utah, June; Henry's Lake, Idaho, August; Yellowstone River, elevation 6,400 feet; Téton Basin, July.

Potentilla glandulosa, L.—Upper Téton Cañon, July; Henry's Fork of Snake River, August.

Potentilla arguta, Pursh.—Divide between Marsh and Malade Valleys, June.

Ivesia Gordoni, T. and G.—Red Mountain, elevation 10,000 feet, September; Téton Range, elevation 10,000 feet, July.

Rosa blanda, Ait.—Divide between Marsh and Malade Valleys, June; Fall River, Idaho, July.

Rosa fraxinifolia, Bork.—Téton River, July 23. Collected in fruit but not in flower.

Cratægus rivularis, Nutt. (?) (Watson, in Clarence King's Rep., vol. v, p. 92.)—Near Ogden, Utah, June.

Cratægus sanguinea, Pallas, var. *Douglasii*, T. and G.—Fort Ellis, Montana, July.

Amelanchier Canadensis, T. and G., var. *alnifolia*, T. and G.—Divide between Marsh and Malade Valleys, June; Téton Mountains, elevation 10,000 feet, July.

SAXIFRAGACEÆ.

Saxifraga oppositifolia, L.—Téton Mountains, elevation 12,000 feet, July.

Saxifraga bronchialis, L.—Mountains near Henry's Lake, Idaho, August.

Saxifraga punctata, L.—Yellowstone River, July; Upper Téton Cañon.

Saxifraga nivalis, L.—Mountains near Henry's Lake, Idaho, August; Upper Téton Cañon, July; Clark's Fork, Wyoming.

Saxifraga hieracifolia, Waldst. and Kit.—Téton Basin, July.

Saxifraga Jamesii, Dougl.—Téton Mountains, elevation 11,000 feet, July.

Tellima parviflora, Hook.—Téton Cañon, July.

Tellima tenella, Benth. and Hook.—Near Ogden, Utah, June; Téton Mountains, elevation 10,000 feet, July.

Mitella pentandra, Hook.—Upper Téton Cañon, July.

Mitella trifida, Graham.—Upper Téton Cañon, July.

Heuchera rubescens, Torr.—Near Ogden, Utah, June.

Heuchera cylindrica, Dougl.—Hot springs along the Yellowstone, elevation 6,200 feet, September; Grand Cañon of the Yellowstone, August; Lower Fire-Hole Basin.

Heuchera parvifolia, Nutt.—Ogden Cañon, Utah, June; divide between Marsh and Malade Valleys; Téton Basin, July. A very dwarf form was found at Fort Ellis, Montana.

Parnassia parviflora, D. C.—Lower Fire-Hole Basin, August.

Parnassia fimbriata, Banks.—Téton Cañon, July; spray flower of the Great Falls of the Yellowstone, August; headwaters of Snake River, September.

Ribes lacustre, Poir.—Upper Téton Cañon, July.

Ribes lacustre, Poir., var., an Alpine form, (Watson, in Clarence King's Rep., vol. v, p. 99.) (*R. setosum*, Dougl.) Téton Mountains, elevation 11,500 feet, July.

Ribes viscosissimum, Pursh.—Upper Téton Cañon, July; mountains near Henry's Lake, Idaho, August.

Ribes bracteosum, Dougl.—Téton Cañon, August.

CRASSULACEÆ.

Sedum Rhodiola, D. C.—Mountains near Henry's Lake, Idaho, August; Téton Mountains, elevation 12,000 feet, July.

Sedum rhodanthum, Gray.—Tower Falls, August; Upper Falls of the Yellowstone.

Sedum stenopetalum, Pursh.—Mountains near Ogden, Utah, June; Fire-Hole River, August.

Sedum debile, S. Watson.—Mountains near Ogden, Utah, June.

HALORAGEÆ.

Myriophyllum verticillatum, L.—Henry's Fork of Snake River, August.

Hippuris vulgaris, L.—Near Ogden, Utah, June; common on Henry's Fork of Snake River, July.

ONAGRACEÆ.

Epilobium augustifolium, L.—Divide between Marsh and Malade Valleys, June.

Epilobium suffruticosum, Nutt.—Mountains near Ogden, Utah, June.

Epilobium tetragonum, L.—Near Brigham City, Utah, June; Téton Cañon, July; Snake River Valley, August.

Epilobium paniculatum, Nutt.—Plains near Ogden, Utah, June; Téton foot-hills, August; Snake River Valley, July; mountains near Henry's Lake, Idaho.

Zauschneria Californica, Presl.—Mountains near Ogden, Utah, June.

Clarkia rhomboidea, Dougl.—Mountains near Ogden, Utah, June.

Gayophytum ramosissimum, T. and G.—Near Ogden, Utah, June.

Gayophytum racemosum, T. and G.—Téton foot-hills, August.

Gayophytum diffusum, T. and G.—Téton foot-hills, August.

Œnothera biennis, L.—Snake River Valley, July.

Œnothera albicaulis, Nutt.—Near Ogden, Utah, June.

Œnothera albicaulis, Nutt., var. *Nuttallii*, Engelm.—Divide between Marsh and Malade Valleys, June 29; Yellowstone River, August.

Œnothera triloba, Nutt.—Ogden Cañon, Utah, June 15; Port Neuf Cañon, Idaho, July 2; Henry's Fork of Snake River, July 18; Yellowstone Lake, August 23.

Œnothera marginata, Nutt.—Port Neuf Valley, Idaho, July 1.

Œnothera marginata, Nutt., var. *purpurea*, S. Watson.—Hot springs along the Yellowstone, elevation 6,700 feet, September 29.

Œnothera scapoidea, Nutt.—Snake River Valley, July 16.

Œnothera heterantha, Nutt.—Téton Basin, July 11.

Œnothera Andina, Nutt.—Twin Buttes on Henry's Fork of Snake River, Idaho, July 16.

Gaura biennis, L.—Port Neuf Cañon, Idaho, July 1.

Gaura parviflora, Dougl.—Port Neuf Cañon, Idaho, July 2; Snake River Valley, July 19.

Gaura coccinea, Nutt.—Between Boteler's Ranch and Fort Ellis, Montana, July 21.

LYTHRACEÆ.

Lythrum alatum, Pursh.—Mountains near Henry's Lake, Idaho, August 9.

LOASACEÆ.

Mentzelia albicaulis, Dougl., var. *integrifolia*, S. Watson.—Port Neuf Cañon, Idaho, July 2.

Mentzelia lævicaulis, T. and G.—Mountains along the Yellowstone; Twin Buttes on Henry's Fork of Snake River, July 25.

UMBELLIFERÆ.

Bupleurum ranunculoides, L.—Henry's Lake, Idaho, August 9; a taller form from Union Pass, Gallatin River, September 12. (See catalogue in Hayden's Rep. for 1871.)

Cicuta maculata, L.—Port Neuf Cañon, Idaho, July 2; Snake River Valley.

Carum Gairdneri, Benth. and Hook.—Téton River, July; Snake River Plains, August; Fall River, Idaho, July 19. A common article of food among the Indians of Idaho and Wyoming, who call it "yamp." It is very palatable and nutritious, having somewhat the flavor of carrot.

Sium augustifolium, L.—Malade Valley, Utah, June.

Sium lineare, Michx.—Port Neuf Cañon, Idaho, July.

Osmorrhiza nuda, Torr.—Near Ogden, Utah, June; Upper Téton Cañon, July.
Myrrhis occidentalis, Benth. and Hook.—Snake River Valley, July.
Cymopterus fœniculaceus, Nutt.—Mountains near Ogden, Utah, elevation 10,000 feet, June.
Cymopterus longipes, S. Watson.—Near Ogden, Utah, May to June, 1871.
Thaspium trifoliatum, Gray.—Union Pass, Gallatin River, September.
Angelica Breweri, Gray.—Swamps in Snake River Valley, July.
Conioselinum Canadense, T. and G.—Upper Téton Cañon, July.
Peucedanum simplex, Nutt.—Mountains near Ogden, Utah, elevation 9,000 feet, June.
Ferula multifida, Gray, (*Leptotænia*, Nutt.)—Ogden Cañon, Utah, June.
Heracleum lanatum, Michx.—Upper Téton Cañon, July.

CORNACEÆ.

Cornus Canadensis, L.—Madison River Cañon, August.
Cornus pubescens, Nutt.—Swamps on Téton River, July.

CAPRIFOLIACEÆ.

Linnæa borealis, Gronov.—Lower Fire-Hole Basin, August; Yellowstone River; Gibbon's Fork of Madison River.
Symphoricarpus montanus, H. B. K.—Ogden Cañon, Utah, June; Yellowstone River, August; Snake River Valley, July; Téton Cañon.
Symphoricarpus occidentalis, R. Br.—Snake River Valley, July.
Lonicera involucrata, Banks.—Ogden Cañon, Utah, June; Tower Falls; Téton Mountains, elevation 10,000 feet, July.
Lonicera Utahensis, S. Watson.—Upper Téton Cañon, July.
Sambucus racemosa, L., var. *pubens*, S. Watson, (*S. pubens*, Michx.)—Little Cottonwood Cañon, Utah, June; Upper Téton Cañon, July.
Sambucus glauca, Nutt.—Near Ogden, Utah, June.

RUBIACEÆ.

Galium Aparine, L.—Ogden Cañon, Utah Territory, June; along the Yellowstone, elevation 6,400 feet.
Galium multiflorum, Kellogg, (*G. hypotrichium*, Gray.)—Near Ogden, Utah, June.
Galium trifidum, L.—Henry's Fork of Snake River, August.
Galium boreale, L.—Divide between Marsh and Malade Valleys, June; Henry's Fork of Snake River, July.

VALERIANACEÆ.

Valeriana dioica, L., var. *sylvatica*, S. Watson.—Near Ogden, Utah, June; Red Mountain, elevation 9,000 feet, September.
Valeriana edulis, Nutt.—Téton Mountains, elevation, 11,500 feet; July; near Henry's Lake, Idaho, August.
Plectritis congesta, D. C.—Plains near Ogden, Utah Territory, June.

COMPOSITÆ.

Eupatorium purpureum, L.—Snake River Valley, July.
Aster integrifolius, Nutt.—Téton Basin, August; Henry's Fork of Snake River; Upper Cañon of the Madison.

Aster adscendens, Lindl.—Upper Geyser Basin, August.

Aster adscendens, Lindl., var. *Parryi*, S. Watson.—Téton Basin, July; Trail Creek Mountains, September.

Aster multiflorus, Ait.—Shoshone Lake, September.

Aster glacialis, Nutt.—Trail Creek Mountains, September; Téton Mountains, elevation 11,000 feet, July.

Aster pulchellus, D. C. Eaton.—Téton Mountains, elevation 12,000 feet, July.

Aster salsuginosus, Rich.—Téton Mountains, elevation 12,000 feet, July.

Aster salsuginosus, Rich., var. B., T. and G.—Upper Téton Cañon, July.

Aster Haydeni, Porter, (Hayden's Report for 1871.)—Shoshone Lake, September.

Aster Sayi, Nutt, (Gray in Proc. Am. Acad., May, 1872, p. 389; Hall's Oregon Coll., 246.)—Téton Range, elevation 10,000 feet, July.

Aster elegans, T. and G.—Fall River, Idaho, July; Téton Mountains, elevation 10,000 feet.

Aster Engelmanni, Gray, (*A. elegans*, var. *Engelmanni*, D. C. Eaton.)—Madison River Cañon, August; Téton Range, elevation 10,000 feet, July.

Townsendia scapigera, D. C. Eaton.—Union Pass, Gallatin River, July; Téton Mountains, elevation 10,000 feet.

Townsendia strigosa, Nutt.—Snake River Valley, Idaho, July.

Townsendia grandiflora, Nutt.—From Boteler's Ranch to the Yellowstone, July.

Machæranthera canescens, Nutt.—Madison Cañon, August; Téton Basin, July. Several forms were found.

Erigeron grandiflorum, Hook.—Téton Mountains, elevation 10,000 feet, July. A very dwarf form was found at Shoshone Lake, September.

Erigeron acre, L.—Mountains along Clark's Fork, Wyoming, elevation 9,000 feet, August.

Erigeron Bellidiastrum, Nutt.—Near Ogden, Utah, June; Ross Fork to Fort Hall, Idaho, July; Snake River Valley.

Erigeron macranthum, Nutt.—Wooded Cañon of Téton River, July. Very variable in size.

Erigeron glabellum, Nutt.—Near Ogden, Utah, June; Téton Basin, July; Upper Téton Cañon.

Erigeron corymbosum, Nutt.—Divide between Marsh and Malade Valleys, June; Lower Fire-Hole Basin, August.

Erigeron filifolium, Nutt.—Henry's Lake, Idaho, August; from Ross Fork to Fort Hall, Idaho, July.

Solidago Virga-aurea, L.—Téton foot-hills, August.

Solidago Virga-aurea, L., var. *multiradiata*, T. and G.—Mountains near Henry's Lake, Idaho, August; Yellowstone Lake.

Solidago Virga-aurea, L., var. Alpine form, 554 of Watson's collection. (Clarence King's Rep., vol. v, p. 154.)—Red Mountain, elevation 10,000 feet, September.

Solidago Guiradonis, Gray, var. *spectabilis*, S. Watson. (Clarence King's Rep., vol. v, p. 154.)—Téton Basin, August.

Solidago nemoralis, T. and G.—Headwaters of Madison River, September.

Solidago elongata, Nutt.—Téton foot-hills, August.

Solidago gigantea, Ait.—Téton foot-hills, August; Yellowstone Lake; Henry's Fork of Snake River.

Solidago gigantea, Ait.—A form, 562 of Watson's collection. (Clarence King's Rep., vol. v, p. 156.)—Port Neuf Cañon, Idaho, July.

Linosyris graveolens, T. and G.—Lower Fire-Hole Basin, August.

Linosyris viscidiflora, T. and G.—Near Brigham City, Utah, June.

Linosyris viscidiflora, T. and G., var. *serrulata*, Torr. (Stansb. Rep., Ed. 2, p. 389.)—Near Bringham City, Utah, June.

Linosyris viscidiflora, T. and G., var. *latifolia*, D. C. Eaton.—Leaves from 2–3′ long. Mountains along Malade Valley, Idaho.

Linosyris viscidiflora, T. and G., var. *puberula*, D. C. Eaton.—Fall River, Idaho, July.

Linosyris viscidiflora, T. and G. "A form 8 flowered," Professor Porter.—Twin Buttes on Henry's Fork of Snake River, July.

Aplopappus suffruticosus, Gray. (*Macronema suffruticosa*, Nutt.) (Proc. Am. Acad., 6, 542.)—Snake River Valley, July.

Aplopappus lanceolatus, T. and G.—Around the hot springs in both geyser basins, August.

Aplopappus acaulis, Gray.—Mountains near Henry's Lake, Idaho Territory, August.

Aplopappus Nuttallii, T. and G.—Near Fort Bridger, Wyoming, August, *Dr. Joseph Leidy.*

Aplopappus uniflorus, T. and G. A form with the radical leaves entire or nearly so. Henry's Lake, Idaho, August 8.

Grindelia squarrosa, Don.—Port Neuf Valley, Idaho, July 1.

Chrysopsis villosa, Nutt.—Henry's Fork of Snake River, July 18; around the hot springs of Lower Fire-Hole Basin, August 13. Very variable.

Chrysopsis villosa, Nutt., var. *hispida*, Gray.—Madison Lake, September 4.

Iva axillaris, Pursh.—Malade Valley, June; abundant in Snake River Valley, July 26; near hot springs along the Yellowstone, August.

Wyethia amplexicaulis, Nutt.—Malade Valley, Utah, June 27.

Balsamorrhiza sagittata, Nutt.—From Ross Fork to Fort Hall, Idaho, July 3.

Rudbeckia occidentalis, Nutt.—Ogden Cañon, Utah, June 15; Téton Mountains, elevation 10,000 feet, July 24; Snake River Plains, August.

Helianthus lenticularis, Dougl.—Malade Valley, Utah, June 27; Snake River Valley, July.

Helianthus Nuttallii, T. and G.—Lower Fire-Hole Basin, August 29.

Helianthus petiolaris, Nutt.—Weber River, Utah, June 19.

Helianthella multicaulis, D. C. Eaton.—Fall River, Idaho, July 19.

Helianthella uniflora, T. and G.—Upper Téton Cañon, July 26.

Heliomeris multiflora, Nutt.—Téton River, Idaho, July 23.

Chænactis Douglasii, Hook. and Arn.—Ogden Cañon, Utah, June 15; Fire-Hole River, August; Gardiner's River, Montana; Snake River, Idaho.

Chænactis Douglasii, Hook. and Arn.—Alpine form, mountains near Henry's Lake, Idaho, August 9; Lower Fire-Hole Basin.

Bahia leucophylla, D. C.—Henry's Fork of Snake River, July 18; Téton Basin, July 21.

Actinella grandiflora, T. and G.—Téton Mountains, elevation 12,000 feet, July 30.

Layia glandulosa, Hook. and Arn.—Twin Buttes on Henry's Fork of Snake River, July 16.

Layia heterotricha, Hook. and Arn.—Near Ogden, Utah, June 5.

Madia racemosa, T. and G.—Ogden Cañon, Utah, June 15.

Amida hirsuta, Nutt.—Téton Mountains, elevation 10,000 feet, July 24.

Achillea Millefolium, L.—Near Ogden, Utah, May 30; very abundant everywhere on the route.

Matricaria discoidea, D. C.—Great Salt Lake, June 17.

Artemisia dracunculoides, Pursh.—Snake River Valley, October; Yellowstone River, August 23.

Artemisia tridentata, Nutt.—Yellowstone Lake, August 23; Snake River Valley, July. The common form all over the West.

Artemisia discolor, Dougl.—Snake River Valley, October; Lower Fire-Hole Basin, August.

Artemisia Ludoviciana, Nutt.—Weber River, Utah, June.

Artemisia Ludoviciana, Nutt., var. *Douglasiana*, D. C. Eaton. (*A. Douglasiana*, T. and G.)—Yellowstone Lake, August; Market Lake, Idaho, July.

Artemisia Ludoviciana, Nutt., var. *latifolia*, T. and G.—Yellowstone Lake, August 5; Port Neuf Cañon, Idaho, July.

Artemisia cana, Pursh.—Yellowstone Lake, August.

Artemisia frigida, Nutt.—Near Fort Bridger, Wyoming, August, *Dr. Joseph Leidy.*

Gnaphalium luteo-album, L., var. *Sprengelii*, D. C. Eaton.—White Mountain Hot Springs, Montana, elevation 6,400 feet, July; Geyser Basin on Shoshone Lake, September.

Gnaphalium palustre, Nutt.—Great Salt Lake, June.

Gnaphalium microcephalum, Nutt.—Shoshone Lake, September.

Antennaria margaritacea, R. Br.—Henry's Lake, Idaho, August 8.

Antennaria Carpathica, R. Br.—Shoshone Lake, September 6.

Antennaria Carpathica, R. Br., var. *pulcherrima*, Hook.—Henry's Lake, Idaho, August 8; Lower Fire-Hole Basin, September; Téton Basin, July 21.

Antennaria alpina, Gærtn.—Ogden Cañon, Utah, June 15; Fort Hall, Idaho, July; Upper Geyser Basin, August.

Antennaria dioica, Gærtn.—Yellowstone River, August 22; Snake River Valley, July 30.

Antennaria dioica, Gærtn., var. *rosea*, D. C. Eaton.—Téton Basin, July 21.

Antennaria racemosa, Hook.—Mountains near Henry's Lake, Idaho, August 9.

Arnica longifolia, D. C. Eaton.—Grand Cañon of the Yellowstone, August 22.

Arnica augustifolia, Vahl.—Divide between Marsh and Malade Valleys, June 29.

Arnica Chamissonis, Less.—Divide between Marsh and Malade Valleys, June 29; swamps along Henry's Fork of Snake River, August.

Arnica latifolia, Bongard.—Téton Mountains, elevation 10,000 feet, July.

Arnica cordifolia, Hook.—Ogden Cañon, Utah, June; Téton Basin, July; Trail River Mountains, September.

Senecio lugens, Richards.—Téton Mountains, elevation 10,000 feet, July; Yellowstone Lake, August.

Senecio lugens, Richards, var. *Hookeri*, D. C. Eaton.—Mountains near Henry's Lake, Idaho, August.

Senecio lugens, Richards, var. *exaltatus*, D. C. Eaton.—Lower Fire-Hole Basin, August; Mountains near Ogden, Utah, June.

Senecio hydrophilus, Nutt.—Henry's Lake, Idaho, August.

Senecio triangularis, Hook.—Henry's Fork of Snake river, August; Yellowstone Lake; Red Mountain, elevation 10,000 feet, September; Téton River.

Senecio Serra, Hook., (Watson, in Clarence King's Rep., vol. v, p. 189, under *S. Andinus*.)—Téton Mountains, elevation 10,000 feet, July.

Senecio Andinus, Nutt.—Divide between Marsh and Malade Valleys, June; Shoshone Lake, September.

Senecio aureus, L.—Ogden Cañon, Utah, June; Teton Basin, July.

Senecio aureus, L., var. *obovatus*, T. and G.—Divide between Marsh and Malade Valleys, June.

Senecio aureus, L., var. *croceus*, Gray.—Yellowstone Lake, August.

Senecio canus, Hook.—Around hot springs in Lower Fire-Hole Basin, August. The form with entire leaves.

Senecio Fendleri, Gray. (Pl. Fendl., p. 108.)—Malade Valley, Idaho, June. With uncommonly long petioles.

Senecio multilobatus, T. and G.—Near Ogden, Utah, June.

Senecio subnudus, D. C.—Lower Fire-Hole Basin, near hot springs, August.

Tetradymia canescens, D. C.—Snake River Plains, July.

Several species of *Cirsium* were collected, probably *C. foliosum*, *C. Drummondii*, and some others, but the material was too meager for a satisfactory determination of these mixed species.

Stephanomeria minor, Nutt.,(including *S. runcinata*, Nutt.)—Near Brigham City, Utah, June; Fort Hall, Idaho, July; a slender, unbranched form.

Stephanomeria exigua, Nutt.—Snake River Valley, July.

Hieracium Scouleri, Hook.—Snake River Valley, Idaho, July; Malade Valley, June.

Hieracium albiflorum, Hook.—Upper Cañon of the Madison, August. A small, single-flowered, alpine form was found on the hills around the Upper Geyser Basin.

Lygodesmia juncea, Don., var. *dianthopsis*, D. C. Eaton, (Clarence King's Rep., vol. v, p. 200.)—Ogden Cañon, Utah, June; near Great Salt Lake.

Malacothrix sonchoides, T. and G.—Twin Buttes on Henry's Fork of Snake River, July; Port Neuf Cañon, Idaho.

Crepis Andersonii, Gray.—Lower Fire-Hole Basin, August.

Crepis occidentalis, Nutt.—Marsh Valley, June; Fire-Hole River, August.

Crepis occidentalis, Nutt., var. *gracilis*, D. C. Eaton.—Mountains near Henry's Lake, Idaho, August.

Crepis acuminata, Nutt.—Plains near Ogden, Utah, June; Téton Basin, July; Bear River Valley.

Crepis nana, Richards. (Fl. N. Am. 2, p. 488.)—Téton Mountains, elevation 12,000 feet, July.

Macrorrhyncus glaucus, D. C. Eaton, var. *laciniatus*, D. C. Eaton.—Snake River Plains, July.

Macrorrhyncus troximoides, T. and G.—Swamp near Ogden, Utah, June; Henry's Fork of Snake River, July; Red Mountain, elevation 10,000 feet, September.

Taraxacum Dens-leonis, Desf.—Ogden Cañon, Utah, June. Collected in abundance, but lost.

Mulgedium pulchellum, Nutt.—Port Neuf Cañon, Idaho, July.

Mulgedium leucophæum, D. C.—Gallatin Cañon, September.

Sonchus asper, Vill.—Ogden Cañon, Utah, June. Collected with several other specimens and lost.

Gaillardia aristata, Pursh.—Union Pass, Gallatin River, Montana, September.

LOBELIACEÆ.

Porterella carnulosa, Torr. (See Cat. Hayden's Rep. for 1871.)—Swamp on Henry's Fork of Snake River, August.

CAMPANULACEÆ.

Campanula rotundifolia, L.—Elevated plateau, Montana; Snake River Valley, July.

Campanula rotundifolia, L. var. *linifolia*, Gray.—Mountains along the Yellowstone, elevation 6,000 feet; Téton Basin, July.

Specularia perfoliata, A. D. C.—Hot springs ten miles from Ogden, Utah, June.

ERICACEÆ.

Vaccinium uliginosum, L.—Henry's Fork of Snake River, August; Shoshone Lake, September.

Vaccinium myrtilloides, Hook.—Henry's Lake, Idaho, August.

Vaccinium myrtilloides, Hook., var. *macrophyllum*, Gray.—Upper Téton Cañon, July.

Vaccinium Myrtillus, L.—Yellowstone Lake, August.

Vaccinium ovalifolium, Smith.—Upper Téton Cañon, July.

Arctostaphylos Uva-Ursi, Spreng.—Yellowstone River, August; Lower Fire-Hole Basin, July. The "Kinnikinnick" of the Indians.

Kalmia glauca, Ait.—Shoshone Lake, September, growing on geyserite.

Kalmia glauca, Ait., var. *microphylla*, Hook.—Mountains along Clark's Fork, Wyoming; elevation 9,000 feet; August. A small alpine form was found upon the Rocky Mountain divide, near Shoshone Lake, September.

Bryanthus empetriformis, Gray. (Proc. Am. Acad., vol. vii, p. 367.)—Téton Mountains; elevation 12,000 feet, July; Rocky Mountain divide, near Shoshone Lake, September.

Ledum glandulosum, Nutt.—Tower Falls, August; Shoshone Lake, September.

Pyrola rotundifolia, L., var. *incarnata*, Gray.—Téton Cañon, July.

Pyrola chlorantha, Swartz.—Upper Téton Cañon, July; Fall River, Idaho, August.

Pyrola secunda, L.—Fire-Hole River, August; Upper Téton Cañon, July.

Pyrola aphylla, Smith. (Pacific Railroad Rep., vol. vi, p. 80 of the Bot.)—Henry's Lake, Idaho, August.

Pyrola picta, Hook.—Fall River, Idaho, August.

Moneses uniflora, Gray.—Upper Téton Cañon, July.

Chimaphila umbellata, Nutt.—Eastern cañons of the Téton Range, September.

Monotropa Hypopitys, L.—Red Mountain; elevation 10,000 feet, September; Lower Fire-Hole Basin, August.

Pterospora Andromedea, Nutt.—Jackson's Lake, September. Specimens were found at this locality four feet high; along the Yellowstone.

PLANTAGINACEÆ.

Plantago major, L.—Weber River, Utah, June. Doubtless introduced.

Plantago Patagonica, Jacq., var. *gnaphalioides*, Gray.—Near Ogden, Utah, June; Snake River Valley, very abundant.

Plantago Patagonica, Jacq., var. *aristata*, Gray.—Henry's Fork of Snake River, July.

PRIMULACEÆ.

Androsace septentrionalis, L. Alpine form, 753 of Watson.—Trail River Mountains, September; Téton Mountains; elevation 10,000 feet, July.

Dodecatheon Meadia, L.—Ogden Cañon, Utah, June.

Dodecatheon Meadia, L. Alpine form of S. Watson, 756, 2–8′ high.—Upper Téton Cañon; elevation 10,000 feet, July; mountains along Clark's Fork, Wyoming; elevation 9,000 feet.

Lysimachia ciliata, L.—Swamp near Ogden, Utah, June; Twin Buttes, on Henry's Fork of Snake River, July.

Glaux maritima, L.—Malade Valley, Utah, June.

LENTIBULACEÆ.

Utricularia vulgaris, L., var. *Americana*, Gray.—Henry's Fork of Snake River, August 5.

OROBANCHACEÆ.

Phelipæa erianthera, Engelm. (*Orobanche multiflora*, Nutt.)—Snake River Valley, Idaho, July; "The 'Too-whoo' of the Pah-Utes, by whom it is eaten."—Watson.

Aphyllon uniflorum, T. and G.—Mountains near Ogden, Utah, June 13; Téton Cañon, July 16.

Aphyllon fasciculatum, T. and G.—Snake River Valley, Idaho, July 17; from Boteler's Ranch to the Yellowstone, July 23.

SCROPHULARIACEÆ.

Scrophularia nodosa, L.—Near Ogden, Utah, June 5. Abundant everywhere near settlements.

Collinsia parviflora, Dougl.—Plains near Ogden, Utah, June 5; Téton Cañon, July 24; Yellowstone Lake, August 23.

Pentstemon Menziesii, Hook., var. *Douglasii*, Gray. (*P. Douglasii*, Hook.)—Trail Creek Mountains, September; Clark's Fork, Wyoming.

Pentstemon Menziesii, Hook., var. *Lewisii*, Gr.—Henry's Lake, Idaho, and Téton Mountains.

Pentstemon glaber, Pursh.—Near Ogden, Utah, June; Fall River, Idaho, July.

Pentstemon cyananthus, Hook.—Mountains near Ogden, Utah, elevation 9,000 feet, June.

Pentstemon acuminatus, Dougl.—From Ross Fork to Fort Hall, Idaho, July.

Pentstemon cristatus, Nutt.—Mystic Lake, near Fort Ellis, Montana, July.

Pentstemon humilis, Nutt.—Mountains near Ogden, Utah, June.

Pentstemon glaucus, Grah.—Upper Téton Cañon, July.

Pentstemon glaucus, Grah., var. *stenosepalus*, Gray.—Along the Yellowstone, elevation 6,700 feet, July.

Pentstemon confertus, Dougl.—Téton Basin, July.

Pentstemon confertus, Dougl., var. *cæruleo-purpurens*, Gray.—Mountains along the Yellowstone, elevation 7,000 feet, September; Yellowstone

Lake; Snake River Valley, July; Fall River, Idaho. A very dwarf form was found on the mountains near Ogden, Utah.

Pentstemon deustus, Dougl.—Henry's Fork of Snake River, July.

Pentstemon heterophyllus, Lindl., var. *latifolius*, S. Watson. (Clarence King's Rep., vol. v, p. 222.)—Near Ogden, Utah, June.

Mimulus Lewisii, Pursh.—Near Ogden, Utah, June; Upper Téton Cañon, July; Yellowstone Lake, August; Trail Creek Mountains, September.

Mimulus luteus, L.—Near Ogden, Utah, June. This species is found everywhere in the West in the greatest abundance and variety of form and size.

Mimulus luteus, L. Depauperate form, 790 of Watson.—Near Salt Lake City, Utah, June.

Mimulus floribundus, Dougl.—Foot-hills of the Téton Range, August.

Mimulus moschatus, Dougl.—Henry's Fork of Snake River, August; Téton foot-hills, July.

Mimulus rubellus, Gray, (Mex. Bound. Rep., p. 116.) (Watson, in Clarence King's Rep., vol. v, p. 225.)—Near Ogden, Utah, June.

Eunanus Fremontii, D. C.—Crater Hills, Wyoming, August; Twin Buttes on Henry's Fork of Snake River, Idaho, July.

Synthyris alpina, Gray.—Téton Mountains, elevation 10,000 feet, July.

Veronica Anagallis, L.—Near Ogden, Utah, June; Heart Lake, September; Téton River, July.

Veronica Americana, Schwein.—Near Brigham City, Utah, June.

Veronica alpina, L.—Trail Creek Mountains, September.

Veronica serpyllifolia, L.—Téton River, July.

Veronica peregrina, L.—Téton River, July.

Castilleia linariæfolia, Benth.—Divide between Marsh and Malade Valleys, June.

Castilleia affinis, Hook. and Arn.—Malade Valley, Idaho, June.

Castilleia affinis, Hook. and Arn., var. *minor*, Gray.—Mountains along the Yellowstone, elevation 6,400 feet, July.

Castilleia parviflora, Bong.—Divide between March and Malade Valleys, June.

Castilleia pallida, Kunth.—Ogden Cañon, Utah, June; Téton Mountains, elevation 10,000 feet, July. The red variety was also found.

Castilleia flava, S. Watson.—Ross Fork to Fort Hall, Idaho, July; Téton Basin.

Orthocarpus Tolmiei, Hook. and Arn.—Snake River Valley, July; near Fort Bridger, Wyoming, August. *Dr. Joseph Leidy.*

Orthocarpus luteus, Nutt.—Twin Buttes, on Henry's Fork of Snake River, July.

Cordylanthus ramosus, Nutt.—Téton foot-hills, August; Snake River Valley, July.

Pedicularis Grœnlandica, Retz.—Henry's Fork of Snake River, August, in flower; Shoshone Lake, September.

Pedicularis bracteosa, Benth.—Lower Falls of the Yellowstone, August; Trail River Mountains, September; Téton Mountains, elevation 10,000 feet, July.

Pedicularis racemosa, Dougl.—Yellowstone Lake, August; Téton Mountains, elevation 10,000 feet, July; Shoshone Lake, September.

Pedicularis Sudetica, Willd.(?)—Téton Mountains, elevation 10,000 feet, July.

Pedicularis Parryi, Gray.—Uintah Mountains, Wyoming, August. *Dr. Joseph Leidy.*

VERBENACEÆ.

Verbena hastata, L.—Near Brigham City, Utah, June.

Verbena bracteosa, Michx.—Near Brigham City, Utah, June; Blackfoot River, Idaho, July.

LABIATÆ.

Mentha Canadensis, L.—From Ross Fork to Fort Hall, Idaho, July; Henry's Fork of Snake River; Yellowstone Lake, August.

Mentha Canadensis, L., var. *glabrata*, Benth.—Henry's Fork of Snake River, August.

Lycopus Virginicus, L., var.—Lower Fire-Hole Basin, August.

Lophanthus urticæfolius, Benth.—Near Ogden, Utah, June.

Dracocephalum parviflorum, D. C.—Weber River, Utah, June; Snake River Valley, July.

Physostegia parviflora, Nutt. (Gray, in Proc. Am. Acad., May, 1872, p. 371.) (*Dracocephalum variegatum*, Ventenat.)—Snake River Valley, Idaho, July.

Brunella vulgaris, L.—Swamp near Ogden, Utah, June; Henry's Fork of Snake River, August; Téton Basin, July.

Scutellaria resinosa, Torr.—Near Ogden, Utah, June.

Scutellaria galericulata, L.—Henry's Fork of Snake River, August.

Marrubium vulgare, L.—Near Ogden, Utah, June 18.

Stachys palustris, L.—Near Brigham City, Utah, June 25; Snake River Valley, July; Fort Ellis, Montana, August.

Stachys palustris, L., var. *aspera*, Gray.—Weber River, Utah, June 19.

Monarda fistulosa, L.—From Fort Ellis to Boteler's Ranch, Montana, July.

BORRAGINACEÆ.

Lithospermum longiflorum, Spreng.—Omaha, Nebraska, May 18; foot-hills near Ogden, Utah, June.

Lithospermum pilosum, Nutt., (*L. ruderale*, Dougl.)—Port Neuf Cañon, Idaho, July 2.

Mertensia Sibirica, Don.—Red Mountain, elevation 10,000 feet, September 11; Téton range, elevation 10,000 feet, July 24.

Mertensia paniculata, Don.—Near Ogden, Utah, June.

Mertensia brevistyla, S. Watson. (Clarence King's Rep., vol. v, p. 239.)—Mountains near Henry's Lake, Idaho, August; Trail Creek Mountains, September.

Piptocalyx circumscissus, Torr.—Market Lake, Idaho, July.

Eritrichium villosum, D. C., var. *aretioides*, Hook.—Téton Mountains, elevation 12,000 feet, July.

Eritrichium augustifolium, Torr.—Near Ogden, Utah, May; Snake River Valley, July.

Eritrichium Californicum, D. C.—Near Ogden, Utah, May; Snake River Valley, July.

Eritrichium glomeratum, D. C.—Mystic Lake, near Fort Ellis, Montana, July.

Eritrichium leiocarpum, S. Watson. (Clarence King's Rep., vol. v, p. 244.) (*Krynitzkia leiocarpum*, Fisch. and Meyer.)—Snake River Valley, July. A form was found at Ogden, Utah, that answers to *E. muriculatum*, Torr., referred by Watson to *E. leiocarpum*. The nutlets are plainly granulated.

Eritrichium crassisepalum, T. and G.—Mystic Lake, near Fort Ellis, Montana, July.

Echinospermum Redowskii, Lehm., var. *occidentale*, S. Watson. (*E. Redowskii*, Gray.)—Great Salt Lake, June 15.

Echinospermum deflexum, Lehm., var. *floribundum*, S. Watson. (*E. floribundum*, Lehm.)—Little Cottonwood Cañon, Utah, June 21; Téton Mountains, elevation 10,000 feet, July 24.

Coldenia Nuttallii, Hook. (*Tiquilia brevifolia*, Nutt. Bot. Mex. Bound., 136.)—Market Lake, Idaho, July 15. On volcanic sand.

Myosotis sylvatica, Hoffm., var. *alpestris*, Koch.—Along the Yellowstone, July.

HYDROPHYLLACEÆ.

Hydrophyllum capitatum, Dougl., var. *alpinum*, S. Watson.—Téton Mountains, elevation 10,000 feet, July 24.

Nemophila parviflora, Dougl.—Along the Yellowstone, July.

Phacelia circinata, Jacq.—Ogden Cañon, Utah, June 6; Divide between Marsh and Malade Valleys, June 29; along the Yellowstone, elevation 6,400 feet, July; Trail Creek Mountains, Wyoming, September 14.

Phacelia Menziesii, Torr.—Near Ogden, Utah, May 28; Mystic Lake, near Fort Ellis, Montana, July.

Phacelia sericea, Gray.—Upper Téton Cañon, July 28; Red Mountain, elevation 9,600 feet, September 11.

Phacelia sericea, Gray.—A dwarf alpine form was found on the mountains around Henry's Lake, Idaho, August 9.

Phacelia Ivesiana, Torr. (Ives's Col. Exped., Bot. Rep., 21.)—Twin Buttes on Henry's Fork of Snake River, July 16; Market Lake, Idaho, on volcanic sand.

POLEMONIACEÆ.

Phlox canescens, T. and G.—Téton Mountains, elevation 12,000 feet, July.

Phlox cæspitosa, Nutt., var. *rigida*, Gray. (Near *P. Douglasii*, Hook.) —Malade Valley, Utah, June; Trail-Creek Mountains, Wyoming, September.

Phlox cæspitosa, Nutt., var. *condensata*, Gray. (Proc. Am. Acad., vol. viii, p. 254.)—Trail Creek Mountains, September.

Phlox longifolia, Nutt.—Yellowstone River, July; Fall River, Idaho; Market Lake; Fort Hall; several forms were found. Fort Ellis, Montana.

Phlox longifolia, Nutt., var. *brevifolia*, Gray.—Trail River Mountains, September.

Collomia grandiflora, Dougl.—Near Ogden, Utah, June.

Collomia linearis, Nutt.—Near Ogden, Utah, June; foot-hills of the Téton Range, July.

Collomia linearis, Nutt., var. *subulata*, Gray.—Foot-hills of the Téton Mountains, August.

Collomia tenella, Gray.—Near Ogden, Utah, June.

Gilia liniflora, Benth., var., *pharnaceoides*, Gray. (Proc. Am. Acad., vol. viii, p. 263.)—Fort Ellis, Montana, July.

Gilia pusilla, Benth.—Fort Ellis, Montana, July.

Gilia pungens, Benth.—Plains near Ogden, Utah, June.

Gilia pungens, Benth., var. *squarrosa*, Gray.—Along the Yellowstone, elevation 6,200 feet, September; Snake River Valley, July.

Gilia intertexta, Stend.—Foot-hills of the Téton Mountains, August.

Gilia floccosa, Gray.—Snake River Valley, July; Market Lake, Idaho.

Gilia congesta, Hook., var. *crebrifolia*, Gray.—Snake River Valley, July; Twin Buttes on Henry's Fork of Snake River.

Gilia aggregata, Spreng.—Near Ogden, Utah, May; Bear River, June. In the Téton Basin the form with white flowers was found.

Gilia leptomeria, Gray.—Snake River Valley, July.

Polemonium confertum, Gray.—Téton Mountains, elevation 12,000 feet, July; mountains on Clark's Fork, Wyoming, elevation 9,000 feet.

Polemonium cœruleum, L.—Henry's Fork of Snake River, August; Lower Fire-Hole Basin.

Polemonium cœruleum, L., var. *foliosissimum*, Gray.—Yellowstone Lake, August.

CONVOLVULACEÆ.

Calystegia sepium, L.—Malade Valley, Idaho, June.

Cuscuta ——,(?)—The specimen found was too young to determine anything as to its species. It was growing on *Oxytropis Lamberti*, Henry's Fork of Snake River.

SOLANACEÆ.

Solanum triflorum, Nutt.—Uintah Mountains, Wyoming, August. *Dr. Joseph Leidy.*

Nicotiana attenuata, Torr.—Market Lake, Idaho, July.

GENTIANACEÆ.

Gentiana Amarella, L.—Henry's Lake, Idaho, August; Heart Lake, Wyoming, September.

Gentiana detonsa, Fries.—Henry's Fork of Snake River, August. This species occurred in the Fire-Hole Basins in great abundance, but with leaves and stems so black as to be scarcely recognizable. "The peduncles are shorter, and the lobes of the corolla more strongly lacerate fringed than usual. It approaches *G. crinita*, with which it is probably identical." Professor Porter.

Gentiana affinis, Smith.—Téton Basin, August; along the Yellowstone, elevation 6,400 feet; Henry's Fork of Snake River, August.

Gentiana simplex, Gray. (Pacif. R. R. Rep., vol. vi, p. 87, pl. 16.)—"It accords well with the description and figure, except that the leaves are shorter and the lobes of the corolla rounded, very obtuse, and occasionally furnished at the base with a few small teeth." Professor Porter. Henry's Fork of Snake River, August.

Gentiana calycosa, Griesb., (in D. C., Prod. 9, p. 115, and Hooker's Fl. Bor. Am. 2, p. 48, t. 146.)—Téton Cañon, 10,000 feet altitude. "It varies from the typical form in its shorter calyx and calyx-lobes, and the smooth edges of its thinnish leaves." Professor Porter.

Frasera speciosa, Dougl.—Téton Cañon, July; Snake River Valley.

Swertia perennis, L.—Uintah Mountains, Wyoming, August. *Dr. Joseph Leidy.*

Hesperochiron pumilus, Porter. (*Villarsia pumila*, Griesbach.)—Near Ogden, Utah, June.

APOCYNACEÆ.

Apocynum androsæmifolium, L.—Near Ogden, Utah, June.

Apocynum cannabinum, L.—Divide between Marsh and Malade Valleys, June.

ASCLEPIADACEÆ.

Asclepias speciosa, Torr.—Port Neuf Cañon, Idaho, July; Snake River Valley.

Acerates decumbens, Decaisne.—Hot springs ten miles from Ogden, Utah, June.

NYCTAGINACEÆ.

Abronia fragrans, Nutt.—Foot-hills near Ogden, Utah, June. Two or three species of *Abronia* were collected but unfortunately lost.

CHENOPODIACEÆ.

Chenopodium album, L.—Port Neuf Cañon, Idaho, July; Twin Buttes on Henry's Fork of Snake River. Common everywhere on the route.

Chenopodium album, L., var. *leptophyllum*, Moq.—Snake River Valley, July.

Chenopodium album, L., var. "Near the var. *integrifolium*, Ledeb." Professor Porter.—Yellowstone Lake, August.

Chenopodium hybridum, L.—Henry's Fork of Snake River, July; Yellowstone Lake, August.

Blitum capitatum, L.—Henry's Fork of Snake River, August; Téton Basin, July.

Blitum polymorphum, C. E. Meyer, var. *humile*, Moq.—Near Great Salt Lake, Utah, June.

Monolepis chenopodioides, Moq. (*Blitum Nuttallianum*, R. and S.)—Téton Basin, July.

Obione canescens, Moq.—Great Salt Lake, Utah, June; Blackfoot River, Idaho, July; Port Neuf Cañon; Marsh Valley.

Obione confertifolia, Torr.—Great Salt Lake, Utah, June.

Obione argentea, Moq.—Great Salt Lake, Utah, June; Snake River Valley, July.

Grayia polygaloides, Hook. and Arn.—Snake River Plains, July.

Eurotia lanata, Moq.—Near Great Salt Lake, Utah, June; Snake River Plains, July. "Known as 'white sage' and 'winter fat.' Is valuable for fattening stock." Watson.

Kochia prostrata, Shrad.—Near Fort Bridger, Wyoming, August. *Dr. Joseph Leidy.*

Salicornia herbacea, L.—Great Salt Lake, Utah, June; Lower Fire-Hole Basin, August.

Halostachys occidentalis, S. Watson, (Clarence King's Rep., vol. v, p. 293.)—Near Great Salt Lake, June.

Sarcobatus vermiculatus, Torr. (*Fremontia vermicularis*, Torr. Frem. Rep.)—Black Buttes, Utah, June. Known as "grease-wood."

AMARANTACEÆ.

Amarantus albus, L.—Snake River Valley, July. "Remarkably red for the species." Professor Porter.

POLYGONACEÆ.

Eriogonum heracleoides, Nutt.—Near Ogden, Utah, June; along the Yellowstone, elevation 6,200 feet, August; Snake River Valley, July.

Eriogonum umbellatum, Torr.—Near Ogden, Utah, June.

Eriogonum (*Heterosepala*) *ovalifolium*, Nutt.—Near Ogden, Utah, May; Lower Fire-Hole Basin, August; Snake River Valley, July.

Eriogonum ovalifolium, Nutt., var. *tenuis*, Benth.—Near Bozeman, Montana, elevation 6,400 feet, July.

Eriogonum (*Capitata*) *Kingii*, T. and G.—Mountains near Henry's Lake, Idaho, August.

Eriogonum microthecum, Nutt.—Port Neuf Cañon, Idaho, July; Snake River Valley.

Eriogonum brevicaule, Nutt.—Near Fort Bridger, Wyoming, August. *Dr. Joseph Leidy.*

Eriogonum cernuum, Nutt., var. *tenue*, T. and G.—Snake River Valley, July.

Eriogonum flavum, Nutt.—Snake River Plains, August; Lower Fire-Hole Basin.

Eriogonum salsuginosum, Hook.—Fort Bridger, Wyoming, August, *Dr. Joseph Leidy.*

Oxytheca dendroidea, Nutt.—Grows in great abundance in Snake River Valley, July.

Oxyria digyna, Campd.—Near Henry's Lake, Idaho, August; Téton Mountains, elevation 12,000 feet, July; Trail Creek Mountains, Wyoming, September; common on all the mountain-tops in the Snake River region.

Rumex venosus, Pursh.—Snake River Valley, July 14; Black Buttes, Utah, June 16.

Rumex longifolius, D. C.—Near Brigham City, Utah, June 25.

Rumex salicifolius, Weinm.—Near Ogden, Utah, June 7; Téton Basin, July 21.

Rumex maritimus, L.—Henry's Lake, Idaho, August 8.

Rumex (*Acetosa*) *paucifolius*, Nutt.—Snake River Valley, August.

Polygonum aviculare, L.—Near Ogden, Utah, June; Henry's Lake, Idaho, August 8.

Polygonum aviculare, L., var. *latifolium*, S. Watson, (Cl. King's Rep., vol. v, p. 315.)—Snake River Valley, July.

Polygonum aviculare, L., var. *erectum*, Roth.—Weber River, Utah, June 19.

Polygonum tenue, Michx.—Téton Basin, August 2; Snake River Valley, July.

Polygonum tenue, Michx., var. *latifolium*, Engelm.—Snake River Valley, August.

Polygonum amphibium, L.—Henry's Fork of Snake River, August 5.

Polygonum amphibium, L., var. *aquaticum*, Willd.—Divide between Marsh and Malade Valleys, June 29.

Polygonum amphibium, L., var. *terrestre*, Willd.—Madison Cañon, August 10; near Red Mountain, Wyoming, September 12.

Polygonum Persicaria, L.—Near Brigham City, Utah, June 25. Very probably introduced.

Polygonum viviparum, L.—Fire-Hole River, August 10.

Polygonum Bistorta, L., var. *oblongifolium*, Meisn.—Upper Téton Cañon, July 28; Henry's Fork of Snake River, August; Trail Creek Mountains, Wyoming, September 13.

Polygonum Bistorta, L., var. *linearifolium*, S. Watson, (Cl. King's Rep., vol. v, p. 317.)—Mountains near Henry's Lake, Idaho, August 9; Red Mountain, Wyoming, elevation 10,000 feet, September 11.

ELEAGNACEÆ.

Shepherdia Canadensis, Nutt.—Téton Basin, July 21.
Shepherdia argentea, Pursh.—Near Fort Bridger, Wyoming, August. *Dr. Joseph Leidy.*

SANTALACEÆ.

Commandra pallida, D. C., (Prodr. 14, 636.)—Téton Basin, July 21.

LORANTHACEÆ.

Arceuthobium Americanum, Nutt., in Herb. Durand. Found growing on *Pinus contorta*.—Henry's Fork of Snake River, August 5; along the Yellowstone. (See Cat., Hayden's Rep. for 1871.)

CERATOPHYLLACEÆ.

Ceratophyllum demersum, L. (?)—Henry's Fork of Snake River, August 6.

CALLITRICHACEÆ.

Callitriche verna, L.—Henry's Fork of Snake River, August 6.

EUPHORBIACEÆ.

Euphorbia dictyosperma, Fisch. and Meyer.—Plains near Ogden, Utah, June.
Euphorbia serpyllifolia, Pers.—Near Ogden, Utah, June 16; Lower Fire-Hole Basin, August; Snake River Valley, July.

URTICACEÆ.

Urtica gracilis, Ait.—Weber River, Utah, June.
Urtica dioica, L., var. *occidentalis*, S. Watson. (Clarence King's Rep., vol. v, p. 321.)—Foot-hills of the Téton Mountains, August.
Parietaria Pennsylvanica, Muhl.—Blackfoot River, Idaho, July.

BETULACEÆ.

Betula occidentalis, Hook.—Port Neuf Cañon, Idaho, July.
Betula glandulosa, Michx.—Upper Cañon of the Madison, August.
Alnus incana, Willd.—Téton foot-hills, July.

SALICACEÆ.

Salix longifolia, Muhl.—Henry's Fork of Snake River, July; divide between Marsh and Malade Valleys, June; foot-hills of Téton Mountains, August.
Salix nigra, Marsh, var. *amygdaloides*, Anders.—Plains near Ogden, Utah, June; Port Neuf Cañon, Idaho, July; Téton Basin.
Salix cordata, Muhl.—Near Ogden, Utah, June.
Salix cordata, Muhl., var. *augustata*, Anders.—Snake River Valley, August.
Salix Barrattiana, Hook.—"With ovaries nearly smooth!" Professor Porter. Along streams in Téton Basin, July.

Salix glauca, L.—Swamp on Henry's Fork of Snake River, August; Upper Cañon of the Madison.

Salix glauca, L., var. *pullata*, Anders.—Upper Téton Cañon, July; Red Mountain, Wyoming, September.

Salix arctica, R. Br.—Snake River Valley, August; Téton Mountains, elevation 12,000 feet, July.

Salix arctica, R. Br., var. *Brownii*, Anders.—Téton Mountains, elevation 12,000 feet, July.

Salix reticulata, L.—Téton Mountains, elevation 12,000 feet, July; mountains near Ogden, Utah, elevation 10,000 feet, June.

Populus tremuloides, Michx.—Téton foot-hills. Common everywhere in the West on foot-hills and following the courses of streams. It is known as "quaking asp."

Populus balsamifera, L., var. *angustifolia*, S. Watson, (*P. angustifolia*,) James.—Along the streams of the Téton Basin, July 22; common everywhere in the Northwest, in the lower altitudes; known as "bitter cottonwood."

CONIFERÆ.

Pinus contorta, Dougl.—Henry's Lake, Idaho, on mountains, August 5.

Pinus contorta, Dougl., var. *latifolia*, Engelm. (*Red Pine.*)—Mountains along Henry's Fork of Snake River, August 5; Lower Fire-Hole Basin, August.

Pinus ponderosa, Dougl. (*Yellow Pine.*)—Téton Range, elevation 6–8,000 feet, July 22.

Pinus flexilis, James.—Mountains near Henry's Lake, August 9; Téton Mountains, elevation 7–11,000 feet, July 24.

Abies Engelmanni, Parry. (*White Pine.*)—Téton Mountains, elevation 7–9,000 feet, July 24.

Abies Menziesii, Lindl. (*Balsam.*)—Grand Cañon of the Yellowstone, elevation 7–8,000 feet, August 22.

Abies amabilis, Forbes.(?)—Téton Range, elevation 8–10,000 feet, July 26.

Abies grandis, Lindl. (*White Spruce.*)—Mountains near Ogden, Utah, elevation 7–9,000, June 13; Trail River Mountains, Wyoming, elevation 6–9,000 feet, September 13.

Abies Douglasii, Lindl. (*Swamp Pine.*)—Mountains near Ogden, Utah, elevation 7–9,000 feet, June 8; Téton Mountains, elevation 7–10,000 feet, July 24.

Juniperus communis, L., var. *alpina*, L.—Mountains near Ogden, Utah, June 11, elevation 9–10,000 feet; Lower Fire-Hole Basin, August.

Juniperus Virginiana, L. (*Red Cedar.*)—Mountains along Henry's Fork of Snake River, 6–7,000 feet altitude.

Juniperus occidentalis, Hook.—Mountains near Ogden, Utah, elevation 5–7,000 feet, June 8; Téton Mountains, elevation 7–10,000 feet, July 24.

LEMNACEÆ.

Lemna trisulca, L.—Common in the waters of Henry's Fork of Snake River, August; it also occurs in great abundance upon the small streams in the two Geyser Basins.

Lemna polyrrhiza, L.—In the waters of Henry's Fork of Snake River, August; Jackson's Lake, September.

TYPHACEÆ.

Typha latifolia, L.—Snake River Valley, July; in swamps near Fort Hall, Idaho, in great abundance.

Sparganium simplex, Huds., var. *androcladum*, Engelm.—Weber River, Utah, June.

NAIADACEÆ.

Zannichellia palustris, L.—Yellowstone Lake, 1871.

Potamogeton perfoliatus, L., var. *lanceolatus*, Robbins.—Henry's Fork of Snake River, August 6.

Potamogeton pectinatus, L.—Upper Geyser Basin, August.

ALISMACEÆ.

Triglochin palustre, L.—Hot Springs, ten miles from Ogden, Utah, June 24.

Triglochin maritimum, L.—Swamps near Ogden, Utah, June 18; Upper Cañon of the Madison, August 10; Yellowstone Lake, August 23.

Sagittaria variabilis, Engelm.—Near Ogden, Utah, June 16; Henry's Fork of Snake River, August.

Sagittaria variabilis, Engelm., var. *hastata*, Gray.—Divide between Marsh and Malade Valleys, June 29.

Sagittaria variabilis, Engelm., var. *diversifolia*, Gray.—Weber River, Utah, June 19.

ORCHIDACEÆ.

Habenaria hyperborea, R. Br.—Swamps near Ogden, Utah, June 7; Upper Téton Cañon, July 28.

Habenaria dilatata, Gray.—Swamps near Ogden, Utah, June; Henry's Fork of Snake River, August; Téton River, July. Common along almost all the streams in the West.

Habenaria fœtida, S. Watson, (*Platanthera*, Gey.)—Wooded Cañon of Téton River, July.

Spiranthes Romanzoffiana, Cham.—Snake River Valley, July; Téton foot-hills, August; Fire-Hole Basin; Shoshone Lake, September; Jackson's Lake. Common almost anywhere along the route.

Goodyera Menziesii, Lindl.—East cañons of Téton Range, September.

Epipactis gigantea, Dougl.—Swamps near Ogden, Utah, June.

Corallorhiza multiflora, Nutt.—Shoshone Lake, Wyoming, September.

IRIDACEÆ.

Iris tenax, Dougl.—Téton Basin, July.

Sisyrinchium Bermudiana, L.—Malade Valley, Idaho, June; Henry's Fork of Snake River, August.

LILIACEÆ.

Zygadenus glaucus, Nutt.—Upper Cañon of the Madison, August; Téton Cañon, July; Trail Creek Mountains, Wyoming, elevation 10,000 feet, September.

Zygadenus Nuttallii, Gray.—Ogden Cañon, Utah, June; Trail Creek Mountains, Wyoming, September.

Xerophyllum tenax, Dougl.—Fort Ellis, Montana, to the Yellowstone, July.

Veratrum album, L.—Foot-hills of the Téton Mountains, August; swamp near Ogden, Utah, June.

Prosartes trachycarpa, S. Watson.—Mountains near Ogden, Utah, June; Gallatin Cañon, September.

Streptopus amplexifolius, D. C.—Upper Téton Cañon, July 26.

Smilacina racemosa, Desf., var. *amplexicaulis*, S. Watson.—Waterfall Cañon near Ogden, Utah, June 4; Téton Basin, July 21.

Smilacina stellata, Desf.—Near Ogden, Utah, May 31; Téton Mountains, elevation 10-11,000 feet, July 24.

Fritillaria atropurpurea, Nutt.—Mountains near Ogden, Utah, elevation 9,000 feet, June 4. In fruit.

Fritillaria pudica, Spreng.—Mountains near Ogden, Utah, elevation 9,000 feet, June 4; Mountains along Clark's Fork, Wyoming, elevation 9,000 feet.

Calochortus Nuttallii, T. and G.—Near Ogden, Utah, May 31; Snake River Plains, July; Henry's Fork of Snake River, July 17. "The 'Sego' of the Utes and Mormons." Watson.

Calochortus eurycarpus, S. Watson. (Cl. King's Rep., vol. v, p. 348.)—Henry's Fork of Snake River, August 5; differs very slightly from *C. Nuttallii*, and the two are indistinguishable except in mature ovaries.

Lloydia serotina, Reich.—Téton Mountains, elevation 11,500 feet, July; Mountains along Clark's Fork, Wyoming, elevation 9,000 feet.

Erythronium grandiflorum, Pursh.—Mountains near Ogden, Utah, elevation 9,000 feet, June.

Camassia esculenta, Lindl.—Henry's Fork of Snake River, July. The "Cammas" of the Bannock Indians. This species, as well as *Milla grandiflora*, are both known to the Indians as "Cammas," the former "Green Cammas," the latter "Blue Cammas," from the color of the blossoms. The former is the one used for food, while the latter is carefully avoided as being poisonous, although a large quantity must be eaten before any serious effect can be noticed.

Milla grandiflora, Baker. (*Triteleia grandiflora*, Lindl.)—Ogden Cañon, Utah, June; Téton Cañon, July.

Allium brevistylum, S. Watson. (Clarence King's Rep., vol. v, p. 350.)—Upper Téton Cañon, July.

Allium bisceptrum, S. Watson, (*loc. cit.*, p. 351, pl. xxxvii.)—Ogden Cañon, Utah, June.

Allium stellatum, Fraser.—Snake River Valley, July.

Allium acuminatum, Hook.—Téton Basin, July.

Allium Schœnoprasum, L.—Near Ogden, Utah, June; Henry's Lake, Idaho, August.

JUNCACEÆ.

Juncus Balticus, Deth., var. *montanus*, Engelm.—Téton Cañon, July.

Juncus tenuis, Willd.—Fire-Hole Basin, August.

Juncus bufonius, L.—Henry's Fork of Snake River, July.

Juncus longistylis, Torr.—Henry's Fork of Snake River, July.

Juncus Mertensianus, Bong.—Uintah Mountains, Wyoming, August. *Dr. Joseph Leidy.*

Juncus xiphioides, E. Meyer.—Yellowstone River, August.

CYPERACEÆ.

Determined by S. T. Olney, Esq.

Cyperus inflexus, Muhl.—Near Ogden, Utah, June 16.

Scirpus validus, Vahl.—Ogden Cañon, Utah, June 8.

Scirpus microcarpus, Presl.—Swamp near Ogden, Utah, June 18.

Scirpus atrovirens, Muhl.—Henry's Fork of Snake River, July 16.

Carex scirpoidea, Michx.—Swamps near Ogden, Utah, June 18.

Carex disticha, Hudson.—Swamps near Ogden, Utah, June 16.

Carex Douglasii, Boott.—Male. Divide between Marsh and Malade Valleys, June 29.

Carex leporina, L.—Red Mountain, elevation 10,000 feet, September 11; Téton Mountains, elevation 12,000 feet, July 29.

Carex festiva, Dewey.—Mountains near Ogden, Utah, elevation 9,000 feet, June; Twin Buttes, on Henry's Fork of Snake River, July 16; Fall River, Idaho, July 20; Wooded Cañon, Téton River, July 23; Téton Basin, August 2; Mountains near Henry's Lake, Idaho, August 9.

Carex vulgaris, Fries., var. (?)—Growing in the spray of the Lower Falls of the Yellowstone, August 22.

Carex Jamesii, Torr.—Swamps near Ogden, Utah, June.

Carex Jamesii, Torr., var. *Nebraskensis*, Olney, (*C. Nebraskensis*, Dewey,) (Clarence King's Rep., vol. v, p. 368.)—Malade Valley, Utah, June.

Carex laciniata, Boott.—Intermediate between the type and *C. Jamesii*. California specimens have rougher, longer, and more hispid awns to the scales. Swamps near Ogden, Utah, June.

Carex rigida, Good.—Terminal spikes—male. Red Mountain, Wyoming, elevation 10,000 feet, September.

Carex aurea, Nutt.—Henry's Fork of Snake River, July; Téton Basin, Fire-Hole River, August; Mountains along the Yellowstone.

Carex atrata, L.—Téton Mountains, elevation 10,000 feet, July.

Carex alpina, Swartz.—Uintah Mountains, Wyoming, August. *Dr. Joseph Leidy.*

Carex nigra, All., (*C. atrata*, var. *nigra*, Boott.)—Téton Mountains, elevation 11,000 feet, July.

Carex Raynoldsii, Dewey, (*C. Lyallii*, Boott.)—Téton Mountains, elevation 10,000 feet, July.

Carex capillaris, L.—Uintah Mountains, Wyoming, August. *Dr. Joseph Leidy.*

Calex utriculata, Boott., var. *globosa*, Olney.—From the Lower Falls of the Yellowstone to Yellowstone Lake, August.

Carex vesicaria, L.—Wooded Cañon of Téton River, July.

Carex stellulata, L.—Swamps near Ogden, Utah, June.

Carex ———, (?)—Too young for determination. Téton Basin, July.

Carex ———, (?)—Too young for determination. Henry's Fork of Snake River, July.

GRAMINACEÆ.

Determined by Dr. Geo. Vasey.

Alopecurus glaucus, L. (?)—Téton foot-hills, August; Snake River Valley, July.

Phleum alpinum, L.—Weber River, Utah, June; Upper Téton Cañon, July; Grand Cañon of the Yellowstone, August.

Vilfa cryptandra, Torr.—Snake River Valley, July.

Vilfa airoides, Trin.—Great Salt Lake, June; hot springs, ten miles from Ogden, Utah; Marsh Valley, Idaho.

Vilfa asperifolia, Nees. and Meyer.—Port Neuf Valley, Idaho, July; common in both Geyser Basins, August; Twin Buttes on Henry's Fork of Snake River.

Vilfa depauperata, Torr.—Blackfoot River, Idaho, July; Henry's Fork of Snake River; Upper Geyser Basin, August.

Agrostis perennans, Gr.—Lower Geyser Basin, August.

Agrostis scabra, Willd.—Snake River Valley, July; Lower Geyser Basin, August; Jackson's Lake, September.

Agrostis exarata, Trin.—Téton Mountains, elevation 10,000 feet, July.

Agrostis canina, L., var. *alpina*, Oakes.—Growing in the spray of the Grand Falls of the Yellowstone, August.

Cinna arundinacea, L.—Union Pass, Gallatin River, September.

Vaseya comata, Thurber.—Upper Geyser Basin, August.

Calamagrostis Canadensis, Beauv.—Henry's Fork of Snake River, July; Téton foot-hills, August.

Calamagrostis Langsdorffii, Trin.—Henry's Fork of Snake River, July.

Calamagrostis stricta, Trin.—Uintah Mountains, Wyoming, August, 1872, *Dr. Joseph Leidy*; Téton Basin, August; Henry's Fork of Snake River, July.

Calamagrostis sylvatica, D. C.—Téton Basin, July; Henry's Lake, Idaho; August; Téton Range.

Eriocoma cuspidata, Nutt.—Plains near Ogden, Utah, June; Snake River Valley, July; Upper Cañon of the Madison, August. A valuable "bunch-grass."

Stipa spartea, Trin.—Near Brigham City, Utah, June; Fort Hall, Idaho, July.

Stipa comata, Trin.—Snake River Plains, July.

Stipa viridula, Trin.—Henry's Fork of Snake River, July.

Bouteloua oligostachya, Torr.—Union Pass, Gallatin River, September.

Spartina gracilis, Trin.—Snake River Valley, July; found in both Geyser Basins, August.

Kœleria cristata, Pers.—Plains near Ogden, Utah, June; Marsh Valley, Idaho; Téton foot-hills, July; Upper Cañon of the Madison, August.

Eatonia obtusata, Gray.—Port Neuf Cañon, Idaho, July.

Melica bulbosa, Geyer. (Gray, in Proc. Am. Acad., May, 1872.) The *M. poæoides* of Whipple's Rep. and Bolander, but not of Nuttall.—Near Ogden, Utah, June; Snake River Valley, July; Upper Téton Cañon.

Melica stricta, Boland.—Red Mountain, elevation 10,000 feet, September.

Glyceria nervata, Trim.—Port Neuf Valley, Idaho, July; Shoshone Lake, September.

Glyceria pauciflora, Presl.—Snake River Valley, July.

Glyceria distans, Wahl.—Upper Geyser Basin, August.

Brizopyrum spicatum, Hook.—Great Salt Lake, June; hot springs, ten miles from Ogden, Utah; Snake River Valley, July.

Poa alpina, L.—Téton Range, elevation 10,000 feet, July.

Poa Eatoni, S. Watson.—Near Great Salt Lake, Utah, June.

Poa Kingii, S. Watson.—Near Great Salt Lake, Utah, June; Téton Range.

Poa tenuifolia, Nutt.—Uintah Mountains, Wyoming, August, 1872. *Dr Joseph Leidy*.

Atropis Californica, Munro.—Malade Valley, Utah, June.

Festuca tenella, Willd.—Plains near Ogden, Utah, June.

Festuca microstachys, Nutt.—Plains near Ogden, Utah, June.

Bromus breviaristatus, Thurber, (?) (*Ceratochloa*, Hook.)—Marsh Valley, Idaho, June; Téton Basin, July.

Bromus ciliatus, L.—Upper Cañon of the Madison, August.

Phragmites communis, L.—Port Neuf Valley, Idaho, July.

Triticum repens, L.—Port Neuf Cañon, Idaho, July; Snake River Valley. It is known as "blue-joint," and is valuable for hay and grazing. Found also in the Upper Geyser Basin, August.

Triticum caninum, L.—Upper Geyser Basin, August.

Triticum strigosum, Steud., (*Bromus*, Bieb., *T. ægilopoides*, Turcz.)—Téton Basin, July.

Triticum glaucum, Desf. (?)—Port Neuf Valley, Idaho, July; Snake River Valley.

Hordeum pusillum, Nutt.—Marsh Valley, Idaho, July; Snake River Valley; Téton foot-hills, August.

Hordeum jubatum, L.—Ogden Cañon, Utah, June; Snake River Valley, July.

Hordeum jubatum, L. var.—Peculiar to the Upper Geyser Basin.

Elymus mollis, Trin.—Henry's Fork of Snake River, July.

Elymus condensatus, Presl.—Fort Hall, Idaho, July; Téton Basin; Snake River Valley; Blackfoot River.

Elymus Sitanion, Schult., (*Sitanion elymoides*, Raf., and *Polyantherix Hystrix*, Nees.)—Great Salt Lake, Utah, June; Henry's Lake, Idaho, August; Lower Geyser Basin, September.

Elymus Sibiricus, L.—Henry's Fork of Snake River, July; Upper Geyser Basin, August.

Danthonia Californica, Boland.—Henry's Fork of Snake River, July; Téton foot-hills, August.

Trisetum subspicatum, Beaud.—Trail River Mountains, elevation 10,000 feet, September.

Trisetum subspicatum, Beaud., var. *muticum*.—Téton Cañon, July.

Trisetum subspicatum, Beaud., var. *molle*, Uintah Mountains, Wyoming, August, 1872. *Dr. Joseph Leidy.*

Aira flexuosa, L.—Hot springs ten miles from Ogden, Utah, June.

Aira cæspitosa, L.—Fire-Hole River, August.

Phalaris arundinacea, L.—Marsh Valley, Idaho, June; Snake River Valley, July; Upper Cañon of the Madison, August. "Known as 'crazy grass,' from its reputed injurious effect upon horses." Watson.

Panicum capillare, L.—Yellowstone Lake, August; very common in both Geyser Basins.

EQUISETACEÆ.

Equisetum arvense, L.—Ogden Cañon, Utah, June.

Equisetum hyemale, L.—Henry's Fork of Snake River, July.

Equisetum pratense, Ehr.—Henry's Fork of Snake River, July.

Equisetum variegatum, Schleicher.—Lower Fire-Hole Basin, August.

Equisetum scirpoides, Michx.—Snake River Valley, July.

FILICES.

Pteris aquilina, L.—Shoshone Lake, September; Upper Geyser Basin, August.

Pellæa Breweri, D. C. Eaton.—Mountains near Ogden, Utah, June; Téton Range, July.

Pellæa densa, Hook.—Jackson's Lake, September 23.

Cryptogramme acrostichoides, R. Br.—New Geyser Basin on Shoshone Lake, September 6.

Aspidium Lonchitis, Swartz.—Upper Téton Cañon, July 28.

Aspidium spinulosum, Swartz.—Eastern cañons of the Tèton Range, September.

Cystopteris fragilis, Benth.—Téton Range; along Snake River.

Botrychium lunarioides, Swartz., var. *obliquum*, Gray.—Common in both Geyser Basins, August.

Woodsia scopulina, D. C. Eaton.—Lower Falls of the Yellowstone, August; Eastern cañons of the Téton Range, September.

Woodsia Oregana, D. C. Eaton.—Mountains near Ogden, Utah, June.

LYCOPODIACEÆ.

Selaginella rupestris, Spreng.—Common everywhere on the route.

HYDROPTERIDES.

Marsilia vestita, Hook. and Grev.—In the water of Henry's Fork of Snake River, July 18.

CHARACEÆ.

Chara fragilis? Desv., no fruit.—Yellowstone Lake, August 23.

Nitella ———, (?) Species undeterminable.

MUSCI.

Determined by Leo Lesquereux, Esq.

Sphagnum acutifolium, Ehrh.—Shoshone Lake, September.

Dicranum interruptum, Bryol. Eur.—Upper Téton Cañon, July 24.

Dicranum scoparium, Hedw., (Bryol. Eur.)—Upper Téton Cañon, July 24.

Ceratodon purpureus, Brid.—Téton Cañon, July; Snake River, September; Fort Hall, Idaho, October.

Encalypta vulgaris, Hedw.—Near Fort Hall, Idaho, July.

Grimmia (*Schistidium*) *conferta*, Funk.—Near Fort Hall, Idaho; Yellowstone Valley, August.

Grimmia Scouleri, Müll.—Yellowstone Valley, August.

Grimmia calyptrata, Hook.—Fort Hall, Idaho, July.

Racomitrium fasciculare, Brid.—Hot springs near Ogden, Utah, June; Henry's Fork of Snake River, July; Jackson's Lake, September.

Racomitrium fasciculare, Brid., var.—Téton Cañon, July 26.

Racomitrium lanuginosum, Brid.—Upper Téton Cañon, July 26.

Hedwigia ciliata, Ehrh.—Shoshone Lake, September.

Bartramia fontana, Brid.—Hot springs near Ogden, Utah, June; Fort Hall, Idaho; Téton Cañon, July; Fire-Hole Basin; Yellowstone Valley, August; Jackson's Lake, September; Snake River Cañon, October.

Bartramia fontana, Brid., var.—Téton Cañon, July 24.

Bryum pyriforme, Hedw.—Yellowstone Lake, August 23.

Bryum intermedium, Brid.—Téton Cañon, July 24; First Cañon of the Gallatin; Jackson's Lake, September.

Bryum bimum, Schreb.—First Cañon of the Gallatin, sterile; Fort Hall, Idaho, July.

Bryum pseudo-triquetrum, Bryol. Eur.—Shoshone Lake, September.
Bryum turbinatum, Hedw.—Upper Téton Cañon, July 26.
Bryum inclinatum, Hedw.—Upper Téton Cañon, July 26.
Bryum ——, (?) undeterminable, no fruit.—Téton Cañon, July.
Bryum ——, (?) undeterminable, no fruit.—Téton Basin, August.
Bryum ——, (?) undeterminable.—Téton Range; elevation 10,000 feet, July 24.
Bryum ——, (?) undeterminable, no fruit.—Téton Cañon, July 26.
Bryum ——, (?) no fruit.—Yellowstone Valley, August 23.
Bryum ——, (?) undeterminable, no fruit.—Jackson's Lake, September.
Bryum ——, (?) undeterminable, no fruit.—Lower Fire-Hole Basin, August.
Mnium punctatum, Hedw.—Near Fort Hall, Idaho, July.
Mnium cuspidatum, Hedw.—Shoshone Lake, September.
Mnium affine, Bland.—Upper Téton Cañon, July 26.
Mnium ——, (?) undeterminable.—Téton Cañon, July 24.
Aulacomnion palustre, Schwægr.—Téton Cañon, July 24; Shoshone Lake, September.
Timmia megapolitana, Hedw.—Fort Hall, Idaho, July; Téton Cañon, July 24.
Polytrichium juniperinum, Hedw.—Fort Hall, Idaho, July 5.
Fontinalis antipyretica, L.—Henry's Fork of Snake River, July 16.
Dichelyma falcatum, Myrin.—Snake River Valley, July 15.
Camptothecium Nevadense, Lesqx.—First Cañon of the Gallatin, September 18.
Climacium dendroides, Web. and Mohr.—Upper Cañon of the Madison, August.
Hypnum triquetrum, L. (*Hylocomium triquetrum*, Bryol. Eur.)—Téton Cañon, July 24; First Cañon of the Gallatin, September 18.
Hypnum splendens, Hedw. (*Hylocomium splendens*, Bryol. Eur.)—First Cañon of the Gallatin, September 18.
Hypnum giganteum, Schimp.—Upper Téton Cañon, July 26.
Hypnum uncinatum, Hedw.—Téton Cañon, July 24; Yellowstone Valley, August 23; First Canon of the Gallatin, September 18.
Hypnum fluitans, L.—Jackson's Lake, September.
Hypnum aduncum, Hedw.—Yellowstone Lake, August 23.
Hypnum salebrosum, Hoffm., (*Brachythecium salebrosum*, Bryol. Eur.)—Upper Téton Cañon, July 26.
Hypnum lætum, Brid.—Yellowstone Valley, August 23.
Hypnum rivulare, Bruch., (*Brachythecium rivulare*, Bryol. Eur.)—Upper Téton Cañon, July 26.
Hypnum Nuttallii, Wils., (*Leskea Californica*, Hampe in Linæa, 1859, p. 460.)—Téton Cañon, July 24; First Cañon of the Gallatin, September, 18.
Hypnum riparium, L., (*Amblystegium riparium*, Bryol. Eur.)—Yellowstone Valley, August 23; Fire-Hole Basin, September.
Hypnum riparium, L., var.—Snake River Valley, July.
Hypnum filicinum, L.—First Cañon of the Gallatin, September 18.
Hypnum irriguum, Wils., var. *fallax*, Brid.—Near Fort Hall, Idaho, July 5.

HEPATICÆ.

Riccia crystallina, L.—Téton Cañon, July 26.
Marchantia polymorpha, L.—Henry's Fork of Snake River, July: Shoshone Lake, September 6.

Fegatella conica, Corda.—Upper Téton Cañon, July 28; Lower Fire-Hole Basin, August.

LICHENS.

Determined by Henry Willey, Esq.

[The order is that of Tuckerman's *Genera Lichenum*.]

Evernia vulpina, Wulf.—On trees at the Grand Falls of the Yellowstone. Fertile. (1.)

Usnea trichodea, Ach.—In some of the specimens the fibrils are tipped with minute black points resembling spermogones, but no spermatia could be detected. (2.)

Alectoria jubata, Fr.—Shoshone Lake, September. Infertile. (3.)

Alectoria jubata, Fr., var. *implexa*, Fr.—On branches of Coniferæ. Infertile. (3*a*.)

Theloschistes parietinus, (L. Desf.) Nyl., var. *lychneus*, Schær.—On dead wood, Jackson's Lake, September. (4.)

Parmelia saxatilis, Ach.—Fragments. Infertile. (5.)

Parmelia conspersa, Ach.—Infertile fragments. (6.)

Parmelia physodes, Ach.—On branches. (7.)

Parmelia olivacea, Ach., var. *exasperata*, (D.N.)—Very small and scanty specimens on dead wood. (8.)

Umbilicaria polyphylla, Hoffm.—Shoshone Lake, September. Infertile. (9.)

Umbilicaria cylindrica, Ach. (?)—Infertile. (10.)

Umbilicaria hirsuta, Ach.—Infertile. (11.)

Umbilicaria rugifera, Nyl.—Téton Mountains, elevation 12,000 feet, July 29. (12.)

Peltigera aphthosa, Hoffm.—Mystic Lake, near Fort Ellis, Montana, July. (13.)

Peltigera canina, Hoffm.—Téton Cañon; hot springs, and elsewhere. (14.)

Peltigera canina, Hoffm., var. *spuria*, Ach.—Téton Cañon. (14 *a*.)

Solorina saccata, Ach., var. *spongiosa*, Nyl.—On the earth among Algæ; Cañon Creek, Idaho, September. (14*b*.)

Placodium cladodes, Tuckerm.—Téton Mountains. Infertile. (15.)

Placodium coralloides, Tuckerm.—Téton Cañon, (16.)

Placodium murorum, (Hoffm.,) D. C.—The specimens are numerous. (17.)

Placodium murorum D. C., var. *citrinum*, (Ach.) Nyl.—With the above, but less abundant. (17*a*.)

Placodium callopismum, Ach.—The specimens are numerous. (18.)

Placodium peliophyllum, Tuckerm., (Genera, p. 108.)—Thallus crustaceous and white at the center, at the circumference laciniate linear multifid, glaucous fuscescent. Apothecia central crowded, the margin entire, disk-plane white, pruinose, cracked. Paraphyses articulate. Hymenial gelatine blue with iodine. Spores polar-bilocular, .016–21 min. long, .008–10 min. wide. On rocks, Fort Ellis, Montana. (19.)

The specimens are scanty, but I venture to refer it as above, though I have only seen the brief description cited.

Placodium variabile, (Pers.,) Nyl.(?)—Thallus tartarious, rimose areolate, whitish. Apothecia sessile, the disk black. Spores polar-bilocular, .015–18 min. long, .007–9 min. wide. (20.)

The single fragment is very small, and hardly sufficient for satisfactory determination.

Placodium vitellinum, (Ehrh.,) Ach.—On dead wood. (21.)

Placodium luteo-minium, Tuckerm. Lich. Calif., p. 18.—A small Placodium growing among mosses, which seems referable here. (22.)

Placodium ———, (?)—A few scattered apothecia with a plane ferrugineous disk, in rocks among other lichens, not sufficient for determination. (23.)

Lecanora rubina, Ach., var. *peltata*, D. C. (24.)

Lecanora rubina, Ach., var. *opaca*, Ach.—The specimens of both these varieties abundant. (24*a*.)

Lecanora muralis, (Schreb.) Schær. (25.)

Lecanora ———, (?) (26.)

Lecanora ———, (?) (27.)

These two lichens belong to the section *Squamaria*, but I am unable to identify them from the scanty fragments. The thallus resembles that of *L. cartilaginea*, as described, but the apothecia are like those of *L. subfusca*; in the one with a convex, rufous fuscous disk and entire margin; in the other with a plane, black disk and flexuous margin. Spores simple, .012–15 min. long, one-half as wide. Both are perhaps forms of the same plant.

Lecanora subfusca, Ach.—On stones and dead wood. (28.)

Lecanora varia, Fr.—On dead wood. (29.)

Lecanora Hageni, Ach.—On stones. (30.)

Lecanora cinerea, L., var. *Hoffmanni*, Ach.—Some of the specimens have a plicate crust, but seem not separable. (31.)

Lecanora rhagadiosa, Ach. (*Acaraspora scabra*, Th. Fr. Scand., p. 208.)—Red Mountain, elevation 9,000 feet. New to this continent, and, with *Lecidia mamillaris* mentioned below, an interesting addition to the few lichens common to only the western slope of North America and Europe. (32.)

Lecanora xanthophana, Nyl.—On rocks. (33.)

Lecanora chlorophana, (Wahl.) Ach.—On rocks.

Lecanora Schleicheri, (Ach.,) Nyl.—On the earth, the specimens scanty. (35.)

Lecanora cervina, (Pers.,) Somf., var. *glaucocarpa*, Somf. (35.)

Lecanora cervina, (Pers.,) Somf., var. *squamulosa*, Fr.—Some of the specimens have prominent brownish-black spermogones with minute spermatia, .002 min. long. (36*a*.)

Lecanora cervina, (Pers.,) Somf., var. *glebora*, (Kbv.)—The specimens are numerous, some of them approaching the var. *disacta*, Fr. (36*b*.)

Lecanora ———, (?) Thallus areolate verrucose, cæsius pruinose. Apothecia immersed, 1 to 3 in the areoles, the disk plane, black or white pruinose. Thekes myriosphorous. Spores elliptical, .005–.006 min. long, one-half as wide. On rocks with the preceding, from which it is perhaps distinct. (37.)

Rinodina sophodes, (Ach.,) var. *exigua*, Nyl.—On dead-wood. (38.)

Rinodina Bischofii, (Hepp.,) Kbv.—On rocks. (39.)

Cladonia pyxidata, Fr. (40.)

Cladonia gracilis, Fr., var. *verticillata*, Fr., Charles H. Peck, esq, (40*b*.)

Cladonia fumbriata, Fr. (40*a*.)

Cladonia rangiferina, Hoffm. (41.)

Cladonia squamosa, var. *delicata*, Fr. Charles H. Peck, esq., (41*b*.)

Biatora decipiens, Fr. (42.)

Biatora luridella, Tuckerm. (43.)

Lecidea contigua, Fr.—A single specimen. (44.)

Lecidea ———(?)—A small lichen on dead wood, with the habit of *L. melancheuria*, but with larger spores. Perhaps to be referred to *L. sabuletorum*, Fr. (45.)

Lecidea spilota, Fr.—A single specimen. (46.)

Lecidea polycarpa, Flk.—A single specimen. (47.)

Lecidea atro-brunnea, (D. C.,) Schær. (48.)

Lecidea fusco-atra, (Ach.,) Fr. (?)—A single specimen, about which I am not certain. (49.)

Lecidea mamillaris, (Gonan Schær.)—On the earth. New to this continent. (50.)

Lecidea caulescens, Anz.—A single fragment. (51.)

Buellia myriocarpa, D. C.—On dead wood. (52.)

Buellia petræa, (Fl.,) var. *geminata*, (Nyl.)—A single specimen. (53.)

Buellia petræa, (Fl.,) var. *Montagnei*, (D. C.)—A single specimen. (53*a*.)

Acolium ———(?)—Thallus verrucose, the verrucæ turgid, glaucescent. Apothecia innate-sessile, on the apex of the verrucæ, the disk-plane surrounded by a cupula, black proper exciple, with no traces of a thallium margin. Hypothecium white. Spores bilocular, .004–23 min. long, .009–11 min. wide. A few specimens occurred on dead wood. Perhaps a new species. (54.)

Endocarpon miniatum, (L.) Schær., var. *complicatum*, Schær. (55.)

Endocarpon pusillum, Hedw.—Two or three squamules, on the earth. (56.)

There are five or six other lichens in the collection, but infertile and insufficient for determination.

FUNGI.

Determined by Charles H. Peck, Esq.

Agaricus geophyllus, Sow.—Téton Cañon, July 24.

Thelephora terrestris, Fr.—Along the Yellowstone.

Lycoperdon pyriforme, Schæff.—Near Yellowstone Lake, August 23.

Melamsora salicina, Lev.—Head-waters of Snake River, September 11.

Æcidium pyratum, Schw.—Head-waters of Snake River, September 11.

Peziza (*Macropodes*) *vulcanalis*, *n. sp.*—Cup fleshy, funnel-form, stipitate, crenate on the margin, smooth when fresh, rugulose and more or less brown when dry; hymenium pale orange; stem slender, solid, smooth, brown; asci cylindrical; paraphyses slightly thickened at the tips; spores elliptical, smooth, 0.0004–0.0006 inch long, 0.0003 inch broad. Plant, 6–10 lines high; cup 4–6 lines broad. Ground. Extinct volcano, Snake River, July 16; Twin Buttes.

Hysterium Pinastri, Fr.—Near Yellowstone Lake, August 23. On pine leaves with the following:

Sphæria (*Byssisedæ*) *Coulteri*, *n. sp.*—Subiculum effused, indeterminate, brown; perithecia small, gregarious, subglobose, fragile, involved in the subiculum, the ostiole prominent, naked, irregular, rough, black; asci fugacious; spores uniseriate, uniseptate, constricted in the middle, colored, 0.0008–0.001 inch long, 0.0003–0.00035 inch broad. Leaves and branchlets of pines. Near Yellowstone Lake, August. The soft, almost cottony subiculum creeps extensively over the leaves, binding them together in masses, and sometimes presenting upon the surface a shining membranous appearance. The perithecia are closely invested by it, the rather large ostiola alone protruding above it. Dedicated to its discoverer, J. M. Coulter.

Clavaria formosa, Pers.—Jackson's Lake, September.

Geaster hygrometricus, Pers.—No locality.

ALGÆ.

Zygnema fontana, (?)—Common in Henry's Fork of Snake River.

PART IV.

REPORT

ON

ASTRONOMY AND HYPSOMETRY.

REPORT ON ASTRONOMY AND HYPSOMETRY.

By Henry Gannett, M. E.

WASHINGTON, D. C., *April* 11, 1873.

SIR: I have the honor to submit to you the following report on the astronomical, hypsometrical, and meteorological work of the United States Geological Survey of the Territories during the season of 1872.

The field-work of the Yellowstone division was conducted by myself, assisted by Professor E. B. Wakefield, of Hiram College; Mr. A. E. Brown, and Mr. T. O'C. Sloane.

The field-work of the Snake River division was conducted by Mr. Rudolph Hering, assisted by Messrs. Thomas W. Jaycox and W. A. West. Mr. William Nicholson was stationed at Fort Hall through the summer taking barometric observations. During the winter he has assisted me in the office-work.

Mr. Hering left the survey early in the spring, shortly before his report was completed. I have finished it, and present it in as complete a form as possible.

The meteorological observations at Fort Hall, and at the camps of the two divisions, I have thought best to print in a volume separate from the report, putting in the report only a few deductions from them.

I would express my thanks for assistance received from the United States Coast Survey, the Navy Department, the Signal Service of the United States Army, Captain J. E. Putnam, at that time in command at Fort Hall, and to General J. E. Blaine, surveyor-general of Montana.

I am, sir, very respectfully, yours,

HENRY GANNETT.

Dr. F. V. HAYDEN,
United States Geologist.

The astronomical instruments placed at my disposal were: an astronomical transit, belonging to the United States Coast Survey, of one and a half inches aperture and sixteen inches focal length; a zenith telescope belonging to the United States Coast Survey; two sextants and artificial horizons; a box-chronometer rated on sidereal time; two pocket-chronometers, the property of the United States Navy, rated on mean time.

Of these, a sextant and horizon and one of the pocket-chronometers were put in charge of Mr. Hering for use in the Snake River division. The chronometer ran very badly, stopping on several occasions, of course making longitude determinations by it worthless. I append the list of latitudes.

The pocket-chronometer taken by me got out of order while at Fort Ellis, and was of no use on the trip.

The latitude of Fort Hall was determined with the zenith telescope by observations on five pairs of stars on three nights. The result, with a probable error of 0″.80, is given below.

Having been disappointed in my plans for determining longitude by telegraph, where the telegraph was available, I was compelled to resort to moon culminations, whenever the time permitted.

At Fort Hall I observed through one lunation, obtaining seven culminations, which gave the result submitted below, with a possible error of 7.4 seconds.

The latitude of Fort Ellis, and of all other stations besides Fort Hall, was determined with the sextant, by observations on Polaris and a south star, whenever possible, and on the sun whenever the movements of the party permitted.

For the determination of the longitude of Fort Ellis, I succeeded in obtaining only two moon culminations. I have adopted the longitude given by chronometer in preference.

The longitudes of the other stations in the list of astronomical positions appended depend on observations with the sextant on the east and west stars, or on the sun, and the rate of the chronometer. This has been exceptionally good, having lost from observations made at Salt Lake City at the beginning and end of the trip, by 2 minutes, 13.65 seconds, between May 28 and October 29. Its rate was checked during the season by returning to Fort Ellis, the Three Forks of the Missouri, and Fort Hall, and, in all cases, was found to be very uniform.

YELLOWSTONE DIVISION.

List of astronomical positions.

	ϕ			ω		
	°	′	″	°	′	″
Fort Hall, Idaho	43	8	54.98	112	6	30
Virginia City, Mont., (United States signal-service office)	45	19	1.5	111	56	30
Fort Ellis, Mont., (camp 1)	45	40	40	111	0	15
Helena, Mont., (surveyor-general's office)	46	35	36.8	111	52	45
Camp 3	45	26	20.6	110	46	58
Camp 4, Bottler's Ranch	45	19	58	110	50	15
Camp 5	45	12	27.1	110	56	30
Camp 6	45	4	52.9	110	50	26
Mouth of Gardiner's River, northern boundary of Yellowstone National Park	45	2	2	110	43	15
White Mountain Hot Springs, (camp 7)	44	58	31.2	110	43	25
Camp 8	44	59	27.8	110	36	30
Camp 9	44	56	8.2	110	30	10
Yellowstone Falls, (camp 11)	44	44	17.1	110	33	48
Camp 12	44	36	26.3	110	32	27
Head of Yellowstone River, at lake	44	32	47.3	110	32	14
Camp 13	44	35	35.4	110	50	35
Lower Geyser Basin, (camp 14)	44	34	30.6	110	55	15
Camp 15	44	38	32.2	110	58	54
Camp 16	44	41	30.2	111	8	52
Camp 17	44	48	15.7	111	23	45
Camp 18	44	52	47.4	111	26	36
Camp 19	44	50	43.3	111	33	27
Camp 21	45	7	35.3	111	44	0
Camp 22	45	13	4.1	111	50	12
Camp 25	45	39	19.4	111	40	40
Three Forks of the Missouri, (camp 27)	45	55	51	111	34	6
Camp 28	45	47	51.8	111	16	31
Camp 35	45	14	51.1	111	21	46
Camp 36	45	10	58.6	111	12	5
Camp 39	45	34	8.1	110	39	10
Camp 41	45	44	14.4	110	58	23
Camp 42	45	51	56	110	58	42
Camp 43	45	58	19	111	10	15
Camp 44	46	1	17	111	29	40
Western boundary of Yellowstone National Park				111	14	33
Southern boundary of Yellowstone Nat'l Park, (approx)	44	9	30			
Eastern boundary of Yellowstone Nat'l Park, (approx)				110	9	0

The magnetic variation was determined by observing the azimuth of Polaris with the gradienter, an instrument reading to minutes; the results are to be depended on to that degree of precision. I append the list:

Date.	Place of observation.	Mag. var., east.	
		°	′
July 12, 1872	Fort Ellis	19	41
July 27, 1872	White Mountain Hot Springs	19	17
Aug. 7, 1872	Yellowstone Falls	19	0
Aug. 15, 1872	Lower Geyser Basin	18	29
Aug. 31, 1872	Mouth of Indian Creek	19	22
	Virginia City *	19	15
Sept. 9, 1872	Gallatin City	19	31
Sept. 23, 1872	Head of Gallatin, (latitude 45° 15′)	19	9
Oct. 12, 1872	Helena	19	59

* Given me by Mr. Corbett, of Virginia City, United States Dep. Min. Sur.

The instruments placed at my disposal for hypsometric and meteorological work were six of Green's cistern barometers, two of these being single and four of them double, vernier barometers, with a sufficient supply of wet and dry bulb and maximum and minimum thermometers, and a good supply of aneroids.

I decided upon Fort Hall, Idaho, and Virginia City, Montana, as suitable and available base-stations. The altitude of the former place was determined by coincident observations at this point, and Ogden, Utah, (the elevation of which was taken from railroad levels,) for three weeks during the month of June; that of Virginia City, by coincident observations between that point and Fort Hall, during the months of June, July, August, and September.

The base observations at Fort Hall were made by Mr. Wm. Nicholson, of the survey. They were made hourly from 7 a. m. to 9 p. m., during the whole time that the parties were in the field.

The United States signal-service, through its sergeant observer at Virginia City, Mr. A. B. Knight, kindly allowed me the use of the observations taken there, for hypsometric purposes, modifying slightly, to suit my wishes, their method of observation. One of the single vernier barometers, with dry and wet bulb and maximum and minimum thermometers, was left at Fort Hall, for Mr. Nicholson's use. I gave to Mr. Hering, who took charge of this work in the Snake River division, two of them, with the other necessary instruments, and reserved the others for use in the Yellowstone division.

Aneroids have been used considerably, especially where closely accurate results were not required, and have been found, if compared daily with the mercurial barometers, and carefully used, to be sufficiently accurate for the purposes for which they were employed.

I have paid some attention to elevations of the water-level of streams, not only for getting the rate of fall, which may be of use for purposes of irrigation, &c., but as indicating what may be called the water-contour of the country, which certainly expresses the general elevation of the country better than any other class of observations.

As the question of the location of a railroad from some point on the Central Pacific Railroad to the settled portions of Montana is now of much interest, I paid considerable attention to that portion of the route up Henry's Fork of the Snake River, over Raynold's Pass and down the Madison, a route which has recently begun to attract attention, over which we traveled; *i. e.*, from the valley of Henry's Lake over Raynold's Pass, and thence down the Madison River to the Three Forks of the Missouri. The route pursued by our train down the Madison, from the foot of the Middle Cañon, is by no means the easiest route. A railroad can follow closely the bank of the river with little expense from this point to the head of the Lower Cañon at Meadow Creek.

The valley of Henry's Lake is broad and perfectly level, but very swampy near the lake. A road coming up Henry's Fork of the Snake, would make a sweep around the lake, keeping at a distance of about a mile from it on the east side. The summit of Raynold's Pass can be reached by easy grades of not more than 60 feet per mile, without any cutting. The pass is very broad, with perfectly smooth approaches on both sides. The Madison Valley here is terraced. From the head of the pass the level of the river can be reached in twelve miles, at which point the valley contracts by a grade not exceeding 75 feet per mile. The valley is narrow for three to four miles, with several spurs crossing it and extending to the river, but which can be avoided by keeping close to the river, which involves some embankment. Below this the valley opens again, with a perfectly level bottom, which extends to the head of the Lower Cañon, at Meadow Creek, and here the only difficulties on this route will be met. The fall of the Madison from the foot of the Middle Cañon to this point averages 23 feet per mile. The Lower Cañon is, from information which I have gathered from reliable sources, impassible for a railroad, nearly so, even, for men on foot. To pass around it, the road must cross the divides between Meadow and Hot Spring Creeks, and between Hot Spring and Cold Spring Creeks, neither of them high, but, so far as I know them, involving grades too steep for a railroad to surmount, except at heavy expense in cutting, as is indicated in the elevations and distances on this route given below. The stage-road crosses the divide between Meadow and Hot Spring Creeks, farther up from the mouth, by a better route, but I have no data concerning it. Still farther from the river the divide rises higher and more abruptly.

The elevation of Yellowstone Lake, as well as that of several other points, as determined by my observations this year, will be seen to differ materially from that given in the report of the survey for 1871. This difference arises from the want of a barometric base for the work of 1871, the observations being referred directly to the sea-level. In the case of Yellowstone Lake, synchronous observations were taken at Butler's Ranch, but they were not used as base observations. Making use of these, they give the same result that I obtain.

For the computation of elevations, Guyot's tables have been used.

The elevations are given in feet above the level of the sea unless otherwise indicated.

Camps of Yellowstone division.

Camp.	Date.	Location.	Elevation.	Distance from previous camp.
				Miles.
1	June 30 to July 20	On East Gallatin, one-quarter mile north of Fort Ellis	4,935	.....
2	July 20 to July 21	Rock Creek, on road to Butler's Ranch	5,639	8
3	July 21 to July 22	Eight-Mile Creek, on road to Butler's Ranch	5,282	18
4	July 22 to July 24	Butler's Ranch	5,086	9
5	July 24 to July 25	Mouth of Cañon Creek	5,101	10
6	July 25 to July 26	At "Devil's Slide"	5,348	10
7	July 26 to July 29	Near White Mountain Hot Springs	6,529	12
8	July 29 to July 30	On Blacktail Deer Creek	6,570	10
9	July 30 to Aug. 4	On Meadow Creek, near bridge	6,236	10
10	Aug. 4 to Aug. 5	On plateau above Grand Cañon	8,162	15
11	Aug. 5 to Aug. 9	On Cascade Creek, near the falls	7,979	5
12	Aug. 9 to Aug. 13	At Mud Springs	7,712	10
13	Aug. 13 to Aug. 14	On East Fork of Fire-Hole	7,297	19
14	Aug. 14 to Aug. 19	Lower Geyser Basin	7,252	5
15	Aug. 19 to Aug. 21	Mouth of Gibbon's Creek	6,811	8
16	Aug. 21 to Aug. 22	On Madison River	6,605	13
17	Aug. 22 to Aug. 25	At mouth of East Fork of Madison	6,568	13
18	Aug. 25 to Aug. 27	In middle of Second Cañon of Madison	6,570	13
19	Aug. 27 to Aug. 29	At foot of Second Cañon	6,309	6
20	Aug. 29 to Aug. 30	Madison River	5,753	16
21	Aug. 30 to Sept. 1	Mouth of Indian Creek	5,524	12
22	Sept. 1 to Sept. 2	Madison River	5,214	10
23	Sept. 2 to Sept. 6	......do	5,027	2
24	Sept. 6 to Sept. 7	Meadow Creek	4,932	14
25	Sept. 7 to Sept. 8	Cold Spring Creek	4,789	16
26	Sept. 8 to Sept. 9	Madison River	4,362	12
27	Sept. 9 to Sept. 10	Near Three Forks of Missouri	4,132	13
28	Sept. 10 to Sept. 11	On West Gallatin, at Cockrel's Bridge	4,512	18
29	Sept. 11 to Sept. 14	Near camp 1	4,947	17
30	Sept. 14 to Sept. 15	On Bozeman Creek, near its exit from hills	5,243	6
31	Sept. 15 to Sept. 16	On West Gallatin	5,317	13
32	Sept. 16 to Sept. 18	On West Gallatin, at foot of cañon	5,241	5
33	Sept. 18 to Sept. 19	On West Gallatin, in middle of cañon	5,589	8
34	Sept. 19 to Sept. 20	On West Gallatin, at head of cañon	5,926	9
35	Sept. 20 to Sept. 25	On West Gallatin	6,153	6
36	Sept. 25 to Sept. 26	Near top of divide between Yellowstone and Gallatin Rivers	8,828	11
37	Sept. 26 to Sept. 27	On Rock Creek, near Yellowstone	5,894	12
38	Sept. 27 to Sept. 30	Near Butler's Ranch	4,996	9
39	Sept. 30 to Oct. 2	On Trail Creek, at Pease's Ranch	4,659	19
40	Oct. 2 to Oct. 3	On Divide Creek	4,767	12
41	Oct. 3 to Oct. 4	On a branch of Bridger Creek	5,572	13
42	Oct. 4 to Oct. 5	At head of Southwest Branch of Shield's River	5,946	10
43	Oct. 5 to Oct. 7	On Pass Creek, near Flathead Pass	5,715	18.5
44	Oct. 7 to Oct. 9	On Missouri, at Horseshoe Bend	3,969	20.5
45	Oct. 9 to Oct. 11	On Gallatin River, near Gallatin	4,049	7.6
46	Oct. 11 to Oct. 12	Near mouth of Dry Creek	4,378	16.7
47	Oct. 12 to Oct. 13	On East Gallatin	4,503	12
48	Oct. 13 to Oct. 15	Near Bozeman	4,842	7.2

Heights of peaks and divides.

	Elevation.
Mount Bechler, near Ogden, Utah	*9,716
Mount Putnam, near Fort Hall, Idaho	8,854
Bridger's Peak	9,002
Mount Ellis	8,419
Electric Peak	10,992
Mount Washburn	10,388
Mount Blackmore	10,134
Liberty Peak	9,162
Mount Delano	10,200
Old Baldy, near Virginia City	9,711
Ward's Peak	10,371
Peak in second cañon of the Madison	10,111
Peak in second cañon of the Madison	10,329*
Peak in second cañon of the Madison, near Henry's Lake	*9,466

Heights of peaks and divides—Continued.

	Elevation.
Peak in second cañon of the Yellowstone	9,478
Divide between the Yellowstone and Gallatin, on Bannock trail	9,317
Raynold's Pass	6,911
Red Rock Pass	7,271
Tyghee Pass	7,063
Flathead Pass	6,769
Divide between Jefferson and Madison, on road from Virginia City to the Madison, at English George's Ranch	7,164
Union Pass, Bridger Range	*7,283
Divide between Yellowstone and Gallatin Rivers, on road from Fort Ellis to Butler's Ranch	*6,037
Divide between the Yellowstone and Gallatin, on the road from Bozeman to the Crow agency	*5,721
Divide on Mount Washburn, where the trail crosses	*9,155
Divide between Clark's Fork and the Rosebud	*8,736
Divide between the Yellowstone and Madison, on the trail from the Mud Geysers to the Lower Geyser Basin	*8,164
Divide between the head of Bridger Creek and that of the west fork of Shield's River	*6,046
Yellowstone Lake	7,788
Henry's Lake	6,443
Mystic Lake	6,468

* Measured by aneroid.

Timber-line.

	Latitude.		Elevation.
On Electric Peak	44	58	*9,442
On Mount Washburn	44	48	*9,900
On mountains in Middle Cañon of Madison	45	0	*9,368
On Ward's Peak	45	30	*9,156
On Mount Blackmore	45	26	*9,550
On Mount Delano	45	32	*8,784
On Bridger's Peak	45	47	*9,002

* Measured by aneroid.

Elevation of White Mountain Hot Springs, from 6,278 to 7,035 feet; boiling-point, 200°.9 to 199°.5.

Elevation of Mud Geysers, 7,756 to 7,800 feet; boiling-point, 198°.5.

Elevation of springs at Crater Hills, 7,828 to 7,979 feet; boiling-point, 198°.2.

The Geyser Basins are very flat; the range of elevation in the area occupied by the springs and geysers not exceeding 100 feet in each basin.

Elevation of the Lower Geyser Basin, 7,250 to 7,350 feet; boiling-point, 199°.3.

Elevation of the Upper Geyser Basin, 7,300 to 7,400 feet; boiling-point, 199°.

Sulphur springs on the divide between the Yellowstone and Gallatin, on the trail from the Mud Geysers to the Lower Geyser Basin, elevation, 8,246 feet. Boiling-point at Yellowstone Lake, 198°.1.

List of elevations on Yellowstone River.

	Miles from mouth of Shield's River.	Elevation.	Fall per mile.
			Feet.
At Yellowstone Lake	105.5	7,788	....
At Mud Geysers	99.5	7,705	13.8
At top of upper falls	90.5	7,693	1.3
Height of upper falls, 140 feet.			
Top of lower falls	90.0	7,485	136.0
Height of lower falls, 397 feet.			
Mouth of Tower Creek	77.0	6,207	67.8
At bridge, mouth of East Fork	74.0	5,978	76.3
Mouth of Gardiner's River	54.0	5,360	30.9
At "Devil's Slide"	48.0	5,160	33.3
Mouth of Cañon Creek	38.0	5,058	10.2
At Butler's Ranch	28.0	4,985	7.3
At head of Lower Cañon	8.0	4,643	17.1

Elevations on the East Fork of the Yellowstone.

	Miles from forks.	Elevation.	Fall per mile.
			Feet.
Mouth of Slough Creek *a*	....	5,986	....
At forks of East Fork *a*	....	6,286	....
a	6	6,436	25
a	8	6,536	50
a	10	6,586	75
a	12	6,746	80
a	13	6,886	140
Head of Middle Branch of East Fork *a*	....	7,586	....

(*a*) Measured by aneroid.

List of elevations on the Madison River.

	Miles from mouth.	Elevation.	Fall per mile.
			Feet.
Extreme source, Madison Lake, (Mr. Hering's report.)	170	8,301	....
In Upper Geyser Basin	160	7,367	93.4
Mouth of East Fork of Fire-Hole	148	7,237	10.8
Mouth of Gibbon's Fork	142	6,808	71.5
At camp 16	129	6,604	15.7
At mouth of East Fork of Madison	116	6,567	2.8
In middle of second cañon	103	6,348	16.8
Three miles above camp 20	81	5,693	29.8
At mouth of Indian Creek	66	5,494	13.3
At camp 23, near English George's Ranch	55	5,026	42.5
At head of Lower Cañon	41	4,848	12.7
At bridge	23	4,521	18.2
At camp 26	13	4,356	16.5
At mouth	....	4,129	17.5

List of elevations on the West Gallatin River.

	Miles from mouth.	Elevation.	Fall per mile.
			Feet.
At forks of West Gallatin, near head, latitude 45°	93	6,823	
At camp 35, in latitude 45° 15′	67	6,149	42.1
At camp 33	52	5,586	37.5
At camp 32	44	5,215	46.4
At bridge	20	4,493	21.8
Mouth		4,098	19.8

Miscellaneous elevations on streams.

	Elevation.
East Gallatin, at Fort Ellis	4,934
Bridger Creek, near head, (camp 41)	5,566
Bridger Creek, in Bridger Cañon	*5,080
Pass Creek, at foot of Flathead Pass, (camp 43)	5,713
Cottonwood Creek, where it issues from the mountains	5,433
Bozeman Creek, where it issues from the mountains	5,247
Middle Creek, near head	6,831
West branch of Shield's River, at head	5,946
Head of Clark's Fork of the Yellowstone	*8,236
Head of Slough Creek	*7,936
Slough Creek, fifteen miles below mouth of Buffalo Creek	*6,386
Slough Creek, four miles more	*6,336
Slough Creek, mouth	*5,986
Cascade Creek, at camp 11	*7,909
Height of Lower Falls, (feet)	132
Height of Crystal Falls, on Cascade Creek, (feet)	129

* Measured by aneroid.

On routes for roads from the settlements to points of interest in the Yellowstone National Park.

The only routes in use at present are the Yellowstone and Madison routes, neither of which is at present practicable for wagons. The former, starting from Bozeman, crosses the Yellowstone near Butler's Ranch, thence follows the river as closely as may be. By this route a wagon-road already extends to the mouth of Cañon Creek, which in the latter part of July was 18 inches deep and 60 feet wide.

In the second cañon, the mountains which form the west wall come down to the water's edge, very steep and rugged, and the passage of it with a wagon-road will involve considerable outlay in blasting and embankment. The east side is comparatively easy of passage, but this would involve throwing two bridges across the river, which is here, at the lowest stage of the water, 500 feet in width. This cañon is about eight miles in length, three-fourths of which, however, present no great obstacle to a road. Above this cañon the valley is level and open, with no timber as far as the foot of the third cañon, at the mouth of Gardiner's River. From this point to the Hot Springs, on Gardiner's River, a distance of about seven miles, a road can easily be made, though it must cross two high spurs from Sepulchre Mountain.

The trail up the Yellowstone crosses Gardiner's River by a bridge, then ascends the plateau above the third cañon. This ascent is very steep, and a wagon-road will require much grading. On the top the plateau is quite level, without timber. The trail keeps the top of the plateau as far as Caché Valley, near the mouth of East Fork, to which it descends by easy grades. Thence it follows the river quite closely to Tower Creek, which it crosses just above the falls. The descent to the creek is extremely steep, and some better point of crossing must be discovered. The creek is in a cañon most of its length, and in the beginning of August was about 18 inches deep and 50 feet in width.

From the mouth of Tower Creek, southward for 15 miles, the Yellowstone is in the Grand Cañon, the numerous impassible cross-cañons of which require that the trail keep back at a considerable distance from the river, passing round to the west of the summit of Mount Washburn, which is the culminating point of the plateau of the Grand Cañon. The grade is easy and smooth up a spur from the mountain, reaching at its highest point nearly to the timber-line on the north side. Passing round to the west side of the spur, the trail becomes very difficult from fallen timber, rock-slides, and steep side-hills.

From the top of the divide to the falls on the plateau no difficulties are met, except steep grades at first, and some timber.

The crossing of Cascade Creek, near the falls, involves, by the trail which we followed, crossing a deep, narrow cañon, difficult even for pack-animals. I have no doubt that a better crossing can be found two or three miles farther up the creek. Between this point and Crater Hills are two sloughs, which extend several miles back from the river. At the time when we were there they were about two feet deep, but this was at the lowest stage of the water. From there to Yellowstone Lake there is no difficulty whatever, except from live timber.

We crossed to the geyser basins from the mud geysers. For nine miles the trail led through an open country, nearly level. Thence to the top of the divide we met with a tolerably heavy growth of timber. On the west side of the divide the live timber is very dense, while the ground is thickly covered with fallen timber, making our passage with the train very difficult. This condition of things extends for four or five miles, when the trail enters the open valley of the east fork of the Fire-Hole River. This valley, as far as the mouth of the east fork, is quite marshy in some places, but little difficulty will be found in locating a hard road.

The route up the Madison is, through the greater part of the distance, much easier. Wagon-roads, on both sides of the Madison, already exist from Virginia City to the foot of the Middle Cañon, within fifty-five miles of the Lower Geyser Basin. These roads then leave the Madison, and cross, by Reynold's Pass, to Sawtelle's Ranch, at Henry's Lake. The trail through the Middle Cañon, and thence to the geyser basins, follows the east side of the river. Wagons have been through this cañon, and a slight outlay would suffice to build a good road through it. At the head of this cañon it will be necessary to bridge the east fork of the Madison, which, in the latter part of August, was a sluggish, winding stream about 200 feet wide and 2½ feet deep.

From the Middle to the Upper Cañon the valley is broad, flat, and sparsely timbered.

The Upper Cañon, in about fifteen miles, presents the only difficulties which are found on this route. The cañon-walls are extremely steep, in some places precipitous, and, much of the way, come close to the water's edge, not unfrequently requiring wading in the river. Gibbon's Fork, which enters the Madison in the middle of the cañon, must be bridged. This stream is 100 feet wide and 2½ feet deep. From this creek up to the mouth of the East Fork of the Fire Hole River the trail is obliged to keep back from the river. It is very rough, and badly obstructed by live and dead timber.

To build a road through this cañon, on this side of the river, will be expensive. The other side, here the south side, of the river appears much easier, and, if the Middle Cañon can be passed on that side of the river, a route on that side, throughout the whole distance, is to be recommended. The road should then cross the Madison to the north side, in the Upper Cañon, two or three miles below the mouth of Gibbon's Fork. There remains on this route the upper part of the cañon to be passed, which, as stated above, presents some difficulties.

LISTS OF ELEVATIONS AND DISTANCES ON ROUTES TO THE YELLOWSTONE NATIONAL PARK.

Route from Bozeman to Yellowstone Lake, by way of Yellowstone River.

	Miles.	Elevation.
Bozeman	....	4,900
Nearly level, with smooth grades to—		
Fort Ellis	3.3	4,935
Divide crossing to Spring Creek, (steep hill on each side)	6.7	5,675
Spring Creek	7.3	5,500
	8.0	5,820
Steep descent, then uniform slope up to—		
Camp 2, on Spring Creek, near head	12.3	5,639
Divide between Spring and Trail Creeks, between Gallatin and Yellowstone	15.7	6,037
Uniform slope to—		
Trail Creek, at crossing	22.5	5,300
Long rolling hills to—		
Divide between Trail and Eight-Mile Creeks	28.5	5,500
Smooth to—		
Camp 3, on Eight-Mile Creek, near Yellowstone	30.2	5,282
Camp 4, at Butler's Ranch, on Yellowstone	39.2	5,086
In level river bottom to—	44.8	5,040
	45.1	5,220
	45.3	5,050
Camp 5, at mouth of Cañon Creek	49.8	5,201
Second Cañon of the Yellowstone River:		
Smooth to—		
	51.8	5,160
	52.1	5,340
	52.7	5,140
	54.7	5,200
	55.3	5,450
Uniform slope to—		
Head of Second Cañon	57.9	5,200
	59.2	5,350
	59.3	5,280
Camp 6, near Devil's Slide	59.9	5,348
Grade nearly uniform in river bottom to	64.6	5,600
Bridge over Gardner's River, near its mouth	67.9	5,360
Level to	68.7	5,360
Very heavy grades to	70.4	6,500
Level to	71.0	6,500
	71.2	6,900
	71.9	6,880
Grade nearly uniform to—		
Camp 8, on Black-Tail Deer Creek	74.2	6,570
	76.2	6,870
Grade very irregular, on rolling plateau, to	81.7	7,600
Grade somewhat irregular to—		
Camp 9, in Cache Valley, near mouth of East Fork	84.0	6,236
Nearly uniform grade to	86.6	6,400
	87.5	6,740

Route from Bozeman to Yellowstone Lake, &c.—Continued.

	Miles.	Elevation.
Crossing of Tower Creek	87.6	6,500
Level to	87.9	6,520
Smooth slope to	89.2	7,280
	90.2	7,200
Grade nearly uniform to—		
Divide on spur from Mount Washburn	94.3	8,800
	95.2	8,600
	95.3	8,700
Camp 10	101.2	8,162
Grade tolerably uniform to—		
Camp 11, on Cascade Creek, near the falls	106.7	7,979
	107.6	7,920
Crossing of Cascade Creek	107.8	7,600
Grade nearly uniform to	109.4	7,700
	109.7	7,940
	110.3	7,920
	110.9	7,580
	112.9	7,620
	113.4	7,900
Grade nearly uniform to	113.7	7,750
Camp 12, at Mud Geysers	116.7	7,712
Grade tolerably uniform to—		
Yellowstone Lake, at head of river	123.9	7,800

Route from Gallatin City to the Geyser Basins, thence across to the Mud Geysers, on the Yellowstone.

	Miles.	Elevation.
Gallatin City, (Three Forks of the Missouri)	....	4,132
Grade perfectly uniform in Madison River bottom to—		
Camp 26, on Madison	16.5	4,360
Grade perfectly uniform in river bottom to	20.4	4,800
Grade somewhat irregular to—		
Camp 25, on Cold Spring Creek	27.7	4,789
Grade tolerably uniform to—		
Divide between Cold Spring and Hot Spring Creeks	29.8	5,400
Grade smooth to	36.1	5,050
Grade tolerably smooth to—		
Divide between Hot Spring and Meadow Creeks	37.8	5,640
	38.6	5,520
	39.3	4,980
Camp 24, on Meadow Creek	42.5	4,932
Grade perfectly smooth to—		
Camp 22, opposite Virginia City, on Madison	61.3	5,214
Grade uniform to—		
Camp 21, at mouth of Indian Creek	71.3	5,524
Grade uniform to	80.5	5,700
	80.6	5,900
Grade tolerably uniform to—		
Camp 20, on Madison	82.9	5,753
Grade good to	88.0	6,300
	88.5	6,200
	88.9	6,500
Tolerably uniform grade to	93.9	6,100
Grade perfectly uniform to—		
Camp 19, at foot of Middle Cañon, near Madison Pass	98.2	6,309
Grade rather irregular to—		
Camp 18, in middle of cañon	104.9	6,570

Route from Gallatin City to the Geyser Basins, &c.—Continued.

	Miles.	Elevation.
Grade irregular to	109.4	6,520
Grade perfectly uniform to—		
Camp 17, at head of Middle Cañon	119.6	6,568
Grade perfectly uniform to—		
Camp 16, on Madison	132.4	6,605
Grade nearly uniform to—		
Foot of Upper Cañon	136.4	6,790
Grade perfectly uniform to—		
Camp 15, at mouth of Gibbon's Fork	145.1	6,811
	146.0	7,200
Very irregular grade to—		
Head of Upper Cañon	148.7	7,240
Grade perfectly uniform to—		
Camp 14, in Lower Geyser Basin	152.8	7,252
Grade perfectly uniform to—		
Camp 13, on East Fork of Fire-Hole River	157.7	7,297
	161.0	7,400
	163.1	8,240
Divide between Madison and Yellowstone	165.8	8,240
	166.2	7,950
Grade irregular to	170.0	7,910
	170.6	7,740
	171.0	7,980
	172.0	7,700
Grade irregular to—		
Camp 12, at Mud Geysers, on Yellowstone River	175.3	7,712

The ordinary meteorological observations were made hourly in camp. They will be found printed in full in the bulletin of meteorological observations. I will make a short *résumé* of them. They were made at various altitudes above the sea-level, from 4,000 to 8,000 feet.

At Fort Ellis, elevation 4,935 feet, the mean temperature during the first three weeks of July was 67°.61, maximum, 99°.7; minimum, 33°.0; lowest relative humidity .21.

On the 1st of July, there occurred a heavy snow storm, in which about four inches of snow fell, which melted on the following day.

On the 17th, there was a smart shower of hail. The minimum temperature, at night, at an altitude above 5,000 feet, was rarely above 32°. The lowest temperature experienced during the trip was in the camp at the mouth of Gibbon's Fork, elevation 6,811 feet, 12°, in the latter part of August. At the head of the West Gallatin River, elevation 6,149 feet, the minimum thermometer indicated 14°., 17°., 17°., on three several nights in the latter part of September. Maximum temperatures, during the day, ranged from 65° to 93°, indicating a great range of temperature during the day.

The range of relative humidity is also very great, reaching, near the middle of the day, as low as .30, and on several occasions even lower. The lowest relative humidity recorded during the trip was .22. Most of the rain which we experienced during the season was in the form of showers, which were of tolerably frequent occurrence, but very few long storms occurring during the season.

A storm of rain and hail of two days' duration was experienced at Yellowstone Falls, near the end of July. A heavy snow storm, in which four inches of snow fell, occurred at the head of the West Gallatin, near the end of September.

In common with two other members of the party, I had rather a singular experience. We were ascending a mountain near the Gardiner's River Springs, called on the map Electric Peak. I quote from my notes written on the following day: A thunder-shower was approaching as we neared the summit of the mountain. I was above the others of the party, and when about 50 feet below the summit the electric current began to pass through my body. At first I felt nothing, but heard a crackling noise, similar to a rapid discharge of sparks from a friction machine. Immediately after, I began to feel a tingling or pricking sensation in my head and the ends of my fingers, which, as well as the noise, increased rapidly, until, when I reached the top, the noise, which had not changed its character, was deafening, and my hair stood completely on end, while the tingling, pricking sensation was absolutely painful. Taking off my hat partially relieved it. I started down again, and met the others 25 or 30 feet below the summit. They were affected similarly, but in a less degree. One of them attempted to go to the top, but had proceeded but a few feet when he received quite a severe shock, which felled him as if he had stumbled. We then returned down the mountain about 300 feet, and to this point we still heard and felt the electricity.

I have received returns of meteorological records kept at Bozeman, Montana, by Mr. Peter Koch, a thoroughly reliable observer. These records are published in full in our annual bulletin of meteorological observations for 1872. From these I deduce the following results:

Date.	Mean temperature.	Maximum.	Minimum.	Inches of rain and melted snow.	Number of storms.
1872.	°	°	°	°	
November	24.00	49.8	—18.8	0.11	3
December	19.61	48.3	—30.0	1.43	6
1873.					
January	23.49	48.1	—26.0	0.38	7
February	19.30	45.1	—19.0	1.57	5

Mr. Koch records, on the 10th of December, "two distinct shocks of earthquake, at 4.30 p. m., and on the 11th one shock, at 6.30 a. m. All the shocks were from west to east. They were more violent at Helena and Deer Lodge than here."

NOTES ON THE CLIMATE OF MONTANA.

By Mr. Granville Stuart, *of Deer Lodge, Montana Territory.*

The winter of 1857–'58 was very mild. Snow did not lie longer than a few days in any of the principal valleys. The cold was not intense, except for a few days in December and January. Cattle and horses in the open air, and without any food or shelter except such as they got on the prairie, gained steadily in flesh all the winter, and came out fat in the spring.

The winters of 1858–'59 and 1859–'60 were very similar, averaging, probably, a little colder, and with a little more snow, but quite pleasant in the main.

The winter of 1860–'61 showed a gradual increase of cold and snow over former years, but still stock did well; and the winter would not have been called a bad one in Iowa or Illinois.

The winter of 1861–'62 was one of great and unusual severity, snow falling to a depth of from six inches to two feet, varying in different valleys and in different parts of the same valley. I have observed that the fall of snow is very capricious and irregular; for instance, the deposit of snow in a given locality may be quite small during a bad winter, while in the following one, even though much milder, the snow-fall at that point will be double or treble as much, while other points, which had deep snow during the first, will be comparatively free from it during the second winter. This is especially noticeable in the higher valleys and in the passes leading from one to another.

The winter of 1862–'63 was quite as mild as that of 1857–'58, and throughout the country, as far as Salt Lake, it was even milder, for wagons drawn by both horses and oxen made two trips, in mid-winter, from Bannock City to Salt Lake City and back, with heavy loads, and without being incommoded by snow or severe cold. They crossed the main range of the Rocky Mountains (by the Medicine Lodge Pass) and the Porte Neuf Mountains twice on each trip, and without any other food for their animals than bunch-grass. This is, however, a feat that has not been accomplished since, many parties having lost large numbers of cattle and mules in trying to make one trip in each of the three succeeding winters. The lowest temperature in Deer Lodge during this winter was 12°, which was during a snow-storm, on the 23d or 24th of October.

The winter of 1863–'64 was but little inferior to the preceding one, snow lying but a few days at a time in the valleys, although it was quite deep on the mountains, and the weather averaged somewhat colder. A severe storm of wind and driving snow occurred on January 7, in which the temperature fell to —33°, but the cold snap lasted only about a week.

The winter of 1864–'65 showed an increased degree of cold and snow again. The temperature fell to —34° on one occasion, while during December and January the cold was severe; but the snow was not deep until March, during which month more fell than in all the rest of the winter, and the minimum temperature was —27°. Stock did well enough without any feed during this winter.

The latter half of the winter of 1865–'66 was quite severe, snow lying in the valleys, while the lowest temperature was —34°. No stock died, however, although none were fed.

The winter of 1866–'67 was very mild until the 24th of December, with no snow, but from this time until April it was the worst winter ever known in the Territory. Snow fell to a considerable depth in all the valleys, and was accompanied by a very long spell of continued cold, varying —10° to —32°. The month of March, in particular, was absolutely terrific, on twenty-eight out of thirty-one mornings the temperature being below zero, being, I believe, without precedent in any other country. Yet, strange and almost incredible as it may appear, scarcely any cattle died, although few of them had any feed or any shelter other than the willows along the streams. No horses died, although they, too, had to subsist on the range all winter.

The winter of 1867–'68 was comparatively mild, with but little snow; coldest day, —30°; no suffering among stock; grass abundant and not covered by snow; no sleighing in Deer Lodge at any time during the winter; valley dry and dusty; the same being the case in nearly all parts of the Territory.

The winter of 1868–'69, as those of 1857–'58 and 1862–'63, was very mild, being almost no winter at all, when the latitude and altitude are taken into consideration. No snow of any consequence.

The winter of 1869–'70 was quite mild, with little snow in the valleys, and little hay was used.

The winter of 1870–'71 was also open and pleasant. Stock kept in good condition on the range.

The winter of 1871–'72 was a very severe one, commencing with a terrific storm of wind and snow on the 23d of November. The greatest depth of snow in Deer Lodge at any time was 12 inches. The depth, however, on the mountains was very great. The loss in cattle could not, however, have exceeded 2 per cent. of the number in the Territory, for a large part of the hay-crops of the three previous years was on hand. Hence there was but little suffering among stock, except in a few localities and among herds of Texas cattle driven in during the fall, which, being thin in flesh and not accustomed to snow and cold weather, suffered severely.

By using a little care and foresight in preserving the hay and straw that can be accumulated with but little labor and expense during the mild winters, all danger of loss of stock during severe seasons will be avoided.

It seems that our hard winters come exactly five years apart; for instance, those of 1861–'62, 1867–'68, and 1871–'72 were all severe, while the intermediate ones were all very mild.

The snow-fall at Deer Lodge (latitude about 46° 27′; altitude above sea, 4,768 feet) for the last five years has been as follows:

In the winter of 1867–'68, $20\frac{1}{4}$ inches, in seventeen storms, not including what melted as it fell. Greatest depth at any one time, $2\frac{1}{2}$ inches. In the winter of 1868–'69, $16\frac{3}{4}$ inches, in fourteen storms. Greatest depth, 2 inches. In the winter of 1869–'70, $29\frac{35}{100}$ inches, in twenty-six storms. Greatest depth at any time, 4 inches, and that for a few days only. In the winter of 1870–'71, $45\frac{73}{100}$ inches, in forty-seven storms. Greatest depth at any time, 3 inches. In the winter of 1871–'72, $86\frac{44}{100}$ inches, in forty-eight storms. Greatest depth at any time, 12 inches.

	°
The mean temperature at Helena, Montana, for 1866, was.......	44.5
The mean temperature at Deer Lodge, Montana, for 1868	40.5
The mean temperature at Deer Lodge, Montana, for 1869	42.9
The mean temperature at Deer Lodge, Montana, for 1870	42.1
The mean temperature at Deer Lodge, Montana, for 1871	42.5
The mean temperature at Helena, Montana, for January, 1867 ...	17.9
The mean temperature at Helena, Montana, for February, 1867..	18.0
The mean temperature at Helena, Montana, for March, 1867.....	5.9
The mean temperature at Helena, Montana, for April, 1867.......	44.8
The mean temperature at Deer Lodge, Montana, for November, 1867	30.5
The mean temperature at Helena, Montana, for December, 1867..	25.2
The fall of rain and melted snow at Helena, in 1866, inches......	22.96
The fall of rain and melted snow at Deer Lodge, in 1870, inches..	16.50
The fall of rain and melted snow at Deer Lodge, in 1871, inches..	15.74

The average fall of rain and melted snow at Deer Lodge for four years, 19.11 inches.

A series of observations shows that Missoula County, Montana, (altitude 3,300 feet,) enjoys an average temperature of 5°.5 higher than Deer Lodge, and, judging by farm products, this is about the annual mean of the large valleys of Sun River, Missouri, Gallatin, Jefferson, Madison, Stinking Water, and Beaverhead. It thus appears that by far the greater part of the Territory has an annual mean temperature of about 48°.

RESUMÉ OF METEOROLOGICAL OBSERVATIONS TAKEN AT FORT ELLIS, MONTANA, BY THE UNITED STATES MEDICAL DEPARTMENT.

Mean daily and minimum temperatures during the winter of 1871–'72.

Date.	Mean temperature.	Minimum.	Date.	Mean temperature.	Minimum.	Date.	Mean temperature.	Minimum.	Date.	Mean temperature.	Minimum.
1871.	°	°	1871.	°	°	1872.	°	°	1872.	°	°
Nov. 1	37	......	Dec. 3	9	—19	Jan. 3	23	0	Feb. 4	—38	—53
2	40	......	4	31	15	4	18	6	5	—27	—51
3	40	......	5	46	32	5	10	—12	6	12	—30
4	37	......	6	33	25	6	5	—11	7	25	10
5	31	......	7	36	10	7	31	0	8	23	0
6	30	......	8	24	10	8	28	9	9	19	10
7	24	......	9	24	10	9	34	21	10	15	2
8	33	......	10	24	5	10	30	12	11	23	5
9	37	......	11	21	7	11	25	15	12	5	— 1
10	37	......	12	23	15	12	18	7	13	14	—25
11	34	......	13	27	18	13	33	12	14	19	10
12	25	......	14	31	10	14	22	0	15	27	15
13	35	......	15	26	5	15	13	—10	16	22	12
14	35	......	16	25	—15	16	19	0	17	33	10
15	35	......	17	—14	—23	17	19	— 6	18	33	21
16	29	......	18	—22	—26	18	15	1	19	23	6
17	16	......	19	— 2	—16	19	13	—13	20	26	3
18	25	......	20	8	— 5	20	9	—12	21	35	6
19	31	......	21	3	—26	21	6	—31	22	32	4
20	31	......	22	— 9	—21	22	4	—17	23	12	0
21	38	......	23	—24	—30	23	15	—42	24	22	0
22	32	—26	24	—30	—45	24	—41.66	—53	25	32	10
23	50	—21	25	—18	—40	25	....	—17	26	21	10
24	17	—23	26	—32	—42	26	2	—10	27	18	0
25	— 9	—33	27	—16	—33	27	—12	—42	28	17	—13
26	—16	—30	28	33	0	28	— 4	—20	29	23	— 8
27	—11	—24	29	36	6	29	8	—32	March 1	20	8
28	7	— 5	30	33	—10	30	3	—14	2	26	4
29	11	— 4	31	29	—15	31	10	—10	3	29	6
30	13	— 2	1872.			Feb. 1	9	—10	4	27	15
Dec 1	27	6	Jan. 1	29	10	2	19	—11	5	31	15
2	19	—26	2	21	2	3	4	—21	6	25	14

Mean daily and minimum temperatures, &c.—Continued.

Date.	Mean temperature.	Minimum.	Date.	Mean temperature.	Minimum.	Date.	Mean temperature.	Minimum.	Date.	Mean temperature.	Minimum.
1872.	°	°	1872.	°	°	1872.	°	°	1872.	°	°
Mar. 7	27	10	Mar. 14	11	—4	Mar. 21	21	3	Mar. 28	20	8
8	25	0	15	5	—6	22	16	0	29	28	15
9	16	0	16	8	—6	23	15	—10	30	34	12
10	18	3	17	13	—3	24	2	—20	31	32	14
11	19	0	18	21	0	25	16	0			
12	15	2	19	19	4	26	21	8			
13	2	......	20	15	0	27	27	4			

Months.	Dry bulb.	Wet bulb.	Rain and melted snow.	Months.	Mean temperature.	Highest temperature recorded.	Lowest temperature recorded.	No. of days of snow or rain.
1869.	°	°	*Inches.*	1871.	°	°	°	
January	22. 52	21. 56	1. 15	January	29. 85	55. 0	—13	8 snow.
February	28. 15	26. 0	1. 25	February	23. 96	48. 0	—22	5 snow.
March	30. 71	28. 45	2. 90	March	33. 51	67	14	10 snow.
April	41. 33	36. 33	3. 13	April	36. 55	70	15	15 snow, 2 rain.
May	59. 79	48. 04	5. 90	May	42. 27	85	30	2 rain.
June	64. 21	55. 32	2. 65	June	59. 30	95	37	6 rain.
July	72. 66	59. 70	0. 85	July	64. 66	95	49	3 rain.
August	68. 82	56. 07	0	August	63. 04	83	37	3 rain.
September	56. 48	48. 25	. 54	September	57. 0	82	35	
October	43. 53	38. 91	. 40	October	45. 58	68	8	3 snow.
November	36. 83	33. 91	. 13	November	25. 76	55	*—33	12 snow.
December	27. 27	24. 78	. 63	December	10. 77	45	—45	7 snow.
1870.				1872.				
January	23. 59	21. 69	. 06	January	14°. 33	45	—53	7 snow.
February	31. 64	29. 47	. 11	February	20. 21	54	—53	5 snow, 1 rain.
March	27. 01	24. 69	. 20	March	29. 21	50	—20	12 snow.
April	45. 84	41. 70	. 54	April	35. 12	64	— 1	15 snow.
May	56. 83	50. 59	. 18	May	51. 81	75	25	6 rain.
June	66. 62	59. 35	. 15	June	......	80	30	2 rain, 1 snow.
July	69. 44	60. 56	0					
August	58. 35	53. 93	......					
September	56. 17	48. 72	......					
October	42. 68	38. 74	......					
November	36. 99	34. 34	......					
December	20. 78	20. 29	......					

* Minimum.

Summary of wind from July, 1871, *to June,* 1872.

[Observations on the wind are taken at 7 a. m., 2 and 9 p. m.; the force is estimated on a scale of 4; the force for the month is the sum of the forces at time of observation.]

Month.	N.		N. E.		E.		S. E.		S.		S. W.		W.		N. W.	
	No.	Force.	No.	Force.	No.	Force.	No.	Force.	No.	Force.	No.	Force.	No.	Force.	No.	Force.
1871.																
July	1	1	1	1	17	20	12	13	1	2	10	12	41	47	7	8
August	2	3	1	2	6	10	3	5	1	1	10	15	40	47	7	9
September	0	0	1	2	28	47	7	7	3	3	12	13	34	54	6	8
October	0	0	1	1	19	20	5	6	11	13	5	5	41	48	7	8
November	3	4	2	5	12	14	4	7	2	2	6	9	53	55	6	15
December	0	0	0	0	27	46	8	8	2	2	8	10	38	43	2	2
1872.																
January	0	0	0	0	9	9	1	1	1	1	24	24	49	49	6	7
February	0	0	0	0	25	29	2	2	0	0	2	6	58	87	0	0
March	0	0	0	0	24	24	12	12	2	2	5	5	39	39	10	10
April	0	0	0	0	12	12	9	9	3	6	30	30	33	35	0	0
May	0	0	0	0	18	21	3	3	0	0	13	13	51	54	6	7
June	0	0	0	0	38	53	1	1	0	0	6	6	38	43	7	8

SNAKE RIVER DIVISION.

List of latitudes determined astronomically.

	°	′	″		°	′	″
Camp 9	43	8	49	Camp 34	44	25	20
10 and 54		14	17	35		20	25
11		23	30	36		20	37
12		35	25	37		21	12
13		46	31	38		19	18
14		49	9	39		14	20
15		57	47	40		8	00
16	44	0	54	41	43	57	50
17	43	59	57	42		51	31
18 and 21		56	1	43		46	53
19		48	10	44		39	44
20		45	32	45		32	25
22	44	4	28	46		29	5
23		10	34	47		35	10
24		19	20	48		44	3
25		22	14	49		48	57
27		37	42	50		47	51
28		43	28	51		39	40
29		41	28	52		38	28
30		38	30	53		33	53
32		34	25	Beula Lake	44	9	20
33		28	4	Mount Sheridan	44	15	30

MAGNETIC VARIATION.

The magnetic variation was determined by observing the azimuth of Polaris with a Wurdeman's gradienter, the verniers of which read to single minutes.

Place of observation.	Date.	Variation east. ° ′
Camp 16, near mouth of Fall River	July 19, 1872	18 12
20, Téton Cañon, twelve miles west of Mount Hayden	July 24, 1872	17 55
23, Bechler's Fork of Fall River	Aug. 4, 1872	18 15
24, Henry's Fork, (latitude 44° 19′ 20″)	Aug. 5, 1872	18 25
26	Aug. 7, 1872	19 13
27, Henry's Lake Valley	Aug. 8, 1872	18 44
32, Lower Geyser Basin	Aug. 14, 1872	18 29
33, Upper Geyser Basin	Aug. 18, 1872	18 29
36, Shoshone Lake	Sept. 7, 1872	18 15
39, Lewis Fork, near Lewis Lake	Sept. 13, 1872	18 13
40, Mouth of Lewis Fork	Sept. 15, 1872	18 8
Beula Lake	Sept. 17, 1872	18 55
Camp 42, foot of Jackson's Lake	Sept. 24, 1872	17 56
43, East foot of Tétons	Sept. 27, 1872	17 42
44	Sept. 28, 1872	17 38
45, Snake River, near mouth of Gros Ventres Creek	Sept. 30, 1872	17 40
51, Snake River, eight miles below cañon	Oct. 6, 1872	17 59
52	Oct. 7, 1872	18 00
53, Willow Creek	Oct. 9, 1872	17 55
54, Highane's Ranch, seven miles from Fort Hall	Oct. 10, 1872	17 50

Camps of Snake River division.

Camp.	Date.	Location.	Elevation.
1	June 3 to June 24	Ogden, Utah, 2 miles east of city	4,527
2	June 24 to June 25	Water-tank, near Saline Springs	4,255
3	June 25 to June 26	On Bear River, near Brigham City	4,249
4	June 26 to June 27	Near Mound Spring, a stage-station	4,429
5	June 27 to June 29	Keeney's stage-station	4,933
6	June 29 to July 1	Carpenter's stage-station	4.666
7	July 1 to July 2	Port Neuf River, at head of cañon	4,626
8	July 2 to July 3	Pocatillo stage-station	4,512
9	July 3 to July 12	Fort Hall, Idaho	4,754
10	July 12 to July 13	Higham's Ranch, on Blackfoot River	4,601
11	July 13 to July 14	Sand Creek, south of Taylor's bridge	4,716
12	July 14 to July 15	Snake River, 5 miles above Taylor's bridge	4,830
13	July 15 to July 16	Market Lake, stage-station	4,846
14	July 16 to July 17	Crater Buttes, near mouth of Henry's Fork	4,843
15	July 17 to July 19	Eagle Nest Ford, across Henry's Fork	4,951
16	July 19 to July 20	Fall River, 4 miles above mouth	5,126
17	July 20 to July 21	Conant's Creek	5,560
18	July 21 to July 22	Small creek, near Téton River	6,016
19	July 22 to July 23	Cottonwood Creek	6,126
20	July 23 to Aug. 2	Téton Cañon, 12 miles west of Mount Hayden	6,646
21	Aug. 2 to Aug. 3	Small creek, near Téton River	6,016
22	Aug. 3 to Aug. 4	Fall River, 16 miles above mouth	5,668
23	Aug. 4 to Aug. 5	Bechler's Fork of Fall River	5,762
24	Aug. 5 to Aug. 6	Small swampy lake, 4 miles east of Henry's Fork	6,256
25	Aug. 6 to Aug. 7	Henry's Fork	6,247
26	Aug. 7 to Aug. 8	Henry's Fork, — miles above camp 25	6,454
27	Aug. 8 to Aug. 10	East of Henry's Lake, near Tyghee Pass	6,649
28	Aug. 11 to Aug. 12	Madison River, opposite Tyghee Pass	6,584
29	Aug. 12 to Aug. 13	Madison River, 5 miles above	6,603
30	Aug. 13 to Aug. 14	Junction of Gibbon's Fork and Fire-Hole River	6,771
31	Aug. 14 to Aug. 15	First camp, Lower Geyser Basin	7,250
32	Aug. 15 to Sept. 1	Second camp, Lower Geyser Basin	7,261
33	Sept. 1 to Sept. 3	Upper Geyser Basin	7,394
34	Sept. 3 to Sept. 4	Fire-Hole River, 6 miles above camp 33	7,579
35	Sept. 4 to Sept. 6	Head of Fire-Hole River	8,320
36	Sept. 6 to Sept. 9	West end of Shoshone Lake, (Geyser Basin)	7,881
37	Sept. 9 to Sept. 10	East end of Shoshone Lake	7,874
38	Sept. 10 to Sept. 13	Lewis Lake	7,757
39	Sept. 13 to Sept. 14	Lewis Fork, 3 miles below lake	7,750
40	Sept. 14 to Sept. 17	Junction of Lewis Fork and Snake River	6,892
40*a*	Sept. 17 to Sept. 18	Lakes at head of Fall River	7,530
41	Sept. 19 to Sept. 21	Inlet to Jackson's Lake	6,817
41*a*	Sept. 21 to Sept. 22	Jackson's Lake	6,811
42	Sept. 22 to Sept. 25	Outlet to Jackson's Lake	6,808
43	Sept. 25 to Sept. 28	Eastern foot of Mount Hayden, between glacier lakes	6,955
44	Sept. 28 to Sept. 30	Snake River, at junction with creek from glacier lakes	6,446
45	Sept. 30 to Oct. 1	Snake River, below mouth of Gros Ventres Creek	6,234
46	Oct. 1 to Oct. 2	Eastern end of Téton Pass	6,317
47	Oct. 2 to Oct. 3	Western end of Téton Pass	6,312
48	Oct. 3 to Oct. 4	Horse Creek, Téton Basin	6,408
49	Oct. 4 to Oct. 5	Cañon Creek	5,804
50	Oct. 5 to Oct. 6	Moody Creek	5,266
51	Oct. 6 to Oct. 7	Snake River, 8 miles below cañon, north side	5,030
52	Oct. 7 to Oct. 9	Snake River, 8 miles below cañon, south side	5,040
53	Oct. 9 to Oct. 10	Willow or Big Sandy Creek	4,877
54	Oct. 10 to Oct. 11	Higham's Ranch	4,601
56	Oct. 11	Fort Hall, Idaho	4,754

Profile of Henry's Fork.

	Elevation. *Feet.*
Henry's Lake	6,442
At camp 26	6,448
At camp 25	6,242
At camp 15, Eagle's Nest Ford	4,944

Profile of Snake River, from headwaters of Lewis Fork to Stoner's Stage Station.

Head	7,986
Shoshone Lake	7,870
Lewis Lake	7,828
Falls, top	7,804
Falls, bottom	7,765

At camp 39	7,742
Falls, top	7,523
Falls, bottom	7,468
Falls, $2\frac{1}{4}$ miles below	7,110
Two miles above camp 40	6,910
Mouth of Lewis Fork	6,870
Jackson's Lake	6,806
Seven miles above camp 44	6,685
At camp 44	6,429
At camp 45	6,227
At camp 52	5,030
At camp 12	4,825
At Taylor's Bridge	4,814
At Stoner's Stage Station	4,621

Profile of Falls River.

Head	7,580
Beula Lakes	7,525
Rapids below lakes	7,455
Falls, 3 miles below lakes	7,300
Main falls, top	7,047
Main falls, bottom	6,902
At camp 22	5,668
At camp 16	5,116
Shoshone Lake, Geyser Basin, average elevation	7,900
Solitary Geyser, (on Fire-Hole River,) above the Upper Geyser Basin	7,772
The above is the average elevation of the hot springs in that neighborhood.	
Hot Sulphur and Mud Springs, between the Upper Geyser Basin and Henry's Fork	8,544
Hot Spring east of camp 51, on Snake River	5,050

Elevations of lakes.

Shoshone Lake	7,870
Lewis Lake	7,750
Upper Glacier Lake, east of Mount Hayden	6,950
Lower Glacier Lake, east of Mount Hayden	6,945
Jackson's Lake	6,806
Upper Lake, at head of Falls River	7,541
Lower Lake, at head of Falls River	7,525
Lake, one mile above camp 31	7,299
Small lakes at Twin Buttes	7,608
Small lake back of camp 31	7,258
Large hot spring or lake, one and a half miles above camp 31	7,335
Madison Lake	8,301
Small lake at foot of Red Mountain	8,236
Small lake between Lewis and Yellowstone Lakes	8,001
Upper Lake, north of camp 42	6,969
Lower Lake, north of camp 42	6,951

Elevations of mountain peaks.

Mount Sheridan	10,343
Red Mountain	9,806
Rocky Buttes, Falls River Pass	7,356
Top of bluffs, north of same	7,772
Lookout Hill, north of Shoshone Lake	8,257
North Twin Buttes, Lower Geyser Basin, (on main range)	7,962
South Twin Buttes, Lower Geyser Basin	7,979
East Crater Butte, mouth Henry's Fork	5,368
West Crater Butte, mouth Henry's Fork	5,425
Bottom of crater, in West Butte	5,217

Mount Hayden, or the Great Téton, was measured by triangulation with the gradienter. Three different triangulations were made to it from different points, the elevations of the bases above the sea being determined by barometric observations. The several results of the triangulations are as follows: 13,858 feet, 13,705 feet, 13,889 feet.

The first triangulation was made under more favorable circumstances than the others, and I give it a double weight; and adopt, therefore, as the elevation of Mount Hayden above the sea, 13,833 feet.

The result from an aneroid reading was 13,784 feet.

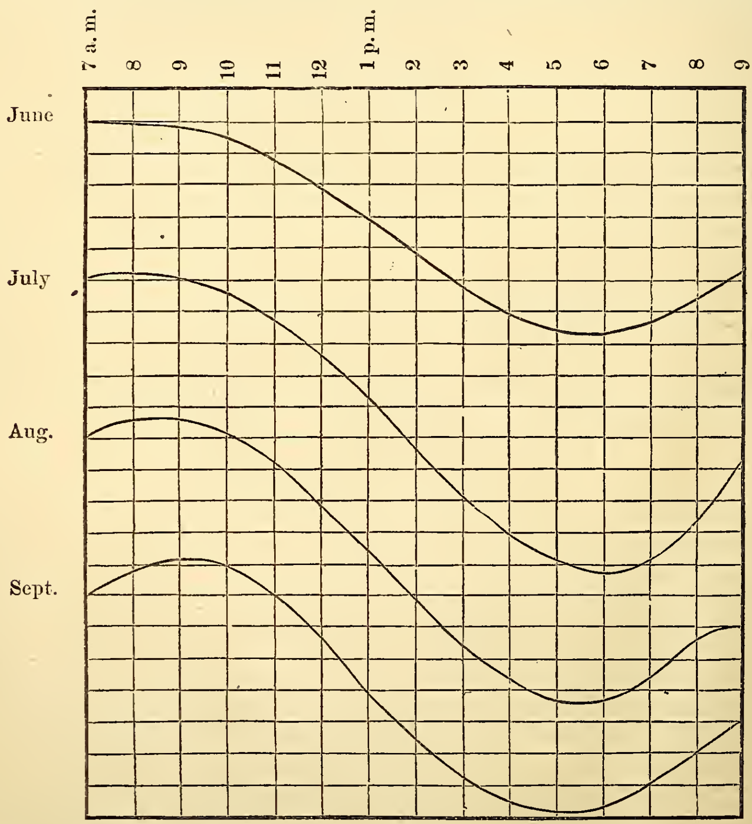
Mount Moran, (elevation determined by triangulation,) 12,809 feet.

Sawtelle's Peak, (measured in same way,) 9,070 feet.

Passes and divides.

	Feet.
Téton Pass	8,464
Tyghee Pass	7,063
Water-shed between Fire-Hole, Snake, and Henry's Fork	8,761
Continental water-shed, between Yellowstone and Lewis Lakes	8,024
Highest point on the divide between the East Fork of the Fire-Hole and Yellowstone Rivers	8,893
Continental divide, between the Fire-Hole River and Shoshone Lake	8,717
Eastern divide, from head of Falls River to Snake River	7,594
Southern divide, from head of Falls River to Snake River	7,533
Continental divide, between the Fire-Hole, west of the Lower Geyser Basin and Henry's Fork	8,267
Divide between Malade River and Marsh Creek	5,651

From the hourly barometric observations at Fort Hall I have constructed the following mean monthly curves of horary oscillations from 7 a. m. to 9 p. m., for the months of June, July, August, and September:



The horizontal divisions represent hundredths of an inch of the barometric column.

The mean temperature from June 4 to 25	64°.62
The mean temperature from July 13 to 31	70°.44
The mean temperature for August	70°.90
The mean temperature for September	57°.79
The mean temperature from October 1 to 18	57°.28

GENERAL INDEX.*

*NOTE.—For names of genera and species see index of systematic names.

INDEX OF SYSTEMATIC NAMES.*

*NOTE.—This index includes the names of all genera and species except those found only in the catalogues. Nothing of the botanical catalogue is included except the family names.