THE

AMERICAN JOURNAL

OF

SCIENCE AND ARTS.

EDITORS AND PROPRIETORS,

PROFESSORS JAMES D. DANA AND B. SILLIMAN.

ASSOCIATE EDITORS,

PROFESSORS ASA GRAY AND WOLCOTT GIBBS,

OF CAMBRIDGE,

PROFESSORS H. A. NEWTON, S. W. JOHNSON,
GEO. J. BRUSH AND A. E. VERRILL,

OF NEW HAVEN,

PROFESSOR A. M. MAYER, OF HOBOKEN, N. J.

THIRD SERIES.

VOL. VI.–[WHOLE NUMBER, CVI.]

Nos. 31–36.

JULY TO DECEMBER, 1873.

WITH THREE PLATES.

NEW HAVEN: EDITORS.
1873.

PRINTED BY TUTTLE, MOREHOUSE & TAYLOR, 221 STATE ST.

CONTENTS OF VOLUME VI.

NUMBER XXXI.

SCIENTIFIC INTELLIGENCE.

◆

NUMBER XXXII.

SCIENTIFIC INTELLIGENCE.

NUMBER XXXIII.

SCIENTIFIC INTELLIGENCE.

NUMBER XXXIV.

◆

NUMBER XXXV.

SCIENTIFIC INTELLIGENCE.

* * *

NUMBER XXXVI.

SCIENTIFIC INTELLIGENCE.

ERRATA.

Page 11, first note, after 1839, insert 1840, 1842.
Page 26, in title, for H. A. Chase, read A. W. Chase.
Page 48, line seven from top, for *Alys* read *Alps.*
Page 147, top line, for Dabken, read Deetken.
Page 170, 23d line from foot, for to LeConte, read one to LeConte and one to Hunt.
Page 172, top line, for LeConte, read Hunt.
Page 265, 9th line from foot, for eastern, read western.
Vol. v, p. 435, 9th line from foot, for ten, read twenty.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. I.—WILLIAM S. SULLIVANT; *a Biographical Notice.* (From the Annual Report of the Council of the American Academy of Arts and Sciences, May, 1873.)

WILLIAM STARLING SULLIVANT died at his residence in Columbus, Ohio, on the 30th of April ult. In him we lose the most accomplished bryologist which this country has produced; and it can hardly be said that he leaves behind him any where a superior.

He was born, January 15th, 1803, at the little village of Franklinton, then a frontier settlement in the midst of primitive forest, near the site of the present city of Columbus. His father, a Virginian, and a man of marked character, was appointed by Government to survey the lands of that district of the "North Western Territory" which became the central part of the now populous State of Ohio; and he early purchased a large tract of land, bordering on the Scioto River, near by, if not including, the locality which was afterward fixed upon for the State capital.

William, the eldest son, in his boyhood, if he endured some of the privations, yet enjoyed the advantages of this frontier life, in the way of physical training and early self-reliance. But he was sent to school in Kentucky; he received the rudiments of his classical education at the so-called Ohio University, at Athens, upon the opening of that seminary; and was afterward transferred to Yale College, where he was graduated in the year 1823. His plans for studying a profession were frustrated by the death of his father in that year. This required him to occupy himself with the care of the family property, then mainly in lands, mills, etc., and demanding much and varied attention. He became surveyor and practical engineer, and indeed took an active part in business down to a recent period. Leisure is hardly to be had in a newly-settled country, and least of all by those who have possessions. Mr. Sullivant must have reached the age of nearly thirty years, and, having married early,[*] was established in his suburban residence, in a rich floral district, before his taste for natural history was at all developed. His brother Joseph, next in age, was already somewhat proficient in botany as well as in conchology and ornithology; and when in some way his own interest in the subject was at length excited, he took it up with characteristic determination to know well whatever he undertook to know at all. He collected and carefully studied the plants of the central part of Ohio, made neat sketches of the minuter parts of many of them, especially of the Grasses and Sedges, entered into communication with the leading botanists of the country, and in 1840 he published "A Catalogue of Plants, native or naturalized in the vicinity of Columbus, Ohio," (pp. 63,) to which he added a few pages of valuable notes. His only other direct publication in phænogamous botany is a short article upon three new plants which he had discovered in that district, contributed to the American Journal of Science and the Arts, in the year 1842. The observations which he continued to make were communicated to his correspondents and friends, the authors of the Flora of North America, then in progress. As soon as the flowering plants of his district had ceased to afford him novelty, he turned to the Mosses, in which he found abundant scientific occupation, of a kind well suited to his bent for patient and close observation, scrupulous accuracy, and nice discrimination. His first publication in his chosen department, the *Musci Alleghanienses*, was accompanied by the specimens themselves of Mosses and Hepaticæ collected in a botanical expedition through the Alleghany Mountains, from Maryland to Georgia, in the summer of 1843, (the writer of this notice being his companion.) The specimens were not only critically determined, but exquisitely prepared and mounted, and with letter-press of great perfection; the whole forming two quarto volumes, which well deserve the encomium bestowed by Pritzel in his Thesaurus.[†] It was not put on sale, but fifty copies were distributed with a free hand among bryologists and others who would appreciate it.[‡]

[*] His first wife, Jane Marshall, of Kentucky, was a niece of Chief Justice Marshall. She died a few years after marriage.

[†] "Huic splendidæ impressæ 292 specierum enumerationi accedit elegantissima speciminum omnium exsiccatorum collectio."

[‡] A tribute is justly due to the memory of the second Mrs. (Eliza G. Wheeler) Sullivant, a lady of rare accomplishments, and, not least, a zealous and acute bryol-

In 1846, Mr. Sullivant communicated to the American Academy the first part, and in 1849, the second part of his "Contributions to the Bryology and Hepaticology of North America," which appeared, one in the third, the other in the fourth volume (new series) of the Academy's Memoirs,—each with five plates, from the author's own admirable drawings. These plates were engraved at his own expense, and were generously given to the Academy.

When the second edition of Gray's Manual of the Botany of the Northern United States was in preparation, Mr. Sullivant was asked to contribute to it a compendious account of the Musci and Hepaticæ of the region; which he did, in the space of about a hundred pages, generously adding, at his sole charge, eight copper-plates, crowded with illustrations of the details of the genera,—thus enhancing vastly the value of his friend's work, and laying a foundation for the general study of bryology in the United States, which then and thus began.

So excellent are these illustrations, both in plan and execution, that Schimper, then the leading bryologist of the Old World, and a most competent judge, since he has published hundreds of figures in his *Bryologia Europæa*, not only adopted the same plan in his Synopsis of the European Mosses, but also the very figures themselves (a few of which were, however, originally his own), whenever they would serve his purpose, as was the case with most of them. A separate edition was published of this portion of the Manual, under the title of "The Musci and Hepaticæ of the United States, east of the Mississippi River," (New York, 1856, imperial 8vo,) upon thick paper, and with proof-impressions directly from the copper-plates. This exquisite volume was placed on sale at far less than its cost, and copies are now of great rarity and value. It was with regret that the author of the Manual omitted this cryptogamic portion from the ensuing editions, and only with the understanding that a separate *Species Muscorum* or Manual for the Mosses of the whole United States should replace it. This most needful work Mr. Sullivant was just about to prepare for the press.

About the same time that Mr. Sullivant thus gave to American students a text-book for our Mosses, he provided an unequalled series of named specimens for illustrating them. The ample stores which he had collected or acquired, supplemented by those collected by M. Lesquereux (who was associated with him from the year 1848) in a journey through the mountainous parts of the Southern States under his auspices,

---

ogist, her husband's efficient associate in all his scientific work until her death, of cholera, in 1850 or 1851. Her botanical services are commemorated in *Hypnum Sullivantiæ* of Schimper, a new moss of Ohio.

after critical determination were divided into fifty sets, each of about 360 species or varieties, with printed tickets, title, index, etc., and all except a few copies for gratuitous distribution were generously made over, to be sold at less than cost, for his esteemed associate's benefit, and still more that of the botanists and institutions who could thus acquire them. The title of this classical work and collection is *Musci Boreali Americani quorum specimina exsiccata ediderunt W. S. Sullivant et L. Lesquereux;* 1856. Naturally enough, the edition was immediately taken up.

In 1865 it was followed by a new one, or rather a new work, of between five and six hundred numbers, many of them Californian species, the first fruits of Dr. Bolander's researches in that country. The sets of this unequalled collection were disposed of with the same unequalled liberality, and with the sole view of advancing the knowledge of his favorite science. This second edition being exhausted, he recently and in the same spirit aided his friend Mr. Austin, both in the study and in the publication of his extensive *Musci Appalachiani.*

To complete here the account of Mr. Sullivant's bryological labors illustrated by "exsiccati," we may mention his "*Musci Cubenses*," named, and the new species described in 1861, from Charles Wright's earlier collections in Cuba, and distributed in sets by the collector. His researches upon later and more extensive collections by Mr. Wright remain in the form of notes and pencil sketches, in which many new species are indicated. The same may be said of an earlier, still unpublished collection, made by Fendler in Venezuela. Another collection, of great extent and interest, which was long ago elaborately prepared for publication, and illustrated by very many exquisite drawings, rests in his portfolios, through delays over which Mr. Sullivant had no control; viz., the Bryology of Rodgers' U. S. North Pacific Exploring Expedition, of which Charles Wright was botanist. Brief characters of the principal new species were, however, duly published in this as in other departments of the botany of that expedition. It is much to be regretted that the drawings which illustrate them have not yet been engraved and given to the scientific world.

This has fortunately been done in the case of the South Pacific Exploring Expedition, under Commodore Wilkes. For, although the volume containing the Mosses has not even yet been issued by Government, Mr. Sullivant's portion of it was published in a separate edition, in the year 1859. It forms a sumptuous imperial folio, the letter-press having been made up into large pages, and printed on paper which matches the plates, twenty-six in number.

One volume of the Pacific Railroad Reports, i. e., the fourth, contains a paper by Mr. Sullivant, being his account of the

Mosses collected in Whipple's Exploration. It consists of only a dozen pages of letter-press, but is illustrated by ten admirable plates of new species.

The *Icones Muscorum*, however, is Mr. Sullivant's crowning work. It consists, as the title indicates, of "Figures and Descriptions of most of those Mosses peculiar to Eastern North America which have not been heretofore figured," and forms an imperial octavo volume, with 129 copper-plates, published in 1864. The letter-press and the plates (upon which last alone several thousand dollars and immense pains were expended) are simply exquisite and wholly unrivalled; and the scientific character is acknowledged to be worthy of the setting. Within the last few years most of the time which Mr. Sullivant could devote to science has been given to the preparation of a second or supplementary volume of the *Icones*. The plates, it is understood, are completed, the descriptions in a good degree written out, and the vernal months in which his mortal life closed were to have been devoted to the printing. The Manual of North American Mosses was speedily to follow. He was remarkably young for his years, so that the hopes and expectations in which we were indulging seemed reasonable. But in January, not far from his seventieth birthday, he was prostrated by pneumonia, from the consequences of which, after some seeming convalescence, he died upon the last day of April. He leaves a wife, Mrs. Caroline E. (Sutton) Sullivant, children, grandchildren, and great-grandchildren, to inherit a stainless and honored name, and to cherish a noble memory.

In personal appearance and carriage, no less than in all the traits of an unselfish and well-balanced character, Mr. Sullivant was a fine specimen of a man. He had excellent business talents, and was an exemplary citizen; he had a refined and sure taste, and was an accomplished draughtsman. But after having illustrated his earlier productions with his own pencil, he found that valuable time was to be gained by employing a trained artist. He discovered in Mr. A. Schrader a hopeful draughtsman, and he educated him to the work, with what excellent results the plates of the *Icones* and of his other works abundantly show. As an investigator he worked deliberately, slowly indeed and not continuously, but perseveringly. Having chosen his particular department, he gave himself undeviatingly to its advancement. His works have laid such a broad and complete foundation for the study of bryology in this country, and are of such recognized importance everywhere, that they must always be of classical authority; in fact they are likely to remain for a long time unrivalled. Wherever Mosses are studied, his name will be honorably remembered; in this country it should long be remembered with peculiar gratitude.

In accordance with his wishes, his bryological books and his exceedingly rich and important collections and preparations of Mosses are to be consigned to the Gray Herbarium of Harvard University, with a view to their preservation and long-continued usefulness. The remainder of his botanical library, his choice microscopes, and other collections are bequeathed to the State Scientific and Agricultural College, just established at Columbus, and to the Starling Medical College, founded by his uncle, and of which he was himself the Senior Trustee.

Mr. Sullivant was chosen into the American Academy in the year 1845. He received the honorary degree of Doctor of Laws from Gambier College, in his native State. His oldest botanical associates long ago enjoyed the pleasure of bestowing the name of *Sullivantia Ohionis* upon a very rare and interesting, but modest and neat Saxifragaceous plant which he himself discovered in his native State, on the secluded banks of a tributary of the river which flows by the place where he was born, and where his remains now repose. A. GRAY.

ART. II.—*On some results of the Earth's Contraction from cooling;* by JAMES D. DANA. Part II, *The Condition of the Earth's Interior, and the connection of the facts with Mountain-making.* III, *Metamorphism.**

II. THE CONDITION OF THE EARTH'S INTERIOR.

THE condition of the earth's interior is not among the geological results of contraction from cooling. But these results offer an argument of great weight respecting the earth's interior condition, and make it desirable that the subject should be discussed in this connection. Moreover, the facts throw additional light on the preceding topic—the origin of mountains.

It seems now to be demonstrated by astronomical and physical arguments—arguments that are independent, it should be noted, of direct geological observation—that the interior of our globe is essentially solid. But the great oscillations of the earth's surface, which have seemed to demand for explanation a liquid interior, still remain facts, and present apparently a greater difficulty than ever to the geologist. Professor LeConte's views, in volume iv, were offered by him as a method of meeting this difficulty; yet, as he admits in his concluding remarks, the oscillations over the interior of a continent, and the fact of the greater movements on the borders of the larger ocean, were left by him unexplained. Yet these oscillations are

---

* For Part I, on the Origin of Mountains, see vol. v, p. 347.

not more real than the changes of level or greater oscillations which occurred along the sea border, where mountains were the final result; and this being a demonstrated truth, no less than the general solidity of the earth's interior, the question comes up, how are the two truths compatible?

The geological argument on the subject (the only one within our present purpose) has often been presented. But it derives new force and gives clearer revelations when the facts are viewed in the light of the principles that have been explained in the preceding part of this memoir.

The Appalachian subsidence in the Alleghany region of 35,000 to 40,000 feet, going on through all the Paleozoic era, was due, as has been shown, to an actual sinking of the earth's crust through lateral pressure, and not to local contraction in the strata themselves or the terranes underneath. But such a subsidence is not possible, unless seven miles—that is, seven miles in maximum depth and over a hundred in total breadth—unless seven miles of *something* were removed, in its progress, from the region beneath. If this *something* was only vapor or gas, then seven miles of open space must have existed there; and this could not have been, except through seven miles of local contraction along the region; but such an open space, if of possible formation, would have been obliterated by catastrophic subsidence, instead of the slow movement that actually took place. And, moreover, such open spaces, of no less extent, must have existed, in one or more ranges, underneath all continental borders. This is proved, and, at the same time, the extreme improbability of their existence demonstrated, by the facts reviewed beyond.

If the matter beneath was not aerial, then liquid or viscous rock was pushed aside. This being a fact, it would follow that there existed, underneath a crust of unascertained thickness, a sea or lake of mobile (viscous or plastic) rock, as large as the sinking region; and also that this great viscous sea continued in existence through the whole period of subsidence, or, in the case of the Alleghany region, through all Paleozoic time—an era estimated on a previous page to cover at least thirty-five millions of years, if time since the Silurian age began embraced fifty millions of years.

The under-Appalachian fire-sea, if a reality, must hence have had a long continuance.

But, on the above condition, it could not have begun its existence later than the period of disturbance closing pre-Silurian time. Earlier, great subsidences were involved in the deposition of the material of which the Blue Ridge, Highland Ridge, Adirondacks, and the Archæan heights farther north were made; and the under-crust sea would have been, through all, a necessity. In fact, it is difficult to find a reason for doubting its having dated back to the era of general fluidity.

Directly following the Paleozoic, or as its closing event, as explained on a preceding page, occurred the plicating of the Alleghany rocks to their depths miles below, and the crystallization of part of them; and this epoch ended in the making of the mountains—a synclinorium—and the annexation of the central and western part of the region to the essentially stable area of the continent; and if motion in the rocks was ever transformed into heat, the under-Appalachian sea should have had its temperature, or its extent, or both, increased. Then, after the Appalachian region had thus become essentially stable, the locus of the region of yielding was moved to the eastward. The long range of the Triassico-Jurassic beds, on the Atlantic border from Nova Scotia to southern North Carolina, show the positions of the new troughs, as stated on page 437.* These subsidences, amounting to 4,000 feet in some parts, ended in a tilting of the beds and in fissure-eruptions through all these sandstone regions from the most northern to the most southern. Now the question arises, whether the great under-Appalachian fire-sea of the Paleozoic continued on through the Triassic and Jurassic periods of the Mesozoic, and thus favored the subsidences and eruptions that then took place; or, whether the old sea of viscous rock, after being increased in extent or temperature by the profound plicating and faulting of the Appalachian revolution, then ceased to exist—in some way difficult to understand—and others were made, farther east, by the later movements? Such a ceasing with a subsequent renewal is seemingly improbable; and if it did not occur, then the under-Appalachian fire-sea continued from the Paleozoic far into the Mesozoic era.

When the material of the under-Appalachian sea was pushed aside by the subsiding Paleozoic deposits of the Appalachian region, what became of it? Some of it may have moved off southward. The chief part would have passed either to the *west*, or to the *east*. That it did not go *west* is evident from the ascertained fact that the oscillations in that direction during Paleozoic time were small; for the region was then, the larger part of the time, a mediterranean salt-water basin or sea, nurturing crinoids, corals and mollusks, and making limestones. If not westward, then it passed *eastward:* and if driven eastward, a geanticlinal elevation of a sea-border region parallel with the area of subsidence must have been in progress from lateral pressure. The height of this geanticlinal, or swell of the overlying crust (anticlinorium), would have depended on the distance to which escape eastward was possible, that is, on the eastward extent of the subterranean region of mobile rock. Its elevation was

---

* Last volume of this Journal.

probably small and of varying extent during the Silurian and Devonian; for Devonian fossils show that the sea-border south of New York had some way an open connection with the Atlantic ocean; but there is no evidence in the Appalachian rocks of the Carboniferous era to prove that off New Jersey it was not, at that time, almost or quite a complete barrier; the marine fossils in the more eastern of the Pennsylvania Coal-measures are rare, and those in the western Pennsylvania beds would have been from the waters of the mediterranean sea over the Mississippi basin, which reached northward from Alabama, and, east of the Cincinnati uplift, bathed all the western part of the Appalachian region, and probably its whole breadth.

When, at the beginning of the making of the Alleghanies, the strata commenced to yield before the pressure and to become pushed up into great folds, the geanticlinal of the sea-border would have subsided in part, in consequence of the removal of resistance in front of it; and this tendency to subside by gravity may have been part of the means by which the plication was made to go forward, its action adding to that of the pressure. But the subsidence did not continue to the obliteration of the geanticlinal; for it was still above the ocean's level during the following era—the Triassico-Jurassic. The absence of all remains of distinctively marine fossils from these rocks, and from any rocks of the Triassic or Jurassic eras in view over the Atlantic border, demonstrate (as I have long held) that an emerged area then existed outside of the present coast line. Moreover, inasmuch as these Triassico-Jurassic areas (situated on the Atlantic slope parallel with the Appalachians) were subsiding while their rocks were in progress, the sea-border anticlinorium should, at the time, have taken another turn upward, as a counterpart to this subsidence.

With the close of the Triassico-Jurassic era, if not before, the great *anticlinorian* barrier began actually to disappear; and by the time the Cretaceous period opened it had so far sunk that the Atlantic coast region south of New York was again exposed to the ocean, and flourished with abundant marine life, the Cretaceous fossils of the coast giving full evidence on this point. Thus the absence from the present Atlantic border of all Triassic and Jurassic marine fossils and the presence of Cretaceous species in great numbers are well accounted for.

Prof. Hunt has recognized the existence, on the Atlantic border of the continent and outside of it, during the Paleozoic era and earlier, of an emerged region, and has appealed to various bare Archæan areas in New England and to the northeast, and to the Archæan character of the Blue Ridge, etc., as proof. He has designated the region, badly, as an "eastern continent," and finds in it, with reason, a source for much of the sedimentary material that was used in making the Appalachian and other rocks. Prof. LeConte also brings into his views such an elevation, and remarks upon its final disappearance. But neither of these authors states that he regards it as part of a system of oscillations set in motion by the lateral pressure resulting from the earth's contraction, and a direct counterpart to the geosynclinal of the Appalachian region. Their views are adverse to such an idea, the subsidence with them being not due to contraction.

The facts thus sustain the statement that lateral pressure produced not only the subsidence of the Appalachian region through the Paleozoic, but also, cotemporaneously, and as its essential prerequisite, the rising of a sea-border elevation, or geanticlinal, parallel with it; and that both movements demanded the existence beneath of a great sea of mobile rock.

The movement and mountain-making over other parts of the Atlantic border (v, 436), and also the grand double series of events on the Pacific or Rocky Mountain border (v, 438), sustain and illustrate the same views. The under-crust fire-sea on the Pacific border must have had great length from northwest to southeast; and also great breadth, for the border region is at least 1,000 miles wide; and great breadth and great length seem plainly its characteristics even till Tertiary times. And did it continue on through the Tertiary and afford the floods of rock that were poured out from the deep fissures of this long era? And was it still in existence when the great floods were poured forth over the drift gravel beds?

It is further to be noted that, in the course of past time, the whole continent has had its surface from one side to the other criss-crossed with oscillations and lines of disturbance, from the lateral pressure acting against its opposite sides, whence it is clear that the continental subterranean seas were *once* continuous. An appeal to the other continents for further testimony is hardly necessary.

The facts from the ocean seem to demand a vastly greater range for the under-crust mobile layer. The coral island subsidence, during the Quaternary and part or all of the Tertiary, could hardly have been due simply to radial contraction from cooling; for this would make the cooling over the tropical part of the ocean in this small part of geological time sufficient to produce there a sixth of the oceanic depression. Is it not proof that even then the plastic layer had enough of extent beneath the tropical part of the oceanic crust to permit of such a sinking, under the irresistible lateral pressure at work? However this be, it stands as a fact to be explained.

In view of the conclusions here reached with regard to the earth's interior, I present the following statements:

1. That this restriction of the interior liquidity of the earth to an undercrust layer, does not require in itself any modification of the views I presented, more than twenty-five years since, on the results of the earth's contraction, since there is still a flexible crust and mobile rock beneath it.

2. The condition of the earth's interior here recognized is, as many readers will have observed, that suggested long ago by Professor W. Hopkins—the author who first offered a mathematical argument in favor of the earth's either having a very thick crust or being solid throughout.* In a paper on Theories of Elevation and Earthquakes, in 1847,† Prof. Hopkins argues that the central mass of the earth became solid in consequence of the pressure, whenever the temperature within reached a limit that permitted of it; that crusting at surface from cooling commenced afterward; and that between the regions of interior and exterior solidification, there long remained a viscous layer, which, in the progress of time, was gradually contracted by the union of the solid nucleus to the thickening shell.

3. The possibility of solidification at center from pressure, in the face of a temperature too high for consolidation from cooling, has not been experimentally demonstrated. Yet a number of facts favor the principle. It has been urged that since the solidification of rocks is attended by contraction, that is, by increase of density, and since pressure tends to produce this greater density, therefore pressure may bring about the condition of the solid. The fact that ice, which has less density than water, changes to water under pressure, has been appealed to in support of the conclusion. The pressure to which the material within the earth is subjected is so great that experiment can never imitate it, or directly test its effects. Beneath only one hundred and fifty miles of liquid rock it would be not less than one million of pounds to the square inch. Less than this may have been sufficient to produce crystallization, and so give rigidity to the viscous rock-material, or at least so, after the cooling the earth has undergone. The rigidity of slowly solidified rock is beyond that of glass or steel—or the degree which, according to Sir Wm. Thompson, must exist in order that the earth should be as completely free as it is from tidal movements in its mass.

---

* Trans. Roy. Soc., 1839.

† Rep. Brit. Assoc. for 1847, p. 33. The theory of elevation advocated in this paper attributes elevation, not to lateral pressure from contraction, but to evolved vapors underneath the elevated region. The array of facts which have been presented respecting the positions of mountain ranges, their relations to the great areas of depression, their successive formation on sea-borders in parallel ranges, and the natural evolution of the whole from the universal action of the one great cause, contraction, has appeared to me to afford the most complete demonstration that the vapor theory is not necessary, at least as regards mountain ranges. The fact also that mountains so raised could not hold themselves up, has seemed to be an insuperable difficulty to the success of the method.

4. According to the above, the solid part of the globe consists, as regards origin, of three parts.

a. The central mass, consolidated by pressure; the solidification *centrifugal*, or from the center outward.

b. The crust proper, consolidated by cooling; the solidification *centripetal*, or from the surface inward.

c. The outer crust, or superficial coatings—the supercrust—made chiefly by the working over and elaborating of the material of the surface through external agencies, aided by the ever-acting lateral force from contraction, and including all terranes from the Archæan upward.

5. As to the thickness of the viscous layer and the overlying crust, or the depth of the later under-crust seas, I have nothing to offer. The Appalachian subsidence might have been accomplished with but seven or eight miles of depth underneath.

The under-crust fire-seas would have had their heat from time to time supplemented through the movements of the crust. But the ordinary oscillations of the crust were so extremely slow and so ineffectual in producing heat, and the greater mountain-making movements occurred at so very long intervals—many millions of years—and then were so very limited in area compared with the earth's surface, that this cause could not have prevented a gradual narrowing of their limits with the progressing refrigeration. But even after the general union of the crust and nucleus, giving the earth *trap-like* "rigidity," had taken place, leaving only local fire-seas, the connection may not have been so complete that it would not have sometimes yielded enough to the slow working of lateral pressure, to have permitted oscillations of nearly continental extent, like those of the Post-tertiary.

A final word on Mountain-making. From the above we learn that, in the work of mountain-making in eastern North America, there was first the commencing and progressing geanticlinal on the sea-border; and, as a concomitant effect of the lateral pressure, a parallel geosynclinal farther west, along the border of the continent. Concurrently, the deepening trough of the geosynclinal was kept filled to the water level, or nearly, by sedimentary accumulations, until these had become seven miles in thickness; and, as a consequence, the lines of equal temperature (isogeotherms) in the crust beneath gradually rose upward seven miles; and further, the geosynclinal crust, owing to this rising of heat from below, lost part of its thickness by a melting off of an under portion, and also part of its strength up to a higher level by the softening action of the heat, while it received, as the only compensation for the loss of thickness, the addition of half-consolidated sediments above. Finally, the geosynclinal region, owing to its position against the more stable continental mass beyond it, and to the weakness produced in its crust in the manner explained, became, under the continued lateral pressure and the gravity of the geanticlinal, a scene of catastrophe and mountain-making after the manner described.

The principle here brought in, that the weakening of the crust through the rise of the isogeotherms was one occasion of the catastrophe, is made of prominent importance by Professor LeConte (vol. iv, p. 468), though by a somewhat different method.

The geological facts thus far gathered have not yet proved that there was a geanticlinal on the Pacific border (like that of the Atlantic), as a counterpart to the geosynclinals in progress; but the evidence may be looked for with confidence.

III. METAMORPHISM.

The fact that all metamorphic or crystalline rocks are upturned or plicated rocks has led many to believe that disturbance and plications were essential features of an epoch of metamorphism; and that Herschel's theory, which attributes metamorphism to the heat that rises into the strata owing to accumulation above (a rise of the isogeotherms) is insufficient. This conclusion is certainly confirmed by finding no evidence of metamorphism in the lowest beds of the Carboniferous series of Nova Scotia, where, since the series has a thickness of nearly 16,000 feet, according to two of the best geologists in the world, Logan and Dawson, the bottom temperature must have been, when the series was completed, at least 330° F. It is still better sustained by the observation that the lower of the forty thousand feet of strata in the Appalachian region, were, where measured by the Professors Rogers, *not metamorphic*—the Chazy and Trenton limestones being ordinary uncrystalline limestones. And yet the temperature in these inferior beds, marked by the ascending isogeotherms, must have been before their disturbance, as calculated by Prof. LeConte, not less than 800° F., and much above this, if more heat escaped from the earth then than now. Thus seven miles of accumulations were not sufficient to bring about metamorphism or crystallization even in the lowest stratum, or any change beyond that of ordinary solidification.*

It seems certain, therefore, that this method of obtaining the heat, by blanketing the surface with strata, is not sufficient.

Neither, as Mallet has observed on page 303 of the last volume of this Journal, can heat be derived from simple pressure or "mechanical compression," as the language of Vose sug-

---

* The arguments here presented are the same that I urged in this Journal, in vol. xlii, p. 252, 1866.

gests.* But with *movements* in the strata, or progressive plications, such as the metamorphic rocks themselves show they have experienced, then, according to the principle of the transformation of motion into heat, first suggested with reference to metamorphism by Prof. Henry Wurtz, of New York, in 1866,† and recently applied to volcanoes and demonstrated by Robert Mallet, Esq., the conditions for metamorphism might be complete, even with comparatively little help from a rise in the isogeotherms. This result would certainly follow if the heat from motion is great enough, as Mallet appears to show, to produce fusion. Such a cause is capable, as others have urged, of producing the heat throughout the strata, just where it is needed for work. Under it, accumulations of strata of like thickness and composition would be differently acted upon according to the three conditions: (1) the amount of motion, one principal source of heat; (2) the thickness of the series of beds undergoing movement, another source of heat beneath; (3) the amount of moisture present in the beds. Thus widely diverse metamorphic rocks might be made of the same material; and if a region of feebly-metamorphic rocks is found to lie side by side with one of thoroughly-metamorphic, the strata of the two may have originally been similar, and of one and the same geological horizon.

Metamorphism over large areas is thus one of the direct results of the earth's contraction. Solidification is often only a lower stage in the same process; and the reddening of sandstones, as already explained,‡ is frequently involved with it.

---

* Vose could hardly have intended to say in place of pressure, the *motion* produced by pressure. For, in one of his paragraphs, he attributes the changes distinctly to "the enormous pressure generated in the folding of masses of rock, the depth of which is measured by miles"; and this pressure was that of gravitating sediments alone, while the additional heat required came from a rise in the isogeotherms in consequence of surface accumulations. The truth is that, instead of folding generating pressure, the pressure generated the folding; and the movement attending folding was essential to the existence of the heat requisite for metamorphic changes. Thus the views of Vose and Hunt are set aside by Mallet, instead of being, as Prof. Hunt says (the last volume of this Journal, p. 270), "confirmed by them." In a letter of May 10th to the writer, Mr. Mallet refers to his opposition to Herschel's theory, and adds that he was "rather amused" at finding himself brought forward by Prof. Hunt in support of it. Mr. Vose's views are contained in his work on Orographic Geology, published in Boston in 1866 (136 pp. 8vo).

† This Journal, v, 385. Prof. Wurtz's opinion was first published in a paper on "Gold genetic metamorphism," in the American Journal of Mining (New York), Jan. 25, 1868. The paper was read at the meeting of the American Association at Buffalo, in August, 1866.

‡ Page 430 of the preceding volume.

ART. III. — *Photography of Southern Star-clusters;* by C. S. SELLACK, at present Professor of Physics in the University of Cordoba, South America.

IN the beginning of last year, under an arrangement made with Mr. Rutherfurd in New York, and at the expense of some gentlemen from Boston, I went to Cordoba to take, in the Argentine National Observatory,* photographs of southern star-clusters, employing the methods of Mr. Rutherfurd. The method of Mr. Rutherfurd is the following. After an exposure of the photographic plate for some minutes, the telescope, which is driven by a good clockwork, is moved to another position by the slow motion, and a second exposure is made; then the telescope is stopped and an exposure made so that the image of the central star, while moving out of the field, leaves a trail. The images of the stars being double, the recognition and discrimination from specks produced by impurities of the plate is very much facilitated; the trail serves to fix a direction for the angles of position on the plate. When the trail could not be obtained for want of brightness of the central star, I made a third exposure some minutes distant from the first, by starting the telescope again after some minutes stopping.

The photographic refractor of about $0{\cdot}280^{\mathrm{m}}$ aperture, formerly owned by Mr. Rutherfurd, now property of the Cordoba Observatory, was to be used for the work. On my arrival in Cordoba the lens, which for a long time had been kept packed up in Cordoba, was found broken; the flint-lens was divided in two by a crack near the middle. The object of my voyage seemed to be frustrated. The optical refractor of the same dimensions, which the observatory possesses, proved unfit for photographic purposes. In using only one half of the broken flint-lens the intensity of light would have been too much reduced for the intended work. If anything at all was to be accomplished, the two pieces of the broken lens had to be fitted together.

I undertook this task with the assistance of a watchmaker in Cordoba, constructing an adjusting apparatus. On the circumference of each of the two segments of the lens, at the corners of the break and in the middle, were put three little metal clasps; pairs of pulling and butting screws, inserted in small metal pieces fastened on to the frame of the lens, worked on these clasps, so that with them the pieces of the lens could be lifted and lowered. A slight motion of the pieces of the lens parallel to its surface could be effected by little wedges, the frame giving some play to the lens.

---

* Under the charge of Dr. B. A. Gould.

The adjustment of the lens was to be done by continued photographing of stars, as the image is not sharp for mean visible rays, and even observation through a blue glass did not show it distinctly enough. The lens had to be taken out of the telescope for each correction, which was done many a hundred times. The image of the star was photographed, not only in its true focus, but at different distances before it, so that the section of the converging light was obtained; the shape and arrangement of light in these sections allowed a better judgment of the state of the different parts of the lens. As the object was not the adjustment of parts of a simple lens, but of the diverging lens of a system, it is obvious that mistakes in correcting the screws were easily made. Displacement of the two pieces of the lens produces double images in the manner of the heliometer, except that in this case the concave lens alone makes the effect; tilting of the pieces about the edge of the crack has a similar effect. The surface of the crack being very irregular, it was difficult to fit the pieces exactly together. Otherwise local tensions and changes of curvature were easily produced by which the image was deformed and the focus of parts of the lens changed. Continued wearisome experiments yielded at last an adjustment sufficient under the circumstances.

The lens gives now with short exposures a well defined, nearly circular, photographic image of stars of the first and second magnitude, and admits adjustment of the focus to $0{\cdot}2^{\mathrm{mm}}$. In its former perfect state Mr. Rutherfurd obtained a trail on the photographic plate of stars of the third to the fourth magnitude, as of several stars in the Pleiades. The image of the broken lens does not seem to have the same concentrated sharpness; only slow moving stars, fainter than third magnitude, leave a trail. However, with exposures of eight minutes stars of the ninth magnitude, of white color, give a photographic impression; this result does not seem to have been surpassed formerly.

The greatest difficulty in stellar photography is to make the image on the plate stationary during a long exposure. The steadiness is absolutely necessary for the production of circular images; the images must be circular, because in elliptically lengthened images the eye cannot fix the center with the sharpness required for the measurements. Employing even the most perfect clockwork, the steadiness of the image is affected by the effect of the atmospheric refraction, by the variations in the refraction produced by disturbances in the atmosphere, and by the increase of refraction dependent on the zenith-distance.

The photographic image of stars is circularly spread by prolongation of exposure; this is principally the effect of the scintillating motion of the image, not of want of definition, as its amount depends on the state of the atmosphere. Bond has found the increase of the area of the image proportional to time. This admits the explanation of the scintillating motion as consisting of transversal vibrations round the central position in all azimuths, and with *uniform* velocity. When the state of the atmosphere produces a strong scintillating motion, the images of bright stars become very large by long exposures, and faint stars do not produce any impression. In great zenith-distances another obstacle combines with the increased scintillation, the strong absorption of chemical rays by the atmosphere.

The increase of refraction depending on zenith-distance, for an exposure of eight minutes, is computed in right ascension and declination for declinations from +20° to — 80° for Cordoba, southern latitude 31° 15′ 30,″ thermometer 20° C, and barometer 725 ^{mm}.

Differences of refraction.

Interval of Hour-angle,	+20°		+10°		0°		−10°		−20°		−30°		−40°		−50°	
	α	*δ*	*α*	*δ*	*α*	*δ*	*α*	*δ*	*α*	*δ*	*α*	*δ*	*α*	*δ*	*α*	*δ*
	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″
0°– 2°	0·00	0·09	0·00	0·07	0·00	0·07	0·00	0·08	0·02	0·13	0·58	0·48	0·02	0·14	0·00	0·07
7°– 9°	0·11	0·67	0·11	0·57	0·14	0·56	0·23	0·62	0·51	0·77	1·54	0·34	0·63	0·68	0·17	0·39
13°–15°	0·34	1·18	0·33	0·97	0·38	0·90	0·55	0·93	0·97	0·92	1·61	0·29	1·08	0·64	0·46	0·62
28°–30°	1·51	2·63	1·30	1·95	1·29	1·58	1·23	1·50	1·69	0·94	1·88	0·36	1·65	0·29	1·17	0·63
43°–45°					2·75	2·37	2·33	2·01	2·50	1·17	2·39	0·59	2·19	0·04	1·79	0·38

Only the component of the refraction in right ascension can be reduced to less than 0·″1, by retarding the clock by the mean amount, and for intervals of 8^m within the given limits (with exception of the zenith-stars near culmination). The corrections of the clock per hour are:

Interval of Hour-angle,	+20°	+10°	0°	−10°	−20°	−30°	−40°	−50°	−60°	−80°
	s.	s.	s.	s.	s.	s.	s.	s.		
0°– 2°	0·00	0·00	0·00	0·00	0·01	0·33	0·01	0·00	0·00	0·00
7°– 9°	0·06	0·05	0·07	0·12	0·27	0·59	0·41	0·13	0·08	0·06
13°–15°	0·18	0·17	0·19	0·28	0·52	0·93	0·70	0·36	0·22	0·15
28°–30°	0·80	0·66	0·64	0·63	0·90	1·08	1·08	0·91	0·74	0·66
43°–45°			1·37	1·18	1·33	1·38	1·43	1·39	1·32	1·38

The component of refraction in declination cannot be eliminated. But the table shows that a double exposure of eight minutes can be made for all stars in which the motion of the image of the central star is less than 0·″2 or $0·004^{mm}$ on the photographic plate. The field comprehends a circle of 80′ diameter; however, the difference of the motion of stars near the border, and of the central one, is always less than 0.″1. The favorable time for taking photographs is for north culminating stars near culmination, for stars culminating near the zenith at some distance from culmination, for south culminating stars near culmination, or at greater hour-angle, when the parallactic angle is near right angle.

As the circumstances have been utterly unfavorable, the lens being broken, the clockwork not of sufficient delivery, the results of the enterprise could not fulfill the legitimate expectations of the liberal originators.

The objects of the southern heavens are numerous and glorious. I selected and photographed some twenty star-clusters, most of them in the constellation Argo, some in Canis Major and Scorpio. The cluster near Carinæ Argus gave a hundred and twenty-three stars on the photograph in the most favorable night. The Pleiades, the richest northern group, did not yield to Mr. Rutherford more than forty-five stars; in fact, the Pleiades do not contain within 40′ round Alcyone more than seventy-five stars, inclusive of the tenth magnitude. The groups near ρ Argus and Lacaille 4375 Argus gave about sixty stars; four other clusters t_2 Carinæ, Lac. 4145, Lac. 3134 Argus, Lac. 7478 Scorpionis about forty stars; altogether twenty-seven clusters, about eight hundred stars.

The elaboration of the results which the plates are capable of giving has been reserved to Dr. Gould.

The Argentine Government is going to provide a new photographic lens for the National Observatory, and has asked me to continue the experiments with the new lens.

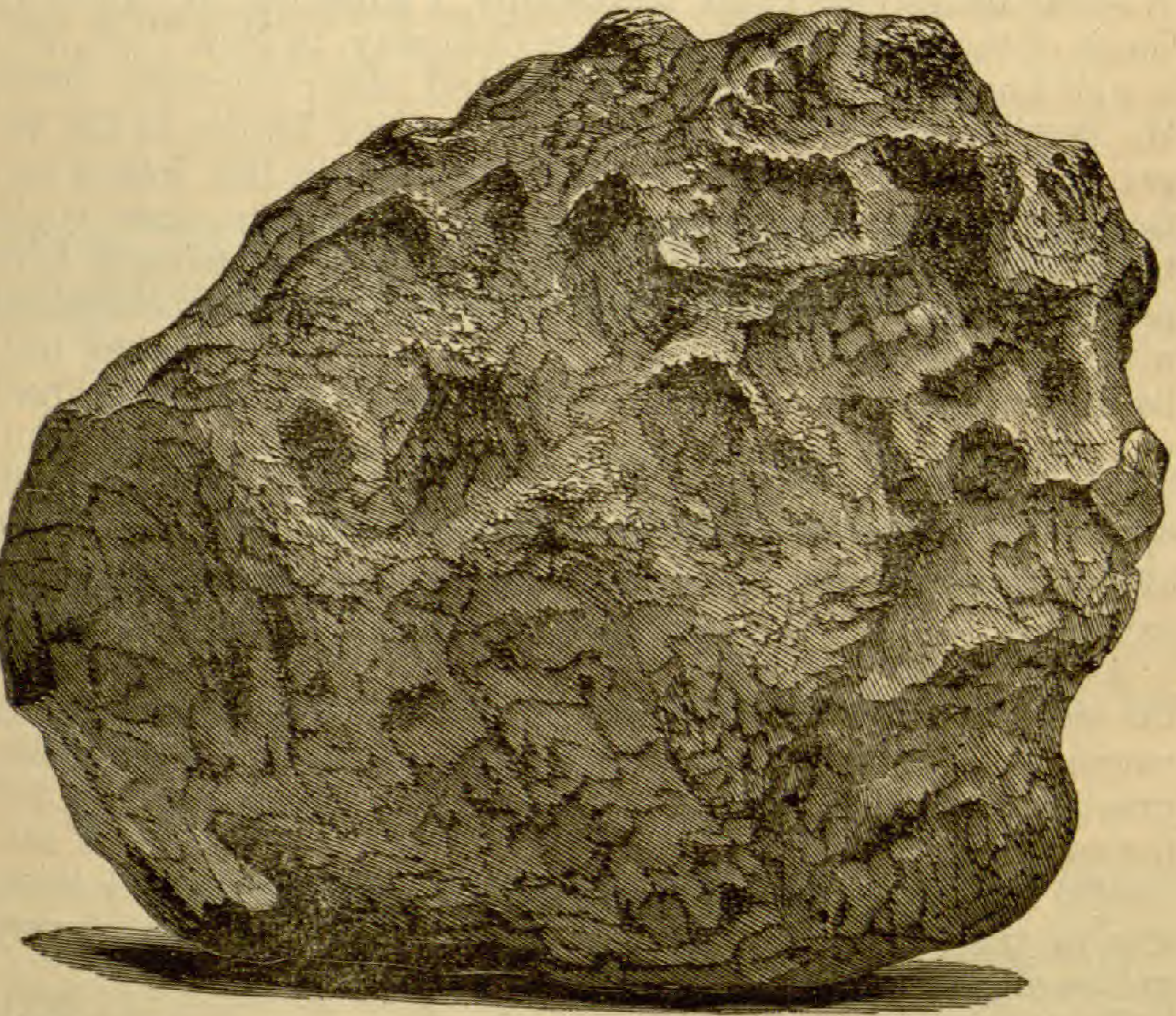
Cordoba, March 8, 1873.

Art. IV.—*On the Meteoric Iron found near Shingle Springs, Eldorado County, California;* by B. SILLIMAN.

(Read before the National Academy of Sciences, Washington, April, 1873.)

An Eldorado meteoric mass was found by the writer in March, 1872, in the cabinet of Mr. W. H. V. Cronise, of San Francisco, where it was placed by its discoverer, Mr. James H. Crossman, who in 1871 rescued it from the forge of a smith at Shingle Springs, California. It was found in 1869 or '70, in a field belonging to the same smith, about half a mile from the town named. It is said to be the first meteoric mass discovered in California. Mr. C. F. Watkins of San Francisco has photographed this specimen of the natural size, and from this photograph the accompanying figure has been reduced to one-third the linear dimensions of the original.

The mass was intact when I first saw it, and weighed about eighty-five pounds avoirdupois. It was flattened upon one side and presented the usual familiar features of iron meteors. It has since been cut in several sections, one of which (which was exhibited with this communication) shows a cross section measuring 12×18 centimeters. The section is approximately a semicircle, having the flattened side for its diameter, with the outline and exterior coating perfectly preserved on all sides. Its weight was over 800 grams. The largest dimensions of the entire mass were about 24 and 29 centimeters.



This meteoric mass is remarkably homogeneous in structure and singularly free from included minerals. Only two very small masses of pyrites, of 3 and 5 millimeters diameter, are visible on one side of the slab, and exteriorly I could detect no heterogeneous substance. When the surfaces of the section exhibited were reduced in the planing machine, it was observed that the exterior or crust was so much harder than the general surface of the section as to cause the tool to rise a little, thus leaving a distinct margin slightly elevated above the adjacent parts, and of a whiter color. This hardened crust had a depth of four to five millimeters.

The density of this iron, determined on a mass of over 750 grams in weight, is 7·875, while the density of the shavings cut by the planing tool from the same mass is 8·024, showing a condensation of 0·149 by this mechanical process. This density (of the mass) is above the average specific gravity of meteoric iron, owing probably to its large percentage of nickel, which, as will be observed, by reference to the accompanying analysis, is more than twice the average amount of that metal found in other meteoric irons.

The crystalline structure of this mass is obscure. The Widmannstättian figures are not developed on it by etching, although a confused granular structure was evident after this process. Wishing to test this point thoroughly, I consulted Mr. John E. Gavit, of the American Bank Note Company, in New York, who is well known for his microscopic and other scientific tastes. Mr. Gavit very kindly tried all the resources known to the engraver's art with a view to develop, by etching this iron, a surface from which its curious cryptocrystalline structure could be transferred to paper by printing. All these attempts have proved unsuccessful. The etched surface, however, examined with a lens, shows a reticulated structure with numerous brilliant points, and V-shaped lines, but so small that when charged with ink the impression upon paper is only a muddy tint. The specimen exhibited shows this peculiar structure developed in four compartments by different etching agents. Some of the printed impressions taken from this surface were also exhibited.

An attempt to develop this cryptocrystalline structure by the aid of a fine "tint," laid on an etching ground by a ruling machine and bitten in; and also by a medallion ruled in orthographic projection, upon which the crystalline lines, it was hoped, might appear in symmetrical form, was not more successful than the other trials. Thus it appears practically hopeless to transfer to paper, by printing, a structure which may yet be clearly seen by the lens.

The suggestion, made long since by Berzelius, that the Widmannstättian figures were due to the segregation of the nickel alloy, in lines of the octahedron, which the etching developed, owing to the inferior solubility of the alloy as compared with the pure iron, seems to meet no support from this mass, in which the uncommonly high percentage of nickel would naturally lead us to expect a proportionate clear development of the crystalline structure. Is it not rather the probable solution of this structure that it is due to the length of time during which the meteoric mass is kept at a high temperature, while slowly cooling.? Under such conditions, the molecules can rearrange themselves in symmetrical forms, and over broad surfaces. In the mass before us, it would appear from what has been said of the crust, that the heat did not penetrate to a greater depth below the surface than 4 or 5 millimeters.

The Cape of Good Hope iron analyzed by Uricochœa resembles this both in the absence of Widmannstättian figures, and in its high proportion of nickel; but its cobalt is much larger, and there are only five elements found, in place of twelve in the California iron.

The following analysis was made upon the clean shavings cut from the entire surface of the section by the planing tool, thus securing a perfectly fair average sample. The analysis was made by Mr. F. A. Cairns, assistant in the School of Mines, Columbia College, whose constant devotion to the analysis of iron gives to his work on this metal great trustworthiness.*

Analysis.

Iron	81·480	Calcium	0·163
Nickel	17·173	Carbon	0·071
Cobalt	0·604	Silicon	0·032
Aluminium	0·088	Phosphorus	0·308
Chromium	0·020	Sulphur	0·012
Magnesium	0·010	Potassium	0·026

Total, ...99·987

Of the twelve elements quantitatively determined by this analysis, aluminium, calcium, and potassium have been rarely observed in meteoric iron—meteors free from silicates—while the absence of copper, tin, manganese and sodium will be noticed.

No room is left, it will be observed, by this analysis for any notable quantity of occluded gases, for which no search was consequently made.

---

* The plan of analysis adopted by Mr. Cairns was as follows:

For nickel, cobalt, aluminium, magnesium, calcium, silicon, ten grams were dissolved in hydrochloric acid and chlorate of potassa, and the solution evaporated in platinum, etc.

In the filtrate, the iron and alumina were removed by double precipitations by acetate of soda, and the alumina determined by fusion in silver with pure soda, etc.

From the filtrate, the nickel and cobalt were precipitated by sulphide of ammonium, (the filtrate being acidified by acetic acid, and boiled to recover nickel in solution in the sulphide of ammonium). The sulphides were then dissolved, and the cobalt precipitated by nitrite of potassa, and determined as double sulphate of potassa and cobalt, and the nickel precipitated as hydrated protoxide. In the filtrate from the sulphides, the lime and magnesia were determined as usual.

The iron was determined in a separate portion of the sample, volumetrically.

The chromium was determined in the residue of 20 grams, insoluble in cold dilute hydrochloric acid.

The carbon was determined by dissolving 10 grams of iron in neutral sulphate of copper, and then the precipitated copper by chloride of copper and hydrochloric acid; filtering through asbestos and oxidizing the carbon with chromic and sulphuric acids, by what is commonly known as Elliott's process, really a modification of a process adopted by Prof. Rogers, of the University of Virginia, in 1848. (See Am. Jour. of Science for 1848; also Am. Chemist, Oct., 1871, p. 140.)

For the phosphorus and sulphur, 10 grams were dissolved in hydrochloric acid and chlorate of potassa, and evaporated to extract silica. The solution was then divided, and in one half the sulphuric acid was precipitated by chloride of barium, as usual. In the other half, the phosphoric acid was determined by molybdate of ammonia, after expelling all chlorine, as usual.

The potassium was determined in 10 grams of the iron by the usual process for alkalies; dissolving, precipitating by baryta, etc.

The amount of nickel in this iron is exceptionally large. In comparing all the analyses conveniently accessible, I find only one other meteoric iron showing so much nickel. That of Greenville, Tenn., by Clark, has Ni 17·10 Co 2·04=19·14, which is the highest before recorded, so far as I can discover. That of Tazewell County, Tenn., by Smith (this Jour., II, xix, 155), has Ni 14·62 — 15·02 and Co 0·43 to 0·50; that of Cape of Good Hope, by Uricochœa (*Rammelsberg*, *Mineralchemie*, pp. 919–920), contains Ni 15·09 and Co 2·56 = 17·65, almost identical with the sum of Ni and Co in the Shingle Springs=17·777 per cent.

The Clairborne, Ala., iron, analyzed by Jackson (this Jour., I, xxxix, 335, and quoted by Gmelin, v, 395 of Cavendish ed.), gave him Ni 24·708—27·708, but this was subsequently reduced by A. A. Hayes (this Jour., I, xlviii, 153) to Ni 12·665 per cent. Very few of the analyses have obtained over 10 per cent of Ni, and an average of this element in some 80 analyses compared by me, is not over seven and a quarter per cent.*

ART. V.—*Contributions to Mineralogy;* by ALBERT R. LEEDS, Prof. of Chemistry in the Stevens Institute of Technology.

I. *A Hydrous Unisilicate approaching Pyrosclerite.*

OCCURS at the so-called Magnesia Quarries, from which the deweylite, at one time largely employed in the manufacture of Epsom salts, was quarried, in the Bare Hills, Md. Since this mineral, in common with the other hydrous unisilicates of a similar character, is to be regarded as most probably one of the results of a process of alteration which has operated powerfully upon the rock masses constituting the Bare Hills, it is important to mention exactly its method of occurrence, which I do from a personal examination of the locality. It is found in a nearly vertical seam several inches wide, between walls of deweylite on one side and talc on the other: the deweylite graduates into albite; the talc is bounded by common serpentine with folia, whose surfaces are normal to the line of contact with the talc.

H.=1·5–2. G.=2·558. Color grayish, inclining in some places to bronze-yellow. Golden luster on fresh cleavage surface. Translucent in thin folia; transmitted light, brownish-yellow. Brittle. Orthorhombic. Largest crystals from this locality 3^{mm}· long in the direction of the macrodiagonal. Basal cleavage eminent. Optically biaxial. Heated in closed tube yields much water of a neutral reaction, and exfoliates vigorously. The folia are pearly-white and opaque. Decomposed by hydro-

---

* A brief notice of this meteoric iron was published by Prof. C. U. Shepard, in this Journal for June, 1872.

chloric acid, the silica being left behind in microscopic colorless scales. Iron reaction with microcosmic salt. With calcic chloride in spectroscope, the lithium band. Composition:

	I.	II.	Mean.	Calculated.	O ratio.	
SiO_2	36·03	35·84	35·99	37·45	19·195	6
Al_2O_3	9·19	9·85	9·52	14·27	4·436	2
Fe_2O_3	5·48	5·21	5·35		1·605	
FeO	0·94	1·21	1·08		0·240	4
MgO	33·05	32·93	32·94	33·30	13·176	
Na_2O	0·41	0·41	0·41		0·106	
Li_2O						
H_2O	14.66	14·53	14·60	14·98	12·978	4
	99·76	99·98	99·89	100·00		

Or for the bases and silica, O ratio = 19·56 : 19·19. This makes the mineral a hydrous unisilicate of the formula $(\frac{2}{3}\dot{M}g^3+\frac{1}{3}(\dddot{\bar{A}}l,\dddot{\bar{F}}e)^2\ddot{S}i^3+4\dot{\bar{H}}$. It will be seen by a comparison of this formula with that of pyrosclerite $(\frac{2}{3}\dot{R}^3+\frac{1}{3}Al)^2\ddot{S}i^3+3\dot{\bar{H}}$, that it differs from the latter by one molecule of water only.

II. *Talc pseudomorphous after Pectolite.*

Occurs in the veins of calcite which traverse the trap rock in the vicinity of the Bergen Hill Tunnel, Hoboken, N. J. Structure radiate, forming arrow-headed masses. Folia easily separable, brittle and varying in length from 1 to 50^{mm}; smooth to the touch, satin luster on faces of folia; crumbling quickly to an impalpable powder when crushed in the mouth, the powder being destitute of grittiness and with a faintly alkaline taste; subtranslucent on their edges, becoming translucent when wet.

H.=2·5. G.=2·565. Heated in closed tube blackens, gives much water, the vapor of which turns litmus paper blue, fumes when brought near a rod moistened with hydrochloric or acetic acid, and when collected by distillation gives with Nessler reagent a strong reaction of ammonia. Partially decomposed by hydrochloric acid, with separation of aluminic and ferric oxides. Iron reaction with microcosmic salt. B.B. darkens, then becomes white, slightly exfoliates and fuses at the ends of thin splinters to a greyish-white enamel. Gives with cobalt solution a pink color on ignition. Composition:

	I.	II.	Mean.	O ratio.
SiO_2	60·54	60·57	60·55	32·293
MgO	26·46	26·67	26·56	10·624
Al_2O_3	1·06	0·98	1·02	10·401
FeO	0·70	0·74	0·72	
MnO	0·55	0·76	0·65	
CaO	1·19	1·63	1.41	
H_2O	9·52	9·09	9·30	
	100·02	100·44	100·21	

O ratio for $\dot{\text{R}}$, $\ddot{\text{Si}}$ and $\dot{\text{H}} = 1:3:1$, corresponding to the hydrous silicate $\dot{\text{Mg}}^2\,\ddot{\text{Si}}^3 + 2\dot{\text{H}} = \text{SiO}_2\ 60{\cdot}8$, $\text{MgO}\ 27{\cdot}0$, $\text{H}^2\text{O}\ 12{\cdot}2 = 100$. While closely approaching talc in its physical characters, this pseudomorph after pectolite is near sepiolite in its chemical composition.

III. *Leucaugite from Amity, N. Y.*

Occurs in rounded, undefinable prismatic crystals and coarse grains, along with seybertite, in calcite.

H. = 5·5. G. = 3·26. Luster vitreo-resinous, bright on cleavage surface; dull on fracture; color light-brown; streak white; translucent in thin splinters; fracture coarse granular; very brittle; B.B. fuses slightly on the edges becoming greyish-white; feeble iron reaction with microcosmic salt.

It resembles in color and general appearance the spinel occurring along with chondrodite and plumbago at Warwick, Orange Co., N. Y. It is likewise almost identical in composition, color, etc., with the leucaugite from Bathurst, W. Canada, described and analyzed by Prof. T. S. Hunt (Dana's Min., 5th ed., pp. 216 and 218). Composition:

		O Ratio.		O ratio.
SiO_2	50·05	26·693	30·030	2
Al_2O_3	7·16	3·337		
Fe_2O_3	0·56	0·504	15·093	1
MgO	14·48	5·792		
CaO	25·63	7·321		
H_2O	1·66	1·476		
	99·54			

This composition is that of a bisilicate of lime and magnesia, with some of the silica replaced by alumina. It is, therefore, an aluminous pyroxene of the formula $(\dot{\text{Ca}}, \dot{\text{Mg}})\,(\ddot{\text{Si}}, \overset{\cdots}{\text{Al}}\,\tfrac{2}{3})$, which is the formula of leucaugite.

IV. *Mineral associated with Corundum and approaching Ripidolite.*

Occurs at the Lesley farm (corundum locality), now owned by Messrs. Pusey & Ball, in Newlin Township, Chester Co., Pa. Encountered in a mass of about 30 lbs. at the borders of a great mass of corundum, of which about 60 tons (Jan., 1873) have now been laid bare. In the specimen from which the material used in the analysis was taken, the corundum is bordered by a soft mineral, which Dr. Isaac Lea pronounces "lesleyite" (App. Dana's Min., p. 18). It contains both lithia and potash. As it recedes from the corundum, the lesleyite alters in character, becoming white and diminishing in its potash percentage. The mineral analyzed contained no potash whatever, but abundant lithia.

H.=1·5–2. G.=2·718. Massive; color light olive-green; streak greenish-white; powder greasy; entirely decomposed by hydrochloric and sulphuric acids, the silica being left behind in an amorphous powder; in closed tube yields water; B.B. turns yellow from oxidation of ferrous oxide, but quite infusible; does not exfoliate; turns flame bright yellow (soda); with calcic chloride paste strong lithium band in spectroscope. Composition:

		O ratio.	
SiO_2	30·62	16·331	4
Al_2O_3	21·73	10·126	3
Fe_2O_3	0·42	0·378	4·84
FeO	5·01	1·113	
MgO	29.69	11·876	
Li_2O	0·11	0·058	
Na_2O	0·14	0·036	
H_2O	12·26	10·898	3·23
	99·98		

The small percentage of ferric oxide is due to a superficial oxidation of some of the ferrous oxide in the mineral, and is consequently calculated as protoxide. The presence of lithia, which I have not been able to detect in any of the accompanying ripidolites, and the unsatisfactory aspect of the oxygen ratio, forbid not only the supposition that this is a variety of ripidolite, but also that it is a new and independent mineral. It seems more probable that it is composed of one or more secondary products derived from a process of alteration. I am indebted for this mineral to the kindness of Dr. Isaac Lea. After arriving at these results, I learned from Dr. F. A. Genth that these minerals, associated with corundum, had been for a long time past the object of his studies, and we shall look with the greatest interest to the results of his investigations in this direction.

V. *Moonstone from Media, Delaware Co., Pa.*

H.=6·5. G.=2·59. Brilliant blue reflections from surface of principal cleavage; finely striated upon second cleavage surface; white, imbedded in white granular albite; closely resembles the peristerite of Canada.

Composition: SiO^2 67·70, Al^2O^3 19·98, Fe^2O^3 trace, CaO 1·47, MgO 0·11, Na_2O 8.86, K_2O 1·36, Ign. 0·08 = 99·56. Oxygen ratio for $\dot{R}$, $\bar{\bar{R}}$ and $\ddot{Si}$ = 2·951 : 9·310 : 36·126 or 1 : 3 : 12, which assigns to this variety of moonstone the normal composition of albite.

VI. *Antholite from the "Star Rock," Concord, Delaware Co., Pa.*

H. = 5–5·5. G. = 3·20. Luster vitreo-pearly; color yellowish-grey; streak dirty-white; broadly bladed and subfibrous, with evidence of incipient alteration; translucent; doubly refracting. An analysis gave:

		Oxygen ratio.	
SiO_2	55·12	29.396	29·652
Al_2O_3	0·55	0·256	
FeO	8·20	1·822	15·152
MnO	0·33	0·074	
CaO	0·75	0·214	
MgO	31·18	12·472	
K_2O	1·01	0·170	
Na_2O	1·55	0·400	
H_2O	2·21	2·044	
	100·90		

It is, therefore, a somewhat altered and hydrated bisilicate of lime and iron of the general formula $(\dot{Mg}, \dot{Fe})\ddot{Si}$. In other varieties of this mineral, which in common unfortunately goes by the name "anthophyllite," the departure from the normal composition is still wider.

VII. *Wernerite from Van Arsdale's Quarry, Bucks Co., Pa.*

Occurs interpenetrated with sphene, cryst. graphite, pyroxene and oligoclase. H.=5·5. G.=2·708. Luster greasy; white, but with faint greenish tinge from admixed impurities; very translucent; structure columnar massive. Composition: SiO_2 47·47, Al_2O_3 27·51, Fe_2O_3 trace, MgO 1·20, CaO 17·59, Na_2O 3·05, K_2O 1·40, H_2O 1·48 = 99·70. Oxygen ratio for $\dot{R}$, $\overline{Al}$ and $\ddot{Si}$ = 6·53 : 12·82 : 25·316 = 1 : 1·97 : 3·88. This ratio is unusually near the mean oxygen ratio of the least altered varieties of wernerite, and there appears no good reason for giving to this variety of scapolite from Van Arsdale Quarry, as has usually been done, the name of ekebergite.

Stevens Institute, April 7th, 1873.

ART. VI.—*Indian Mounds and relics on the Coast of Oregon;*

by ~~H. A.~~ CHASE.

A. W.

THE Indian tribes that once inhabited the coast line of the northern portions of California and the southern of Oregon have almost entirely disappeared, if we except the powerful tribe of the Klamaths, still living on the river of that name. The reasons for this disappearance are to be found, not only in the usual destiny of the aborigine to fade away when brought into contact with the strong civilization and also the strong vices of the white—but war, both between different tribes, and between the Indians and the white settlers. The particular section of coast referred to was depopulated after the great war of 1856, called the Rogue River war. The coast tribes generally participating in this were either destroyed by the enraged settlers, or at the conclusion of the fight transferred to the different reservations by the General Government. They have, however, left behind them relics of ages of occupancy of favorite haunts, which offer an opportunity to trace their gradual improvement from remote times and their after decline as the influence of the whites became general.

These relics are in the shape of mounds, consisting of the debris of many years, perhaps centuries, of occupation, and the stone and other implements found in their graves. The traditions of the few Indians still remaining, and the stories told the first settlers, all point to the fact that a constant state of predatory warfare went on between the different tribes in the early times. The chief of a class or family, then, in selecting a spot for his encampment, would have several points in view. First security from a sudden surprise on the part of inimical tribes; whence he would select some prominent knoll or hill which would offer a view both up and down the coast, and be far enough away from the forest to prevent an ambush. Second, a supply of food and water; not difficult to find, since the rocky coast afforded him an abundant supply of mussels, and other shell-fish easily obtained at any point; salmon in the season were abundant in the small streams, and cod, bass and halibut were found in schools, around the outlying rocks and reefs, which also afforded a shelter for the seal and sea lion; the great fir and redwood forests that, commencing on the slopes of the coast range, extended into the interior, were filled with elk, deer and bear; the marshy meadows near the streams afforded him camas root, and the sea beach a glutinous and edible sea weed; finally, the acorn of the chesnut oak, ("Quercus densiflora,") and the nut of the laurel, ("Oreodaphne Californica,") were also used.

Wherever, then, we find a prominent knoll commanding a good view, with a sand beach near it, and outlying rocks, we find the remains of the Indian occupancy. Passionately attached to a spot once chosen, especially after any of the tribe had been buried there, they would live and die on their mound, never venturing farther from it than was necessary to procure food.

At first it is probable that their habitations were holes dug in the ground, and covered over with brush or drift wood; these were afterward improved by puncheons, or rough-hewn planks from the cedar or redwood. The shells of the mussels and clams, the bones of sea-lions, bear, deer, and other animals and fish consumed, were thrown outside the hut. When an Indian died, an excavation was made in this debris, and he was placed in the grave in a sitting posture, facing the east. His arms, trinkets, all that he possessed, were then disposed about his person, the grave was filled up, and a rude fence erected around it. His house, or hut, was then burned down, and the ashes cast over the grave.

Of course in the lapse of years, the accumulation of debris on the mound was immense, and completely covered the original hill often to a depth of 25 or 30 feet.

An Oregon farmer owning the land on which one of these mounds was situated, cut a portion of it away for the purpose of getting a secure foundation for his house, and also to use the shells and debris for manuring his lands.

Being on the spot, I was afforded an excellent opportunity of observing the formation of the mound, and also of securing the different stone implements to be described. The vertical section exposed was about twenty-five or twenty-six feet. The original ground being a stiff clay, the accretions were easily distinguished from it. For the first two or three feet, the shells and bones were so far decomposed that they formed a fine black loam. The articles found in this stratum were of the rudest construction; and, of course, only those of stone remained In the next stratum, however, articles of bone and ivory and an occasional perfect skull were exhumed, while ten feet from the surface the skeletons were intact, and articles of bone and ivory and even of wood perfect.

The articles obtained may be divided into four classes, and in giving a description of characteristic specimens of each, I shall endeavor to account for its use, basing my information on the present habits of the old Indians remaining and the traditions of the whites. These classes are, first, objects of superstition and personal ornament; second, implements used in preparing food; third, implements of warfare and the chase; and fourth, those used in manufacture.

Of the first class, the most remarkable are knives, or swords, of black and bluish obsidian. The bones found with these implements were of unusual size, the skull being especially large. The owner was probably a chief, or perhaps a medicine man or doctor.

One of these obsidian knives is double edged and double ended, in shape not unlike a Greek sword, 14¾ inches long, 2 inches broad at one end, 1¾ inches at the other, tapering toward both ends and edges, and ¼ of an inch thick at the center. This knife is most carefully knapped, and considering the brittle character of the material, must have required no mean amount of ingenuity and patience to fashion. A second is of the same material, but not so large, being 8½ inches long with a uniform width of one inch, tapering to a point and to both edges. A third smaller one, but of the same shape, is composed of red jasper, mottled with black. Others, smaller still, are of green jasper, and of obsidian of a bluish cast. These knives could not have been used for practical purposes, as too much labor has been bestowed on them (considering the brittle character of obsidian); then again there is no place where they could have been grasped without injury to the hand. Now at the present time obsidian is highly valued by the Klamath Indians, and an arrow or spear head of any size fashioned of it will command a high price, either in "Siwash," i. e., alacachic or Indian shell money, or in gold and silver. (The Klamaths at the present time are well armed with both muskets and pistols, and have discarded the use of stone for weapons.) The value attached then to these arrow and spear heads is a purely fictitious one, and connected with the superstition that one of these stones in the possession of a family will ensure to it health and a permanent occupation of a favored spot. These knives were probably held in high value, and brought out to display the wealth of the owner on some festive occasion, such as a medicine dance, etc. Prescott mentions the knives of obsidian used by the priests of the fire-god in Mexico, in their abhorrent human sacrifices. Found with the knives were several polished stones, oblong in shape, rounded on the sides, and flattened on the upper and lower surfaces. They are of an exceedingly hard black rock not found in the immediate vicinity, and as the polish is equal to that of a lapidary of to-day, one is at a loss to conceive how it could have been done, unless by the attrition of another rock or stone of equal or superior hardness, and by immense labor.

Other articles coming under this head are flattened pieces of bone with carved edges, used probably as ear-rings, pipes of slate and sandstone with straight tubes, whistles formed of the thigh bones of birds, etc.

Of the second class, a great variety of pestles and mortars were found, those of the lower strata being exceedingly rough in shape, but as the upper layers were approached becoming more regular and some of them even artistic in fashion. The mortars are simply a round stone of trap or greenstone, selected from the beach most probably; the center of this stone is hollowed out to form a receptacle for the article to be powdered. The pestles are of all sizes and forms, the most frequent being a shaft of hard serpentine or sandstone, ending in a little ball.

One of them, however, is composed of dark greenstone exceedingly hard, and is well polished. In shape it is like a bell, being full below and tapering to the handle, which ends with an ornamental top.

These implements were undoubtedly used then, as they are now by the Klamaths, in the preparation of acorn food. The nuts being roasted, were divested of the outside shell and pounded into meal in the mortars by the squaws. The meal mixed with water was then baked into cakes before an open fire, and formed a not unpalatable substitute for flour.

Of the third class, viz., implements of warfare and the chase, a great variety was found. The arrow and spear heads are fashioned with great care out of jasper, flint, and obsidian. There seems of the former to be two classes, one most probably used in hunting, the other for war. The former are larger and rougher in shape, the latter delicate in form and of small size; the latter were most likely poisoned when used, the method of obtaining the poison being to capture a rattlesnake alive, and by irritating it, induce it to thrust its fangs into a putrid deer's liver, in which the arrow heads were placed, and removed just before a battle. The spear heads were of two kinds, stone and ivory, the latter made from the teeth of the sperm-whale and sea-lion, which were occasionally stranded on the beaches. These were evidently intended for fish alone.

The stone spears are about three inches long, fashioned from black and white flint, also from jasper of different colors. The bows used with these arrow-heads, and the handles of the spears, had rotted away, but there is no doubt but that they were made of the northern yew, "*Taxus brevifolia*," which is the material still in use by the Klamaths. It is a tough elastic wood of close fibre and dark red color. The favorite method of taking elk was to dig pits, from 15 to 20 feet in depth, in the trails used by the animals in traveling from one pasture to another. In the bottom of the pit sharpened stakes were planted, and on the top a light covering of branches and leaves. When the animal fell into the pit the stakes impaled him.

It is dangerous to travel at the present time over the country in the vicinity of the mounds, unless the beaten trails are kept, on account of these pits, which are concealed by the luxuriant growth of brake and fern, which covers all open spaces on the sea coast of Oregon.

Of the fourth class, several stone adze handles were found. These were made of sandstone, one of dark greenstone. The tops were curved and rounded to a point, and protruding knobs afforded an opportunity of lashing a knive or adze of flint to the handle.

These were probably used in hollowing out the canoes. A log of redwod being selected from the beach drift, free of knots, a fire was built in the center, and as the wood charred, it was chipped away, until a shell was formed; the outside was then shaped in the same way. The canoe in use at present by the

Klamaths will stand a very heavy sea without upsetting. Before the introduction of iron, it was a work of many weeks to fashion a canoe, and once completed it was regarded as a valuable piece of property. The canoe is always burned over the grave. Under this head would also come needles of bone and ivory. These were used in the manufacture of nets, the material being a tough grass.

The most remarkable article, however, of this class was exhumed from a mound at the mouth of the Chetko River, some five miles below those from which the implements above described were taken. It is a brass hatchet or adze. It is about 4 inches long by 2 at the head and 3 at the cutting edge, and $\frac{1}{4}$ of an inch thick. It bears evident marks of being hammered out, and the edge shows continuous use. The perforation for the handle is in the flat part of the hatchet, and not in the edge as in our tools. The depth at which this was found, and the character of the deposit over it, precludes the idea that it could have been introduced by the whites, whose settlement does not date back more than thirty years.

There are large deposits of native copper in the mountainous country at the head of this river, and ores said to be zinc have been discovered. Whether then it was manufactured from these ores, which would argue a degree of skill that is not evidenced by the other implements, or from some copper or brass picked up from a wreck, possibly of one of the early Spanish navigators, is a question. There have been, it is well known, a number of Japanese junks driven over and wrecked on the Pacific coast. It is possible the material may have been obtained from one of them. In this connection a curious and well authenticated legend (that is familiar to the remaining Indians of the Chetko tribe, one or two families of whom still exist) will bear relation. The Chetkos say that many seasons ago their ancestors came in canoes from the far north, and landed at the river's mouth. They found two tribes in possession, one a warlike race, resembling themselves; these they soon conquered and exterminated. The other was a diminutive people, of an exceedingly wild disposition, and *white*. These called themselves, or were called by the new comers, "Wogies." They were skillful in the manufacture of baskets, robes, and canoes, and had many methods of taking game and fish unknown to the invaders. Refusing to fight, the "Wogies" were made slaves of, and kept at work to provide food and shelter and articles of use for the more warlike race, who waxed very fat and lazy. One night, however, after a grand feast, the "Wogies" packed up and fled, and were never more seen. When the first white men appeared, the "Chetkos" supposed that they were the Wogies returned. They soon found out their mistake, however, but retained among themselves the appellation for the white men, who are known as Wogies by all the coast tribes in the vicinity.

In concluding this imperfect sketch of the Oregon mounds, I would express the hope that they be made the subject in the future of an exhaustive exploration by scientific men familiar with Indian habits, confident that they will repay such a search, and that the discoveries made will throw much light on the history of the race, now so nearly extinct.

ART. VII.—*A local Thunder Storm presenting evidence of strong wind blowing outwardly in all directions from its center;* by GEORGE SUTTON, M.D., Aurora, Indiana.

(Read before the Cincinnati Society of Natural History.)

THERE is a phenomenon connected with our local thunder storms occasionally occurring in summer, and doing immense damage to the growing crops, which I think has not received the attention that it deserves, as scarcely any allusion is made to it in our works on meteorology. I refer to a strong wind suddenly blowing *outwardly* in all directions from under a storm cloud during an unusually heavy fall of rain, the wind subsiding as the cloud disappears; the cloud itself remaining about stationary, having concentrated and nearly dissolved over the same place. This phenomenon is local, being independent of the great storms which sweep over our country; neither does it present the evidence of a cyclone or tornado, but occurs on a still sultry day in summer, when masses of cumuli, after gradually concentrating at one point, rapidly dissolve and pour down immense torrents of rain, sometimes intermingled with hail, accompanied with this strong wind blowing outwardly to every point of the compass from the body of the storm. Being accustomed daily for many years to record meteorological observations, I have noticed, at different times since 1840, evidences of this outward wind occasionally accompanying our local thunder storms, although I never have given the subject careful investigation until recently.

On the 26th of August last I had an opportunity of witnessing the formation and progress of a storm of more than usual violence, which, after careful examination, has presented the most conclusive evidence of this outward blow of wind. This storm was on the south side of Langhery Creek, within two minutes and a half of Aurora, Indiana. The morning of the 26th was clear and beautiful. At 7 A. M. not a cloud was to be seen. The atmosphere was perfectly calm, though the vane was pointing toward the N.E. I marked the thermometer that morning 76, the barometer 29·50 in.; the dry bulb of the thermometer 88, the wet 29; these last instruments were under cover in my office. At 2 P. M. cumuli were seen in different directions, with a scarcely perceptible motion from the west. I marked the amount of clouds as six. The atmosphere was calm, the vane pointing toward the S.W. The thermometer 98, although it stood shortly before at 100, the temperature varying as clouds obscured the sun. The barometer stood at 29·49 in., attached thermometer 92, dry bulb of the thermometer 88, wet 82. About 3 o'clock P. M. I noticed heavy cumuli forming to the south of Aurora, in which, shortly after, thunder was heard, and I saw that light rain was falling from one of the clouds near the mouth of Langhery Creek. Black-looking cumuli were forming near this cloud to the west. It was evident that from those clouds there would soon be heavy rain, and in company with one of my neighbors I watched the progress and formation of this storm, hoping, as the ground was dry and parched, it would extend over Aurora. The atmosphere was remarkably still and sultry.

About 4 P. M. these cumuli had united, forming a black massive-looking cloud, which appeared stationary. This cloud was not extensive, as clear sky could be seen all around the horizon under it, except a small portion to the east, where light rain was still falling. A few minutes after 4 (the exact time is not known, as it was not marked) I noticed a number of dark streaks of rain falling from different portions of this cloud: these could easily be seen shading the clear sky beyond; but in a few minutes afterward they had increased so rapidly that the whole cloud from the horizon upward presented a dark and streaked appearance, showing that the storm was fully developed, and that heavy rain was falling; at the same time there was stream after stream of the most brilliant flashes of lightning, followed by heavy peals of thunder. The atmosphere, as I before mentioned, had been remarkably calm and sultry up to this time. While the storm was at its height a strong wind arose blowing directly from it. This wind at Aurora was not sufficiently violent to blow down or damage the corn in the neighborhood, but it produced a sudden change in the temperature of 29 degrees, from 98 to 69. The cloud rapidly dissolved almost over the same place in which it had formed, and in less than an hour, or before 5 o'clock, the grand mass of cumuli which at first attracted our attention had disappeared and in its place was a narrow cirrus cloud from which light rain was falling; shortly after we could see clear sky again beyond this cloud, showing that the storm had not been extensive. A little after 5 o'clock we had a slight sprinkle of rain at Aurora, scarcely sufficient to lay the dust, which I marked at three-hundredths of an inch. About 6 o'clock another storm formed to the southwest, about 12 miles distant. In the evening cumuli were seen to the northwest, in which there was occasional lightning. At 9 o'clock I marked the amount of cloudiness as eight cirrus. The vane was pointing to the southeast. Thermometer stood at 76, the barometer at 29·44 in., attached thermometer 82, dry bulb of the thermometer 83, wet do., 79. The mean temperature of the day was 83½.

The next morning, August 27th, the topic of conversation with every person I met coming from below the mouth of Langhery Creek was about the terrible storm which they had had the day before. It was represented that the corn crop was flattened to the ground and destroyed; trees and fences were blown down, drift wood piled up along the banks of the creek, and fences, in many instances, washed away. The lightning had set fire to a hay stack. One wealthy farmer, residing in the neighborhood, declared to me that immediately after the storm he could have shoveled up a cart load of hail stones. All represented the fall of rain and hail as unprecedented, doing immense damage to the growing crops. I rode down to this neighborhood, and when within half a mile of Langhery I began to see evidences of a severe wind storm. The corn was blown down, every stalk lying parallel in one direction, pointing up the river or to the north. I would here remark that our extensive fields of corn, of thousands upon thousands of acres, during the months of July, August and early part of September, when the corn is rapidly growing and brittle, presents an excellent means, if not the very best, of tracing the direction a severe wind has blown during our local storms. After crossing Langhery Creek I approached the center of the storm, the evidences of its violence becoming more manifest. The corn was flattened to the ground and uniformly lying to the north until we came near to a small stream known as Shingle Creek, three miles below Aurora; here the corn was blown down in different directions and stripped of its blades by the hail. Trees were broken or uprooted, and the kitchen attached to a dwelling-house on the banks of the creek was overthrown. This small stream, which is not more than a mile in length, rose to an unprecedented height, stopping for a time the travel on the Rising Sun road, washing away fences, carrying down great quantities of drift wood, and overflowing the corn fields before it reached the river. At the head of this stream, which seemed to be about the center of the storm, a large amount of timber was blown down. Following the Rising Sun road toward the south, evidences were seen of the violence of this storm from the drift wood, stone and gravel lying along the road left by the little streams which ran down from the hills. Four miles below

Aurora along this road, after passing the center of the storm, I found the corn lying in the opposite direction, toward the south. Still farther the evidence of the storm was less, and at Rising Sun, eight miles below Aurora, there had been no rain. As we came up the river on the Kentucky or east side of the storm, a little above Bellview, we saw evidences again of the violent wind; here the corn is blown to the southeast; as we still came up the river opposite to the storm we found it lying to the east, and at Split Rock, still farther up the river, to the northeast, and on crossing the river at this point we found it lying to the north, as before mentioned. Following around the north side of this storm, the corn stalks were seen lying to the north or northwest. One mile above Hartford, seven miles from the mouth of Langhery Creek on the west side of the storm we found the corn lying to the west. The violence of the wind, however, did not seem to have been as great here as on the north and east sides, but still showed the most conclusive evidence of having blown toward the west. Crossing over to the south side of the storm, to the farm of W. Higbee, and all along the southern border of the storm, we found the corn lying to the south and southeast, while down the center of the storm it was lying in different directions, presenting no regularity. It was along the center of this storm that the hail and rain fell in such immense quantities, scarcely any hail falling around the circumference, and none on the west end of the storm. The effect of this unusual rain-fall will be seen for years from the stone and gravel and logs and driftwood left along the banks of the little streams near the center of the storm. The amount of rain that fell is not known, as there was no measurement made by any person residing within the boundaries of the storm.

This storm was between six and seven miles in length and two or three miles in width, lying almost east and west, extending over an area of about fourteen square miles. It did not come from the west, but formed or concentrated almost directly over the country where it expended its violence. A farmer residing near the center of the storm informed me that he was at work in some woodland near his house, when it began to rain; although a dark cloud was overhead, he could see clear sky around the horizon, and consequently was not expecting much rain; the atmosphere was remarkably still and oppressive. He got under a tree, but in a few moments the rain came down in such torrents, and the wind began to blow with such violence, that he left the tree and ran to the house. Shortly afterward this tree, with others, was blown down. I have received the same statements of the stillness of the atmosphere previous to the commencement of the rain from other persons residing within the boundaries of the storm.

This storm presented no evidence of progressive motion or a whirlwind. The clouds remained stationary, the wind blew in gusts, but in no particular direction along the center of the storm, and outwardly all around its borders. There was no strong wind or sensible evidence of converging forces accumulating this immense amount of moisture over this small section of country, although there must have been an imperceptible movement of the surrounding atmosphere toward this point. It is difficult to account for the accumulation of so vast an amount of moisture in any other way. That there was a strong converging upward current is not sustained by a single fact, nor by the observation of a single individual residing within the boundaries of the storm. The atmosphere was still, up to the commencement of the rain.

ART. VIII.—*The Diagonal System in the Physical Features of Michigan;* by A. WINCHELL, Chancellor of the University of Syracuse.

IN the study of the topographical features of Michigan, our attention has been arrested by the observation of an interesting method in the disposition of the lines of relief and drainage. This method, which has not been heretofore pointed out, may be enunciated as the *Diagonal System.* By this expression we mean to say that the longitudinal axes of the topographical and hydrographical features of the State, especially of the lower peninsula, lie in directions which are diagonals between the cardinal points of the compass. We propose to cite a few facts for the purpose of illustrating and establishing this generalization.

With reference to the surface configuration of the lower peninsula, we divide it into the northern and southern lobes. These are separated from each other by a depression extending from the head of Saginaw Bay, up the valley of the Saginaw and Bad Rivers, and down the valley of the Maple and Grand Rivers, to Lake Michigan. This, which we have styled the Grand-Saginaw Valley,* nowhere attains a greater elevation than 72 feet above Lake Michigan. The highest elevations of the southern lobe are more than 600 feet, and those of the northern 1200 feet above Lake Michigan.

The southeastern watershed of the southern lobe is an elongated axis of relief, stretching through Huron, Sanilac, Lapeer, Oakland, Washtenaw and Hillsdale Counties. None of the streams of the peninsula cross it, though its easterly and

* See Walling's Atlas of Michigan; also "Topographical Data for Michigan" (nearly ready for publication), by the writer.

westerly slopes are deeply furrowed by the streams issuing at right angles with its main trend.

The northern lobe of the peninsula is divided primarily by the deep valley of the Manistee and Sable Rivers, flowing southwesterly and southeasterly into their respective lakes. The southern division is deeply indented by the basin which holds Houghton and Higgins Lakes. The former has an elevation of 589 feet above Lake Michigan. From this lake the Muskegon River, the largest of the peninsula, takes its rise, and flowing southwesterly, marks the position of a broad, deep valley, having, on the southeast an elongated watershed stretching from Mecosta County through Clare and Roscommon into Ogemaw County. This we have designated the central watershed. It has a general elevation of 700 feet, while some of its summits exceed 800 feet. On the northwest of the Muskegon Valley we note three broad summits ranged in a line parallel with the valley and reaching elevations of 700 feet.

The northern division of the northern lobe of the peninsula, embracing the most elevated land south of Mackinac, being the region of the parting of the waters in all directions except the south, has not preserved any marked longitudinality.

We may now direct attention more particularly to the diagonism to which we have referred.* In the lower peninsula, the southeastern watershed stretches 200 miles from northeast to southwest (euroboreally), and the central watershed, 80 miles in the same direction; while the Grand-Saginaw Valley lies in the midst of the intervening region. To this direction conforms the trend of the water-courses from Lake Huron to Lake Erie, the axes of Saginaw and Green Bays, and Great and Little Bay de Noquet, as well as the northern reach of Lake Michigan. Along the same diagonal lie the valley of the Manistee, Muskegon, White and Crockery Rivers, as well as large portions of the valleys of the Pine, Salt, Shiawassee, Cass, Flint and many smaller streams.

In the northwest and southeast (euronotal) direction lie Thunder Bay and the valleys of the Kalamazoo, Little Manistee, Pine, South Branch of Père Marquette, Sable, Rifle, Tittabawassee, Belle, Clinton, Huron and many smaller streams. Even streams

---

* As our language does not supply the terms for the convenient and brief expression of some of the following ideas, we venture to suggest a few new terms. Lines lying in the direction of the cardinal points of the compass, may be designated as *cardinal*, or *cardinals*; those lying in the angles between the cardinals may be called *diagonal* or *diagonals*. Of the two cardinals, the north-south one may be designated the *meridional*, and the east-west one, the *transmeridional*. Of the diagonals, the northwest-southeast one may be called *euronotal* (from "Euronotus," a southeast wind), and the northeast-southwest one, *euroboreal* (from "Eurus," an east wind, and "Boreas," the north wind). These terms may be used both adjectively and substantively.

whose outlets are east or west of their sources, pursue zigzag courses to their mouths, in order to conform to the diagonal system. The St. Joseph River, from its sources in Hillsdale County, pursues a general southeasterly course to South Bend in Indiana, and then flows northwest to Lake Michigan. The Cass River flows southwest into Saginaw County, and describes a rounded angle toward the northwest, to pursue its course to the Saginaw. The Flint flows southwest 35 miles to Flint, and then northwest 30 miles to the Shiawassee. The Shiawassee flows northwest 35 miles to Owosso, then northwest 35 miles to the Saginaw. The Raisin, traced from its higher tributaries, is found to flow from the southern part of Jackson County, southeast 15 miles, then east-northeast 7 miles, then southeast 7 miles, then northwest 18 miles, then southeast 15 miles to Lake Erie. The Pine River (of the east) flows southeast 28 miles, then northeast 33 miles to the Tittabawassee. This river, from its source to Saginaw Bay through the Tittabawassee, consists of four sections, two almost rigorously at right angles with the other two, and all lying along the diagonals. The Becs Scies (or Betsie) River flows southwest 20 miles, then northeast 15 miles, into Lake Michigan.

Nor are there any considerable streams not included in the foregoing mention, whose valleys conform to the direction of the cardinals. The river St. Clair and a portion of the Detroit constitute an exception to the statement, to which reference will be made in the sequel. The axis of Grand Traverse Bay trends meridionally, as that of Little Traverse Bay trends transmeridionally. There are also some unimportant streams in the southern peninsula whose general direction is cardinal; but even in these, it is interesting to note to how great an extent the general course is made up from a number of inconsiderable reaches conforming to the diagonal system.

If we look toward the upper peninsula, the attention is immediately arrested by the euroboreal trends of Kewenaw Point and Bay, the copper range, the Porcupine Mountains and Ile Royale. The general watershed of the upper peninsula exemplifies the law in a beautiful manner. Beginning at Pt. Detour it pursues a west-northwest course 23 miles; it then proceeds N.N.W. 13 miles, then W.N.W. 10 miles, then S.W. 16 miles, then N.W. 43 miles, then S.W. 34 miles, then N.W. 6 miles, then a little E. of N. 6 miles, then S.W. 12 miles, then N.W. 37 miles, thence S.W. by zigzag courses 50 miles to the Wisconsin line. The Menominee, Escanaba and other affluents of Green Bay flow southeast. The same is true of the upper waters of the Monistique and all its tributaries, while the main river flows southwest. The Montreal, Presqu'Ile, Ontonagon, Flint-steel and all the streams of Kewenaw Point, have their axes along the euronotal. The Sturgeon River rises near Lake Michigan, flows N.W. 11 miles, then S.W. 8 miles (meeting a tributary from the S.W.), then N.W. 7 miles, then N.E. 25 miles, into Portage Lake, thence S.E. 6 miles through Portage River into Kewenaw Bay—thence finally N.E. through Kewenaw Bay into Lake Superior.

These examples may serve to illustrate sufficiently the law enunciated. But its application is not confined to Michigan. The Maumee River of Ohio, with its tributaries, is a striking reproduction of the Saginaw and its affluents. The Maumee, flowing east-northeast, is fed by the Auglaize and St. Mary's from the southeast, the St. Joseph from the northeast and the Tiffin from the northwest—the last named, in its higher reaches, flowing from Hillsdale County, Michigan, first southeast and then southwest. In Wisconsin, the euroboreal basin of Green Bay is prolonged through the Fox River into Lake Winnebago. The euroboreal trend is seen in the shore-lines about Chegowawegon Bay, the Apostle Islands and the western extremity of Lake Superior. Even the upper Mississippi, whose general course is meridional, divides itself into a succession of reaches conforming strangely to the law of diagonism; while, on the other hand, the river and gulf of St. Lawrence are a further indication that something in the course of events which have fashioned the actual surface, has exerted a greater energy in the direction of the diagonals than in the direction of the cardinal points of the compass.

The causes of these curious phenomena are not difficult to discover. Geological structure will, indeed, be found closely connected with them. The watershed of the Monistique Peninsula follows, in its *general* trend, the strike of the Lower Silurian strata; as the southeastern watershed of the lower peninsula follows nearly the belt of outcrop of the Marshall sandstone. So too, the axes of Lake Michigan and its appendages, Georgian Bay, Kewenaw Point and Lake Ontario, conform to the geological trends. But another force has evidently been operative, for the trends of the physical features of the country have often been deflected from the lines of geological strike. Saginaw Bay trends at right angles to geological strike; and so does Little Traverse Bay. The central watershed and most of the river-valleys sustain imperfect relations to rocky structures. As it is now generally admitted that the whole region under consideration has been extensively glaciated, it seems reasonable to presume that this glaciation is the general cause which has deflected the topographical and hydrographical axes from strict relations to the geological strike. As it has been shown by Prof. N. H. Winchell,* that the glacier probably moved toward

---

* Proceedings Amer. Assoc., Dubuque Meeting, 1872.

the southwest through Lake Erie and the valley of the Maumee; and as we long since reported this as the direction of the principal set of glacial furrows at the west end of Lake Erie,* it seems equally probable, even without collateral evidence, which we have, that the glacier moved in the same direction along Saginaw Bay and the valley thence to Grand Haven; and in a similar direction in the regions about Green Bay. This movement shaped the southeastern and central watersheds of the lower peninsula, and may have impressed its action upon the relief of regions much farther toward the west and northwest. The euronotal trends of river-courses, alternating with euroboreal trends have been determined by the breakage of the drainage across the euroboreally disposed barriers, down slopes whose general descent is euronotal, or across the euronotally-disposed barriers, down slopes whose general descent is euroboreal.

Not to pursue the discussion further, we think the facts will justify the enunciation of the following general proposition: *The actual topographical and hydrographical axes of Michigan are the resultant of two forces—a glacial, acting from the northeast, and a stratigraphical, acting along the lines of strike.*

As a corollary, we shall find that where the rocky formations are most consolidated, the resultant lies nearest to the stratigraphical force; and where the rocky formations are little consolidated, the resultant approximates the line of the glacial force.

As a second corollary, physical features determined by causes which have *obliterated* the glacial and stratigraphical trends, do not necessarily express relations to either force. Of this kind are the small streams whose courses over the diluvial beds have been determined by post-glacial erosions, and river-courses, like the St. Clair and Detroit, marked out across lacustrine or other post-glacial deposits which have concealed the surface features due to geological structure or glacial erosion.

Syracuse University, May 26, 1873.

ART. IX.—*Notices of recent Earthquakes;* by Prof. C. G. ROCKWOOD, Jr., Bowdoin College.

Dec. 14 and 15, 1872. Fuller accounts have been received of the earthquake in Oregon and Washington Territory on these dates. (This Journal, III, v, p. 262–3). Shocks occurred at intervals from the evening of Dec. 14 to the evening of Dec. 17. They were felt from Eugene City, Oregon, north into British Columbia, and on both sides of the mountains, i. e.

---

* Michigan Geolological Report, 1861, p. 128.

over an area of 200 miles square; but were most severe in the neighborhood of Puget Sound. The following is from the "Pacific Tribune," Dec. 21, 1872 (Olympia, W. T.): "Capt. James S. Lawson took a scientific observation of the earthquake on Saturday night last. Its direction was from the south to the north at first; subsequently it changed around to a course from the southwest to the northeast. It was timed with a chronometer watch and the direction noted by a swinging lamp. In an unofficial report to Prof. Davidson, at San Francisco, Capt. Lawson says:

Dec. 14, 1872. Shock occurred precisely at $9^h\ 40\frac{1}{4}^m$ P. M. It commenced with a light movement, gradually increasing for eighteen or twenty seconds. Then came the heavy shock, lasting four or five seconds; then it gradually decreased. In six minutes after the first shock there was another, followed by two others one minute apart. At $10^h\ 12^m\ 40^s$ there was another shock, and after 11 P. M. there were five others.

During the night other shocks were reported (I did not feel them), at 3 and 5 o'clock.

On Sunday evening, at $6^h\ 37\frac{1}{2}^m$ a light shock.

Dec. 16, at $9^h\ 17^m\ 30^s$ A. M., another light shock."

A report from Walla Walla, Jan. 4, 1873, says that light shocks had occurred almost daily up to that time.

Jan. 9, 1873. A letter of March 28th, from Reykjavik, Iceland, reports an eruption of Skaptar Jokull on Jan. 9th, which lasted four or five days and was accompanied by slight earthquakes.

Feb. 26, 1873. A slight earthquake was felt at Beauport, on the St. Lawrence River.

March, 1873. A recent issue of the San Diego (Cal.) Union speaks of a newly discovered volcanic region, about 25 leagues from Moleje, a town on the eastern coast of Lower California. It says: "On the mountain side, within an area of about 200 yards, there are over 20 vent holes, from which smoke is emitted in jets a yard or more above the surface. Earthquakes have been of rather common occurrence in Moleje for several years. At times the shocks were unpleasantly heavy, threatening to overthrow the buildings of the town. Last year twenty distinct shocks were felt on different occasions, but they were light. During 1870 five earthquake shocks were felt at Moleje, which created considerable alarm, shaking the houses to their foundations."

March 12, 1873. A severe shock was felt at Rome, Italy, at 9.05 P. M. Its direction was from southeast to northwest, and it lasted twelve seconds. The vibrations were strong enough to ring bells and to stop the clock in the Astronomical Observatory.

On the same date violent shocks are reported to have occurred at Osaka, Japan, by which the city is said to have been almost destroyed.

March 18, 1873. A shock was felt in the forenoon at Canton, St. Lawrence Co., New York.

March 19, 1873. The city of San Salvador in Central America, was entirely destroyed by an earthquake.

Though slight tremblings had been felt for some days previous, the first heavy shock occurred about 4.30 P. M. on March 4. At this time there were three violent shocks, which were felt throughout the Republic, and by which many houses in the city were cracked and ruined. The people fled to the fields and squares, and many removed to adjacent villages. In this shake no lives were lost, though much property was destroyed. For the next fifteen days the vibrations continued with more or less frequency and often with considerable intensity.

At 2 A. M. of the 19th, two light shocks, followed by a third of terrible severity, completed the destruction of the city. Every town and village within 20 miles suffered more or less, and it was felt throughout all Central America, and far out to sea. Only two buildings were left standing in the city, the Hotal del Pasque and the Government Palace. A fine brick bridge lately built over the river on the road to Soropango was destroyed, and other roads were rendered impassable by immense blocks of stone, thrown down from the heights. In some places crevices a foot wide and of considerable depth were formed in the ground. One of these extended across the Plaza and for several blocks each way, and emitted sulphurous gases and smoke. By the continued shocks over forty bodies were displaced from their niches in the cemetery.

Capt. Kennedy, of H. M. S. Reindeer, who visited San Salvador immediately after the earthquake, speaks as follows of the desolation of the city. "The whole town was down, with the exception of one or two wooden houses. All the churches, including the cathedral, were a heap of ruins; the spire of the latter had been arrested in its fall and remained in a standing position, like the leaning tower of Pisa, but at a much greater angle. One of the bells must have been swung completely round, as it remained mouth up. The U. S. Consulate was a mass of ruins inside, though the outer walls were standing. The palace being built of wood remained standing, except where stone had been used, in which places the sides had fallen, leaving great gaps in the building. There was not one single house left in a habitable condition. The stronger the walls the greater was the ruin, and the streets were one mass of debris."

Up to March 27, about 50 bodies had been taken from the ruins, and 150 wounded persons were cared for by the authorities. The destruction of property was estimated at $12,000,000. Up to April 24, the vibrations still continued and the Government Palace had at last fallen. The neighboring volcano of Izalco was in eruption at the time of the earthquake.

San Salvador was situated on a small stream about 30 miles from the seaport of La Libertad, with which it was connected by rail. It contained about 15,000 inhabitants. This is the eighth time the city has been destroyed by an earthquake in the last 150 years. The last catastrophe occurred on the evening of Easter Sunday, April 16, 1854.

The following description of the crater of San Salvador, on the slope of which the city is built, is given by a party who made the ascent in January last. After describing the ascent the writer says: "Suddenly and without expecting it they found themselves on the edge of an abyss; the impression from the sudden view of it brought everyone to a stand-still, to contemplate the better such a startling spectacle. An immense cavity suddenly yawned before them, about a kilometer wide and 400 yards deep, representing an inverted cone, but lined with an exuberant vegetation and ending in a lake at the bottom. After due consideration of the scene before them, with respect to the probable date of the last eruption, of which no tradition exists, and taking into account the thick stratum of vegetable mould, the size of the trees that grow at the bottom and sides of the crater, and the formation of basalt, it was calculated that this volcano has not been in activity for at least 1000 years.

March 20, 1873. Heavy shocks are reported at Mendoza, Chili.

March 21, 1873. A smart shock was felt about 11.30 P. M. in Montreal.

March 31, 1873. A series of severe shocks were felt about 4 A. M. at Makawao, East Mani, Hawaiian Islands. The vibration was from east to west. A volcanic eruption was feared.

April 12, 1873. In the evening three slight shocks were felt at San Francisco.

April 17, 1873. About 1 A. M., a slight shock was felt at Waterville, Me.

April 21, 1873. A shock was felt at Mission San Gabriel (Cal.), continuing about eight seconds. Its course was north and south.

April 22, 1873. At 10^{h} 13^{m} $31^{sec.}$ P. M., a slight shock was felt at Dayton, Ohio.

April 25, 1873. In the afternoon several shocks were felt in northern New York and on the St. Lawrence.

At Malone and Fort Covington, N. Y., four decided shocks were felt, each lasting about 15 seconds, with intervals of about an hour between the first and second, and half an hour between the third and last.

At Cornwall, Canada, there were three shocks of considerable violence between 2 and 3 P. M. At Moulinette there was a slight shock as 1 P. M., and a heavier one at 3^h 20^m P. M.

April 29, 1873. A sharp shock was felt at Doncaster, Eng.

April 30, 1873. In the night a shock was felt at Cornwall and Cateau Landing, and also at Hamilton, Ontario.

About 10.30 P. M., the same night, three shocks were felt at Manor, Tex.

May 3, 1873. About 3 P. M. a shock was felt throughout Gibson and Carroll Counties, Tennessee, and at Cairo, Ill.

For assistance in collecting the above, I am indebted to C. G. Rockwood of Newark, N. J., and to Edward L. Gaul and Jacob P. Thompson of the New York Times.

Brunswick, Me., May 27.

ART. X.—*On a convenient Eye-piece Micrometer for the Spectroscope;* by Prof. O. N. ROOD.

I HAVE recently contrived a very simple eye-piece micrometer for the study of spectra produced by prisms and "gratings," which, while quite inexpensive, is capable of yielding results that are not easily surpassed except by the use of an eye-piece provided with a micrometer screw. A thin semi-circular plate of silver is made quite smooth, and rendered black by holding it over the flame of a lamp: it is afterward flowed with a drop of weak spirit-varnish to cause the lamp-black to adhere. Crossing the straight edge of this dead-black surface, lines $\frac{1}{4}^{mm}$, etc., are ruled with a dividing engine, and the necessary figures added with the help of a lens. The opaque semi-circular plate is then introduced into the interior of a negative, or preferably in front of a positive eye-piece, so that it is in focus and does not occupy quite half of the field of view. Opposite it, and somewhat nearer the eye, an opening is made in the side of the eye-piece, whereby the lines are brightly illuminated—as a general thing, merely by the diffused light of the room; but if this is quite dark, the small flame of a distant lamp easily accomplishes the same end. This arrangement, it will be seen, furnishes a set of bright lines on an almost perfectly black ground, with the least possible outlay of expense or trouble in manipulation, and the *degree* of their brightness, it will be found, can readily be regulated merely by shading the opening more or less with the hand. The distance of the lines apart should not be too small, as is often the case in the photographic scales of ordinary spectroscopes, but such as will facilitate the estimation of tenths of a division. Two such eye-pieces have been constructed, and employed by me with much satisfaction in the mapping of a large number of spectra furnished by prisms and gratings, particularly in those cases where the spectral lines were quite faint.

Columbia College, June 4th, 1873.

ART. XI.—ADAM SEDGWICK.*

GEOLOGY has lost her veteran leader! While yet firm in intellect, full of kind and generous feeling, and occupied on the last pages of the latest record of his labors, in the ninth decade of a noble life, Sedgwick has gone to his rest. Under the shadow of this great loss we look back through more than half a century, and behold no more conspicuous figure in the front ranks of advancing geology than the strenuous master workman, the eloquent teacher, the chivalrous advocate of science, who has now finished his task. Severe illness, borne with fortitude, had gradually withdrawn him from scenes once brightened by his ever-welcome presence, but could not tame the high spirit, or cloud the genial sympathies which had won for him, more than for other men, the loving admiration of his fellows in age and followers in study. Rarely has a patriarchal life been crowned with such enduring and affectionate respect.

Born in 1785, of a family long resident in a secluded Yorkshire valley under the shadow of Warnside, the boy early acquired the hardy habits and imbibed the free spirit of the north, and the man retained, till his latest hour, a romantic love of the bold hills and rushing streams amidst which he first became an observer of nature. Every homestead and every family in his native dale of Dent were treasured in his memory, and one of the latest of his minor literary essays was to plead against the

---

* In connection with this republication of Prof. Phillips' excellent and well merited biographical sketch of Prof. Sedgwick (from "Nature" of Feb. 6,) we would announce that a circular has just been issued with reference to a monument to his memory, which will take the form of a Geological Museum. One of the Secretaries of the London Committee, A. W. Edgell, Esq., has sent us a printed account of the meeting held with reference to the memorial, in the Senate House, Cambridge, on the 25th of March, the Duke of Devonshire, Chancellor of the University, in the chair. The subscription to the fund has been headed by the Chancellor with the sum of £1,000, and others follow on the circular of £200 to £10. The London Committee, consisting of the Duke of Argyll as President, Sir Charles Lyell and many others, "invite the scientific centers across the Atlantic to assist them in their efforts." Prof. Sedgwick was one of the noblest of men, as well as one of the ablest of the foundation-workers in geological science, a man whom all should delight to honor. Subscriptions for "The Sedgwick Memorial Fund" may be sent to Messrs. Robarts, Lubbock & Co.'s, Lombard Street, London.—EDS.

change of the ancient name of a little hamlet situated not far from his birthplace.

Educated under Dawson, at the well-known school of Sedbergh, while Gough and Dalton were residing at Kendal, he proceeded to the great college in Cambridge, to which Whewell, Peacock, and Airy afterward contributed so much renown. Devoted to the Newtonian philosophy, and especially attracted by discoveries then opening in all directions in physical science, he stood in the list as fifth wrangler, a point from which many eminent men have taken a successful spring. He took his degree in 1808, became a fellow in 1809, was ordained in 1817, and for some years occupied himself in the studies and duties of academic life. His attention to geology was speedily awakened, and became by degrees a ruling motive for the long excursions, mostly on horseback, which the state of his health rendered necessary in the vacations.

It was not, however, so much his actual acquirements in geology as the rare energy of his mind, and the habit of large thought and expanding views on natural phenomena, that marked him out as the fittest man in Cambridge to occupy the Woodwardian chair vacated by Hailstone. Special knowledge of rocks and fossils was not so much required as a well-trained and courageous intellect, equal to encounter theoretical difficulties and theological obstacles which then impeded the advance of geology.

The writer well remembers, at an evening *conversazione* at Sir Joseph Banks's, to which, as a satellite of Smith, he was admitted at eighteen years of age, hearing the remark that the new professor of geology at Cambridge promised to master what he was appointed to teach, and was esteemed likely to do so effectually. In the same year Buckland, his friendly rival for forty years, received his appointment at Oxford, where he had previously begun to signalise himself by original researches in paleontology.

At this time the importance of organic remains in geological reasoning, as taught by Smith, was not much felt in Cambridge, where a new-born mathematical power opened out into various lines of physical research,and encouraged a more scientific aspect of mineralogy, and a tendency to consider the phenomena of earth-structure in the light of mechanical philosophy This is very apparent in the early volumes of the Cambridge Philosophical Society, established in 1819, with Sedgwick and Lee for secretaries. Accordingly, the earliest memoirs of Sedgwick, which appear in the Cambridge Transactions for 1820–21, are devoted to unravel the complicated phenomena of the granite, killas, and serpentine in Cornwall and Devon: and to these followed notices of the trapdykes of Yorkshire and Durham, 1822, and the stratified and irruptive greenstone of High Teesdale, 1823–24. In his frequent excursions to the north he was much interested in the varying mineral characters and fossils of the magnesian limestone, and the remarkable nonconformity of this rock to the subjacent coal, millstone grit, and mountain limestone; and at length his observations became the basis of that large systematic memoir which is one of the most valuable of the early contributions to the Transactions of the Geological Society. Begun in 1822 and finished in 1828, this essay not only cleared the way to a more exact study of the Coal formation and New Red sandstones of England, but connected them by just inference with the corresponding deposits in North Germany, which he visited for the purpose of comparison in 1829.

To one of these equestrian excursions the writer was indebted for his first introduction to Sedgwick. In the year 1822 I was walking across Durham and North Yorkshire into Westmoreland. It was hot summer-time, and after sketching the High Force, in Teesdale, I was reclining in the shade, reading some easily-carried book. Came riding up, from Middleton, a dark-visaged, conspicuous man, with a miner's boy behind. Opposite me he stopped, and courteously asked if I had looked at the celebrated waterfall which was near; adding that though he had previously visited Teesdale, he had not found an occasion for viewing it; that he would like to stop then and there to do so, but for the boy behind him, "who had him in tow to take him to Cronkley Scar," a high dark hill right ahead, where, he said, "the limestone was turned into lump-sugar."

A few days afterward, on his way to the lakes, he rested for a few hours at Kirkby Lonsdale to converse with Smith, who was engaged on his geological map of the district, and had just discovered some interesting fossils in the laminated strata below Old Red sandstone, on Kirkby Moor, perhaps the earliest observation of shells in what were afterward called the upper Ludlow beds. The two men thus brought together were much different, yet in one respect alike; alike in a certain manly simplicity, and unselfish communication of thought. Eight years after this Adam Sedgwick was President of the Geological Society, and in that capacity presented to William Smith the first Wollaston medal. The writer may be permitted the pleasure of this reminiscence, since from the day when he learned the name of the horseman in Teesdale, till within a few days of his death, he had the happiness of enjoying his intimate friendship.

Sedgwick had acquired fame before Murchison began his great career. After sharing in Peninsular wars, and chasing the fox in Yorkshire, the "old soldier" beame a young geologist, and for many years worked with admirable devotion to his chief, and carried his banner through Scotland, and Germany, and across the Alps, with the same spirit he had shown when bearing the colors for Wellington at Vimiera.

Important communications on Arran and the North of Scotland, including Caithness (1828) and the Moray Firth, others on Gosau and the eastern Alys (1829–1831), and still later in 1837, a great memoir on the Paleozoic strata of Devonshire and Cornwall, and another on the coeval rocks of Belgium and North Germany, show the labors of these intimate friends combined in the happiest way—the broad generalizations in which the Cambridge professor delighted, well supported by the indefatigable industry of his zealous companion.

The most important work in the the lives of these two eminent men was performed in and around the principality of Wales; Sedgwick, as might be expected, lavishing all his energies in a contest with the disturbed strata, the perplexing dykes, and the cleavage of the lowest and least understood groups of rocks; Murchison choosing the upper deposits exceptionally rich in fossils, and on the whole presenting but little perplexity as to succession and character. One explorer toiling upward from the base, the other descending from the top, they came, after some years of labor (1831 to 1835), in sight of each other, and presented to the British Association meeting in Dublin a general view of the stratified rocks of Wales.

Thus were painfully unfolded the Cambrian and Silurian systems, which speedily became, in a sense, the scientific property of the discoverers, and were supposed to be firmly separated by natural and unmistakeable boundaries. They were, however, not really traced to their junction, though Murchison stated that he had found many distinct passages from the lowest member of the Silurian system into the underlying slaty rocks named by Prof. Sedgwick the "Upper Cambrian," while Sedgwick admitted that his Upper Cambrian, occupying the Berwyns, was connected with the Llandeilo flags of the Silurian system, and thence expanded through a considerable portion of South Wales. (Reports of Brit. Assoc., 1835.) The Bala rocks were disclaimed on a cursory view by Murchison, the Llandeilo beds surrendered without sufficient examination by Sedgwick; thus the two kingdoms overlapped largely; two classifications gradually appeared; the grand volume of Murchison was issued; and then began by degrees a difference of opinion which finally assumed a controversial aspect, always to be deplored between two of the most truly attached and mutually helpful cultivators of geological science in England:—

"Ambo animis, ambo insignes præstantibus armis."

This source of lasting sorrow to both, if it cannot be forgotten, ought to be only remembered with the tenderness of regret.

Familiar as we now are with the rich fauna of the Cambrian and Silurian rocks, and their equivalents in Bohemia and America, it is not difficult to understand, and we may almost feel again the sustained enthusiasm which welcomed the discoveries which seemed to reveal the first state of the sea, and the earliest series of marine life, "primaque ab origine mundi," almost to complete the physical history of the earth. Starting with a general view of the lake mountains of the north of England, and the great dislocations by which they have been separated from the neighboring chains (Geol. Proc., Jan, 1831), Sedgwick won his difficult way through North Wales to a general synopsis of the series of stratified rocks below the Old Red sandstone, and attempted to determine the natural groups and formations (Geol. Proc.. May, 1838). Three systems were named in order—Lower Cambrian, Upper Cambrian, Silurian—the working out of which, stream by stream, and hill by hill, worthily tasked the energies of Ramsay and his friends of the National Survey for many useful years, after increasing ill-health had much reduced the field-work of the Professor.

But now he began to labor more earnestly than ever in the enlargement and setting in order of the collections which were under his personal charge. In 1818, these consisted almost wholly of the small series bequeathed by Dr. Woodward; now they have been expanded, by the perpetual attention and generosity of Sedgwick, into one of the grandest collections of well-arranged rocks and fossils in the world. One of the latest acquisitions is the fine cabinet of Yorkshire fossils, purchased by Cambridge as a mark of loving respect for her great teacher in his fast decaying days.

In this work of setting in order a vast collection gathered from various regions and from all classes of deposits, Prof. Sedgwick, with wise liberality, engaged the willing aid of some of his own pupils, and of other powerful hands brought to Cambridge for the purpose. Ansted, Barrett, Seeley, M'Coy, Salter, Morris, have all helped in this good work, and to their diligence and acumen were added the unrivalled skill and patience of Keeping, one of the best "fossilists" in Europe. Those who in this manner have concurred in the labors of their chief, one and all, found in him the kindest of friends, the most considerate of masters—one who never exacted from others, and always gave to his assistants more than the praise and the delicate attention which their services deserved.

The ample volume entitled "British Palæozoic Rocks and Fossils, 1851–5," by Sedgwick and M'Coy, must be consulted for a complete view of the classification finally adopted by

Sedgwick; and further information is expected from the publication of a Synoptic Catalogue, to which Salter gave some of his latest aid.

Never was a man so universally welcome among the members, and especially the junior members of his own university. Wonderful was the enjoyment of a voyage to Ely with a happy crew of his pupils (1850). If one stopped at Upware, the oolite there uplifted became the topic of an amusing and instructive discourse; the great cathedral was visited in a more serious mood; the shores rang with the merriment of the returning boat; and the evening closed with a joyous banquet in the hospitable college rooms.

During his long tenure of a fellowship in Trinity College, Prof. Sedgwick witnessed great changes in the mathematical training, and contributed as much as any man to the present favorable condition of science in Cambridge.

To defend the University against hasty imputations, to maintain a high standard of moral philosophy, and a dignified preference for logical induction to alluring hypothesis, was always in his thoughts. Hence the "Discourse on the Studies of the University of Cambridge," at first an eloquent sermon, grew by prefix and suffix to a volume which he himself likened to a wasp —large in front and large behind, with a very fashionable waist.

Under such feelings he spoke out against the "Vestiges of Creation" with a fervor of argument and declamation which must have astonished the unacknowledged author of that once popular speculation. Nor was he silent when the views of Darwin came to fill the void places of biological theory, against which he not only used a pen of steel but made great use of his heavy hammer.

The vigor—vehemence we may call it—of his pen and tongue, in a matter which touched his sense of justice, morals, or religion, might mislead one who did not thoroughly know his truth and gentleness of heart, to suppose that anger was mixed with his honest indignation—

ου γαρ μειλιχος εσκε . . . εν δαϊ λυγρῃ

But it was quite otherwise. In a letter addressed to the writer, in reply to some suggestion of the kind, he gave the assurance that he was resolved "no ill blood" should be caused by the discussion which had become inevitable.

He never failed in courtesy to the honest disputant whose arguments he mercilessly "contunded." Taken altogether, Professor Sedgwick was a man of grand proportion, cast in a heroic mould. Pressed in early life through a strict course of study, he found himself stronger by that training than most of his fellow geologists, but never made them feel his superiority. Familiar with great principles, and tenacious of settled truths, he was ready to welcome and encourage every new idea which appeared to be based on facts truly observed, and not unprepared or unwilling to stand, even if alone, against what he deemed unfair objection or unsubstantial hypothesis.

This is not the place to speak of his private worth, or to indulge in reminiscence of his playful and exuberant fancy, the source of unfailing delight to those who knew him in his happier hours. Unmarried, but surrounded by plenty of cheerful relatives, his last hours of illness were soothed by sedulous affection; his kindly disposition no suffering could conceal; his lively interest in passing events nothing could weaken. Ever

> "Against oppression, fraud, or wrong,
> His voice rose high, his hand waxed strong."

With collected mind, on the verge of the grave, he would express, with undiminished interest, his latest conclusions on his own Cambrian system, purely as a matter of scientific discussion, free from all personal considerations. It will be well if this mode of treatment be reverently followed by those who, while speaking of Protozoic and Paleozoic rocks, know enough to feel how much they have been benefited by the disinterested labors of a long and noble life.

ART. XII.—*Discovery of a new Planet;* by Prof. C. H. F. PETERS. (Communication to one of the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., May 26, 1873.)

I TAKE pleasure in giving notice of another planet of the asteroid group, discovered night before last. It resembles a star of 11th magnitude, and was observed in the following positions:

1873.	Ham. Coll. m. t.	α (131).	δ (131).
May 24.	$15^h\ 17^m\ 58^s$	$15^h\ 16^m\ 10{\cdot}90^s$	$-21^\circ\ 17'\ 49{\cdot}8''$
" 25.	13 12 57	16 15 14·03	−21 18 1·6

whence its motion in twenty-four hours is concluded to be $-1^m\ 4^s$ in A.R., and $-13''$ in decl.

Not far from the planet, only about a degree south of it, is that splendid, resolvable nebula 80 (Nessier) Scorpii; and four degrees farther north may now be observed the still extremely faint comet of Tempel, of short period, whose position on May 23d I determined

A $13^h\ 25^m\ 54^s$ m. t. $\alpha\ c = 16^h\ 29^m\ 18{\cdot}06^s$ $\delta\ c = 16^\circ\ 26'\ 28''{\cdot}0$,

with a motion of about ten minutes per day toward the south.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *New Determination of the Velocity of Light.*—CORNU has repeated, with all the precautions suggested by the recent progress in physical science, the experiment of Fizeau to determine the velocity of light. His researches, which have extended over a period of three years, lead him to conclude that the toothed wheel used in this method, is capable of giving more accurate results than the revolving mirror, employed by Foucault. The principal station, containing the toothed wheel and the mechanism for rotating it, the means of illumination, the telescope, the velocity-register, etc., was at the Ecole Polytechnique. The other station, in which the collimating telescope and the reflector were placed, was at Mont Valerien. The distance between them was carefully measured and found to be 10310 meters, with a probable error of less than ten meters. The wheel was carried upon the arbor of the minute-hand of an improved clock-work. Three of these wheels were made use of, having respectively 104, 116, and 140 teeth. To the clock-work an electric apparatus to register the velocity of rotation was attached, and also the means for regulating its motion, and even reversing its direction. A velocity of 700 to 800 revolutions per second could be thus obtained, which was uniform, and perfectly under control. The registering apparatus consisted of a chronograph, upon the revolving cylinder of which three electro-magnetic pens made their marks; one of these marked seconds, the second marked the rotations of the toothed wheel, and the third, controlled by a key in the hands of the observer, marked the instants of eclipse. The calcium-light was generally employed as the source of illumination, though a simple petroleum lamp was also occasionally used. Over a thousand separate observations were made and registered upon the chronograph; but only the best of these, six hundred and fifty in number, were reduced. These reductions gave the following values in kilometers, for the velocity of light as deduced from the various orders of the occultation:

1st order.	2d order.	3d order.	4th order.	5th order.	6th order.	7th order.
----	302,600	297,300	298,500	298,800	297,500	300,400
----	(17)	(236)	(376)	(480)	(91)	(27)

The numbers in parentheses express the relative value of the corresponding observations; and are obtained by dividing by 10 the product obtained by multiplying the number of observations by $2n-1$ (n being the order of the eclipse) and by 1, 2, 3 or 4, according as the observation was recorded as fair, good, very good, or excellent. The mean result is 298,400 kilometers; multiplying this result by 1·0003, the refractive index of air, 298,500 kilometers is obtained as the velocity of light in a vacuum. This, Cornu believes, is accurate to $\frac{1}{300}$ of its value. It is a close approximation to the result of Foucault, 298,000 kilometers, and also corresponds very closely to the value obtained from the solar parallax, which has recently been calculated by Leverrier from observations upon Mars and Venus to be 8″·86. Cornu believes that with stations separated from 20 to 30 kilometers, it would be possible by this method to obtain a value accurate to within a thousandth.—*C. R.*, lxxvi, 338, Feb., 1873. G. F. B.

2. *On the Activity of Chlorine in the dark.*—Melsens has observed that carbon in the form of coke, purified by repeated washings and ignitions in a current of dry chlorine, can absorb nearly its own weight of this gas. If now a current of hydrogen, previously dried over phosphoric oxide, be passed over this chlorinated carbon, even cold and in absolute darkness, notable quantities of hydrochloric acid gas are disengaged. A true combustion of hydrogen in chlorine takes place, the temperature being actually lowered by the return of the chlorine to the gaseous state.—*C. R.*, lxxvi, 92, Jan., 1873. G. F. B.

3. *On the preparation of Chromic Trioxide.*—In the ordinary preparation of chromic trioxide by the action of sulphuric acid upon potassium dichromate, the yield is unsatisfactory, the product is impure, and the process is tedious. Duvillier proposes to boil together for ten minutes 100 parts of barium chromate, 100 parts of water, and 140 parts of nitric acid of 40° B. To the red liquid, 200 parts more of water are added, and the whole is boiled ten minutes longer. On cooling, barium nitrate is deposited in crystals; and on concentration to the bulk of the acid employed, all the nitrate but one half per cent crystallizes out on cooling. The excess of nitric acid is then driven off by evaporation, and on cooling the trioxide separates in black mammillated masses. These may be freed from barium by re-solution, and precipitation with a little dilute sulphuric acid.—*Ann. Chim. Phys.*, IV, xxviii, 260, Feb., 1873. G. F. B.

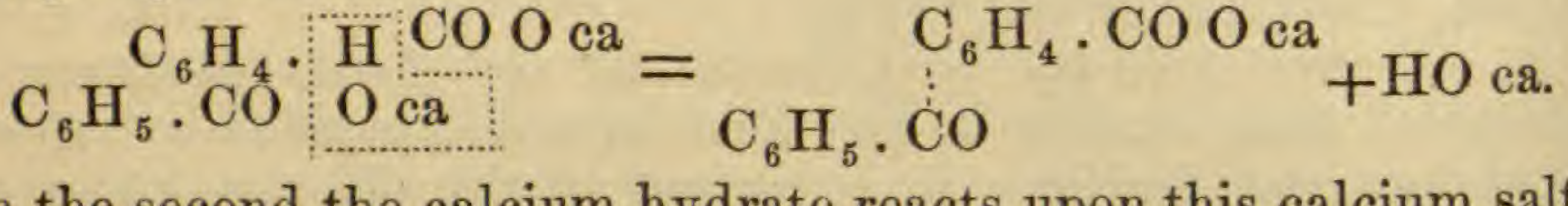
4. *On the Synthesis of Propionic acid.*—The alkali-hydrates absorb carbonous oxide with the formation of formic acid; may not its absorption by the alkali-alcoholates give rise to the higher members of the fatty acid series? thus:

$$C_nH_{2n+1}O\,Na + CO = \left\{\begin{matrix} C_nH_{2n+1} \\ CO\,ONa \end{matrix}\right.$$

Berthelot has re-investigated the action under these circumstances. To exclude every trace of moisture, barium alcoholate was dissolved in alcohol and exposed to the carbonous oxide gas. It slowly absorbed it and produced barium ethyl-formate, a compound soluble in absolute alcohol, decomposed by water, and isomeric with propionic acid, a trace of which is simultaneously formed.—*Bull. Soc. Ch.*, II, xix, 160, Feb., 1873. G. F. B.

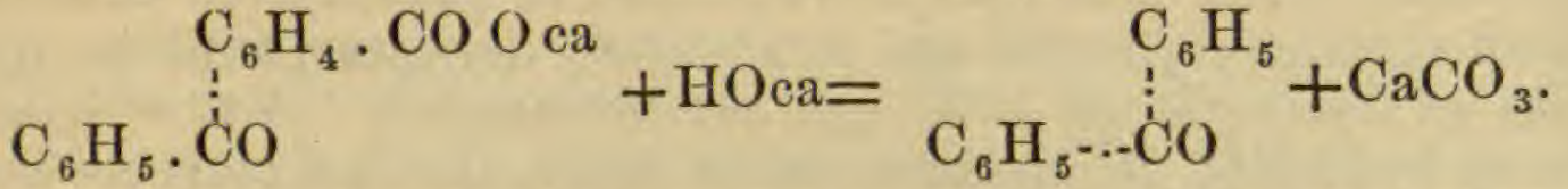
5. *On the formation and decomposition of Ketones.*—The splitting, by fusion with potassium hydrate, of benzophenonparadisulphonic acid into paraoxybenzoic acid and phenol, and of benzophenone into benzoic acid and benzol, led Staedel to apply this method to anthrachinone. The result was the production of

an acid isomeric or identical with the benzoylbenzoic acid of Zincke. From these experiments, Staedel concludes that the formation of ketones by heating the calcium salt of an organic acid, takes place in two stages. In the first, O ca* from one molecule unites with H from the other, the two residues thus produced uniting together thus:



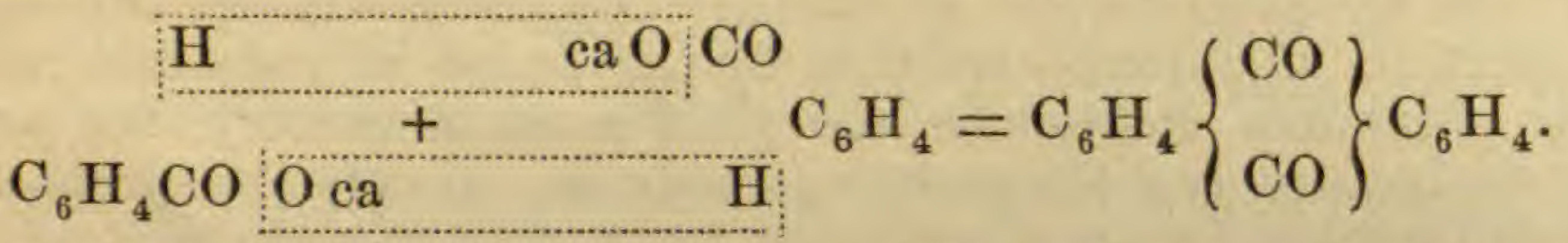
$$\begin{array}{l} C_6H_4 . \boxed{H}\,\boxed{CO\,O\,ca} \\ C_6H_5 . CO\;\boxed{O\,ca} \end{array} = \begin{array}{l} C_6H_4 . CO\,O\,ca \\ \quad\vdots \\ C_6H_5 . CO \end{array} + HO\,ca.$$

In the second the calcium hydrate reacts upon this calcium salt, producing the ketone and calcium carbonate, thus:



$$\begin{array}{l} C_6H_4 . CO\,O\,ca \\ \quad\vdots \\ C_6H_5 . CO \end{array} + HOca = \begin{array}{l} C_6H_5 \\ \quad\vdots \\ C_6H_5 \text{--} CO \end{array} + CaCO_3.$$

In the case of anthrachinone, a repetition of the first stage is observed, however, the second O ca uniting with another H, thus:



$$\begin{array}{l} \boxed{H \qquad ca\,O}\,CO \\ \qquad + \\ C_6H_4CO\;\boxed{O\,ca \qquad H} \end{array} C_6H_4 = C_6H_4 \left\{ \begin{array}{c} CO \\ CO \end{array} \right\} C_6H_4.$$

If this view of the formation of ketones be correct, the ketone of a substituted benzoic acid must be unsymmetrically constituted; the ketone obtained by the dry distillation of calcium salicylate, for example, yielding, on fusion with potassium hydrate, a mixture, besides phenol, of oxybenzoic and salicylic acids. The author is engaged in preparing a dioxybenzophenone synthetically, with which to test this question, by comparing it with the ketone produced as above.—*Ber. Berl. Chem. Ges.*, vi, 178, March, 1873.

G. F. B.

6. *On the Synthesis of Right and Left Tartaric acid.*—Chemical synthesis has hitherto failed to produce any cases of physical isomerism. Indeed, in the case of many bodies having rotatory power, and thus physically different while chemically identical, it has been supposed that the rotatory power came from the living organism which originated these bodies, being given by a process science could not imitate. JUNGFLEISCH, however, has succeeded in producing, by purely synthetic methods, tartaric acid having rotatory power. Pasteur has distinguished four kinds of tartaric acid: (1) the natural or dextrotartaric acid, hemihedral and rotating a polarized ray to the right; (2) lævo-tartaric acid, also hemihedral, and rotating to the left; (3) racemic acid, optically neutral, and capable of splitting into (1) and (2); and (4) inactive tartaric acid, not hemihedral and not rotating, but not capable of splitting up as above. Having succeeded in transforming the inactive acid into racemic, which, on splitting, gave the right and left acids, Jungfleisch attempted the complete synthesis. Starting with ethylene—which, through acetylene, may readily be

---

* Kekulé uses ca to represent ½ Ca.

formed from its elements—this was transformed into ethylene dibromide; and this, by Maxwell Simpson's method, into ethylene dicyanide. This oxidized by nitric acid yielded succinic acid. Treated with bromine, bibromosuccinic acid was obtained, and this by Kekulé's method was converted into tartaric acid. 3800 grams of ethylene bromide gave 300 of cyanide, about the same quantity of succinic acid, and nearly 70 grams of pure calcium tartrate. This tartrate was a mixture of calcium racemate and inactive tartrate, as Pasteur had shown to be the case with that made from the commercial succinic acid. The inactive acid was then converted into racemic acid, and this, by Pasteur's process, was changed into potassio-sodium tartrate. Two sorts of crystals were produced; one, hemihedral to the left, identical with the lævo-tartrate; the other hemihedral to the right, identical with the dextro-acid, and yielding a dextro-rotatory solution whose specific rotatory power was 5° 3′ against 6° 4′ for the perfectly pure natural salt.—*C. R.*, lxxvi, 286, Feb., 1873. G. F. B.

7. *On the Synthesis of Tyrosin.*—LADENBURG has shown that ethylenoxyparamidobenzoic acid—prepared by heating to 50° C equal molecules of ethylene oxide and paramidobenzoic acid in a sealed tube—is not identical, but only isomeric with tyrosin.—*Ber. Berl. Chem. Ges.*, vi, 129, Feb., 1873. G. F. B.

8. *A Treatise on Electricity and Magnetism;* by JAMES CLERK MAXWELL, M.A., LL.D., etc. Professor of Experimental Physics in the University of Cambridge (England). Two vols. 8vo, pp. 425 and 444. Oxford, Clarendon Press; London and New York, Macmillan & Co. Price $12.00.—This treatise is an analytic description of the phenomena of Electricity and Magnetism. It takes up the whole subject in a methodical manner and indicates how each part of it is brought within the reach of methods of verification by actual measurement. It is designed to supply what the various treatises which describe electrical and magnetic phenomena in a popular way do not give to those who are, by reason of the important applications of electro-magnetism to telegraphy and the like, compelled to consider the quantities to be measured in a mathematical form. The author states that he commenced the study of electricity by first reading attentively *Faraday's Experimental Researches on Electricity*, before reading any of the existing mathematical discussions of the subject, aware that there was a supposed difference between Faraday's way of conceiving of phenomena and that of the mathematicians, so that neither he nor they were satisfied with each others language. This difference our author finds to be seeming and not real. Faraday's method of conceiving the phenomena was also a mathematical one, though not expressed in formulæ. He adds: "When I had translated what I considered Faraday's idea into a mathematical form, I found that in general the results of the two methods coincided, so that the same phenomena were accounted for and the same laws of action deduced by both methods, but that Faraday's methods resembled those in which we begin with

the whole and arrive at the parts by analysis, while the ordinary mathematical methods were founded on the principle of beginning with the parts and ending up the whole by synthesis. I also found that several of the most fertile methods of research discovered by the mathematicians could be expressed much better in terms of ideas derived from Faraday than in their original form."

In looking over Prof. Maxwell's book we are impressed with the fact that the demand of late for exact knowledge on the part of practical electricians has greatly advanced this department of knowledge and has carried its proficients beyond the range of ordinary scientific students. Only those well up in mathematical knowledge and the use of the processes of analysis can read Prof. Maxwell's treatise. B. S.

9. *Wöhler's Outlines of Organic Chemistry;* by Dr. R. FITTIG. Translated, with additions, by Dr. IRA REMSEN, Professor of Chemistry and Physics in Williams College, Mass. 530 pp. 8vo. Philadelphia, 1873. (Henry C. Lea.)—This compact treatise is an excellent hand-book of Organic Chemistry for the student attending lectures or engaged in laboratory work. About 40 pages are occupied in introductory and general matters; then, beginning with marsh gas, the remainder of the volume contains brief descriptions of the hydrocarbons, alcohols, acids, aldehydes, ketones, &c., whose chemical structure has been ascertained, together with those substances which are important in Medicine, Physiology and the Arts. Probably no published book contains so complete a list of the numerous isomeres, whose recent discovery is one of the most striking evidences of the fruitfulness of the ideas which underlie the "Modern Chemistry."

The notation is given in the simplest graphic form, and the relations of the various classes of bodies and of individual substances to each other are easily traced. Dr. Remsen has discharged his duty as translator in a thoroughly acceptable manner.

S. W. J.

II. GEOLOGY AND MINERALOGY.

1. *On the Klamath River Mines; remarkable gravel deposits of the Lower Klamath—a sketch of their Geology;* by A. W. CHASE.—The upper portions of the Klamath river and its tributaries, the Trinity, Salmon and other streams, have long been the scene of active placer and hydraulic mining. But little attention has, however, been given, up to this time, to the remarkable deposits on the main river toward its mouth. This is partly owing to the fact that about the time prospecting had commenced in the section, the silver excitement drew off the restless spirits who perform the pioneer work in all mineral development. Being off the regular routes of travel and not easily accessible from stage or steamer lines, and in addition being the home of Indians alone, few white inhabitants being found for many miles above its mouth, the gravel deposits of the lower river have remained unnoticed—almost untouched—while others in different portions of the State

were being actively worked, and, as a rule, paying the owners better than any other class of gold mining. To the geologist, however, and the practical miner, these deposits offer a field of interest and profit second only to the famous blue gravel mines, which they resemble in many particulars.

It is probable, however, that they are not the deposition of an ancient river, but that of the present stream under different conditions from those now existing. In order to present a theory of their formation, it is necessary to take into account the character of the river and the underlying rock strata through which it has cut its way. The Klamath drains an immense extent of mountainous country, through which passes the great auriferous belt of California, as evidenced by the rich quartz leads and placer mines on the tributaries. Being a swift and deep stream, great quantities of water-worn gravel are swept down by the resistless floods of winter. These form at present as gravel bars, increasing in extent toward the mouth, all more or less auriferous, and their presence can be easily accounted for. A remarkable distinction should be noticed here. Any attentive observer who has watched the action of the surf rolling up pebbles on a sea or lake beach has noticed that the shape assumed by the stones is that of a sphere, the grinding action being equal on all sides. On the contrary, the gravel worn by river action alone will be flattened or oblong in shape, the continuous flow of the river being in one direction and the gravel wearing more rapidly on one side than the other. Hence, when deposits of water-worn gravel, flattened rather than rounded in shape, are found four and five hundred feet above the present level of the stream, one must seek some other solution than that of present action, as no flood, however great, could have piled up these masses of gravel.

This solution can be found on observation of the rock strata forming the river bed and cropping out on the sides. Commencing at the mouth of the stream, one will notice that this stratum consists of ledges of metamorphic sandstone of an exceedingly hard nature, and that it continues to appear for about fifteen or twenty miles as you ascend. In this section, although the gravel bars formed by the present action are frequent, yet no old deposits are found on the banks. At the end of this stretch of fifteen or twenty miles, the character of the rock suddenly changes. A soft micaceous slate now appears dipping at an angle of 15 degrees to 45 degrees against the stream. This gradually rises as you proceed up the river, until at a distance of thirty miles from the mouth it is seen cropping out many feet above the level of the stream. It is in this portion that the great banks of gravel appear on the sides. On investigation of the causes that formed them, one is instantly struck by the fact that they are invariably found above and below a rapid or fall in the river, and that the bed rock at these rapids is a hard talcose slate or serpentine. This fact can be seen on the sides of the river also, and suggests a theory. It is that the river, which now has a fall of 234 feet in the thirty miles from the deposits to the mouth, was at one time many hundreds of feet above its present level. Wearing away the soft slate, it has met with an obstacle in the dykes of serpentine forming the lofty waterfalls. Here the gravel was deposited, in the still reach above and the eddies below. Gradually the action of the water has worn away the serpentine, until what was perhaps a thousand years ago a great fall, is now a rapid, over which canoes can be taken. That this is the case, evidence in point is offered by a celebrated and once dreaded rapid, called the Mareep, about 34 miles from the mouth. Within the memory of the oldest white inhabitant of the river, the Indians were accustomed to land at the foot of this rapid and haul their canoes over the bank, as the fall was too great to stem going up, and dangerous to run going down. At the present time no difficulty is experienced in poling up or in paddling down. As the river cut its way down, it also changed its course, perhaps many times, so that the deposits are now on one side, then on the other, of the present bed. Opposite the gravel beds is usually a bare mountain of rock, rising abruptly from the stream.

It is said by one of the old prospectors that, starting at the point where the sandstone formation commences, the gravel can be traced through the mountains, good prospects being found even on the summits, and that it finally ends in the immense cliff known as the Gold Bluff, 25 miles below the present mouth of the Klamath. The spot, the scene of one of the early excitements, is at the present time the theater of active beach-mining operations.

The sea having for ages performed the part of an hydraulic mining pipe, has washed down the gravel bluff and separated the black sand, the gold now being gathered from it when the heavy gales of winter throw it up on the shore. However, this assertion in regard to the continuation of the gravel through the mountains, the writer is not prepared to affirm from personal observation.

Of the deposits on the river one will serve as a sample. This is located about thirty miles from the mouth, and the cut into the hill is 384 feet above the stream and some 500 yards away. The surface bank exposed is about 100 feet, and shows alternate strata of gravel and sand. The bed rock is the same soft slate seen along the river, and is worn into pot-holes and grooves by the old eddies. Above this is a stratum of blue gravel (so-called), decomposed talcose slate, in reality, most probably, the wearings of the dykes before referred to. The stratum is from five to sixteen feet in thickness, and is of course the richest. Above it a reddish or yellow river gravel mixed with sand, and an occasional streak of oxide of iron forming a soft cement.

This entire bank of gravel, as prospected by washing out pansfull from each layer, showed gold at the bottom of each pan, or what is called a color. In the stratum of blue gravel the gold was rather coarse and the pieces flat or oblong in shape, averaging something like two or three cents to the pan. This claim is now in successful operation and will doubtless repay its owners handsomely for the labor expended on it, as they have an abundance of water and a great fall for tailings.

Were, however, the more improved methods in use in Grass Valley and elsewhere, to replace the rude manner in which this and other of these deposits have been and are now being worked, it is believed that their product would soon attract great attention, as the gold is remarkably pure in character. The climate in the vicinity of the mines is very different from the coast, being hot in summer, with long, rainy winters, but no snow. Peaches, melons and tomatoes will ripen and arrive at great perfection, which they will not do on the coast line.

The gravelly soil seems to be especially adapted to the grape, which grows thrifty and ripens early.

In the vicinity of these deposits are also found the groves of cedar, sugar pine and redwood, which, in time, when mills are erected, will furnish abundance of lumber for mining purposes. Now that the new mineral law allows acquisition of titles to mining property, it is to be hoped that these deposits will receive more attention from our miners and prospectors than they have hitherto done, and that they may add another element to the rapidly increasing mineral wealth of our State.

2. *The Great Basin.*—Dr. JAMES BLAKE, after an investigation of the region of the Great Basin, states (Proc. Cal. Acad. Sci., iv, 276) that the "divide" between it and the Columbia River Valley, near the meridian 118°, is in latitude 41° 33′ N.; and has a height of 400 feet above the level of the Humboldt Valley, 1,000 feet above the lowest part of the sink of that river, and 600 feet above Queen's River Valley, and also the level of the Great Salt Lake basin. Dr. Blake observes that this may not be the lowest "divide." Leading up to the "divide" from the south there is a broad valley, rising 600 feet in 24 miles; and to the north of it there are two broad valleys separated by a low spur of granite having a basaltic axis. This paper concludes with the following paragraph:

"As already stated, the height of the divide above the level of Queen's River Valley is about six hundred feet, but I am of opinion that other outlets must exist, which allowed the waters of the basin to attain a still lower level, before their disappearance solely by evaporation began. There must, however, have been a large body of water left to disappear by evaporation, as the concretionary deposits, to which I last year called the attention of the Academy, are found at an elevation of two hundred feet above the level of the valley, and they could only have been deposited as the water became concentrated by evaporation. I am of opinion that Queen's River Valley, and a large extent of country to the south and west of it, formed part of a secondary basin, in which water to the depth of three or four hundred feet must have disappeared by evaporation. Over the whole of the area of this secondary basin, as far as I have visited it, unmistakable evidences are seen of the gradual evaporation of a large body of water. Not only are the rocks and boulders surrounded by a thick coating of concretionary matter, but every solid body that was beneath the surface of the water seems to have afforded a nucleus for its deposition. Large numbers of *Anadonta* shells are found on the surface of the ground, entirely encased in this concretionary substance to the thickness of two or three inches. I propose, however, in a subsequent paper, to describe more fully the structure and composition of these deposits. The eastern edge of this secondary basin is formed by the Santa Rosa mountains. On the north is the high land between the Vicksburg and Santa Rosa ranges, and the low divide between Divide and Puebla Valleys. Directly south of the Bottle Creek range the basin is separated from the valley of the Humboldt by a low range of hills about fifteen miles north of the latter river. As to its extent farther to the westward, I have no data. It certainly includes the Black Rock Desert, and I think a considerable extent of country still more to the south and west."

3. "*Lignitic Formation*" *of the Rocky Mountains.*—The second part of Dr. Hayden's Report for 1872 commences with details of explorations connected with the Lignitic formations of the Rocky Mountains by L. Lesquereux, and is followed by an enumeration, with descriptions, of the fossil plants from the same formation and from the Cretaceous of Kansas.

As stated in the letter serving as an introduction to Prof. Lesquereux's report, the arrangement of the paper conforms to the directions given by Dr. Hayden for the author's exploration, namely, to follow from the Rocky Mountains in New Mexico, northward along the base of the Rocky Mountains to Cheyenne and then along the Union Pacific Railroad to Evanston. It first gives the details of the geological distribution of the strata and their kinds, in the localities which were examined. It then compares the geological and paleontological data which have been recorded and discusses at length the age of the Lignitic beds, refering the whole to the Eocene. A second part considers the Lignitic beds with reference to the mode of formation of the combustible material; then treats of the extent of the areas over which it is distributed, and the thickness of the coal beds; the value of the lignite as a combustible, the amount of material available for the present demand and reserved for the future, etc.

The last part of the report, which is at least one half of the whole, is made up of an enumeration and description of the species of fossil plants, from good specimens mostly obtained by the author in his explorations. It is a valuable contribution to our vegetable paleontology, adding to our Tertiary flora one hundred and thirty species, of which sixty-one are considered as new. The Cretaceous flora, too, though explored only at two localities in Kansas, is also increased by a comparatively large number of new species.

A number of facts and also some discussions interesting to science may be selected from this report for future publication.

4. *The Eozoon Canadense, and related Paleozoic species;* by Dr. J. W. Dawson. (From Dr. Dawson's Annual Address before

the Natural History Society of Montreal, May, 1872, published in the Canadian Naturalist, vol. vii, No. 1, p. 1.)—There remains one point still before leaving this subject. It is the gap between the fauna of the Primordial and that of the Laurentian—the latter still represented only by that Titan of foraminifers, *Eozöon Canadense.* Barrande refers to this gap in his memoir above mentioned; and I had hoped ere this time to have done something to bridge it over. I may here state in anticipation of the results of researches still incomplete, (1) That in rocks of Huronian age in Bavaria, and probably also in Ontario, Eozoon has been found. (2) In the Middle and Upper Cambrian we know as yet few limestones likely to contain such a fossil, but we have in Labrador species of *Archæocyathus*, one of which I have ascertained to be a calcareous chambered organism of the nature of a foraminifer; though there seems little doubt that others are, as Mr. Billings has shown, allied to sponges. (3) In the Cambro-Silurian, in the limestones of the Trenton group, animals of the type of Eozoon return in full force. The concentrically laminated fossils which sometimes form large masses in these limestones, and which are known as *Stromatopora*, are mostly of this nature, though it is true that fossils of the nature of corals have been included with them. In the Silurian proper, we have the similar, if not identical forms known as *Cœnostroma*, and which according to Lindstrom form masses in the shales and limestones of Gothland a yard or more in diameter. In all these fossils the skeleton consists of a series of calcareous layers connected with each other by pillars or wall-like processes. The layers are perforated with minute orifices, which are, however, less delicate and regular than in Eozoon, and have in the thickened parts of the walls radiating tubes of the nature of the canals of Eozoon. (4) On a still higher horizon, that of the Devonian, these organisms abound, so that certain limestones of this age in Michigan contain, according to Winchell, masses sometimes twelve feet in length, and in one place constitute a bed of limestone twenty-five feet in thickness. A beautiful collection of these Devonian forms, recently shown to me by Mr. Rominger, of the State Survey of Michigan, who has worked out these fossils with great care, fully confirms their foraminiferal affinities, aud also shows that in some respects these Devonian forms are intermediate between the Eozoon of the Laurentian and the *Parkeria* and *Loftusia* of the Greensand and Eocene. We thus learn that these gigantic representatives of one of the lowest forms of animal life have extended from the Laurentian, through the Huronian, Cambrian and following formations, down nearly to the close of the Paleozoic. I have no doubt that when these successive forms are studied more minutely, they will show, like the Trilobites, indications rather of successive creations than of evolution, though in creatures of so low organization the differences must be less marked. The point I now wish to insist on is their continuance from the Laurentian down to a comparatively modern geological period.

5. *Elephas Americana in Mexico.*—F. R. Diffenderfer, of Lancaster, Pa., reports to one of the editors, that in May, 1870, he opened, in Chihuahua, Mexico, a bed containing a large number of teeth of the extinct elephant. The teeth formed with coarse gravel a compact conglomerate. It is probable that search in the region would bring to light the tusks and other parts of skeletons of the elephant.

6. *Report of the Geological Survey of Ohio;* officers of the Survey, J. S. Newberry, Chief Geologist; Edward Orton and E. B. Andrews, Assistant Geologists; T. G. Wormley, Chemist, F. B. Meek, Paleontologist. Volume I, Geology and Paleontology; Part I, *Geology.* 680 pp. 8vo. 1873. Columbus, Ohio. Published by authority of the Legislature of Ohio.—The publication of the first volume of this report has already been briefly announced. The volume opens with a historical sketch of the previous geological survey of the State under W. W. Mather, entered upon in 1837, and by the legislative action and other matters of general interest connected with the survey just completed. Dr. Newberry, after a chapter on the topography of the State, treats in a popular way of the general geological relations of the rocks of the State to those of the other States, in order to prepare the unscientific reader to appreciate the scientific facts presented beyond. He then enters upon the general subject of the geological structure of Ohio, giving a clear exposition of the facts both as regards the system of rocks and the progress of life. The structure and age of the Cincinnati anticlinal—a region nearly parallel with the Alleghanies, made up at surface about Cincinnati and elsewhere of Lower Silurian rocks, and ranging southeast from Lake Erie into Tennessee—are treated at considerable length, and the conclusion established that this geanticlinal or upward bending of the crust took place after the last period of the Lower Silurian—the Cincinnati period, as it is now called (Hudson River period in New York geology). The extension of this geanticlinal into Tennessee was long since made known by Prof. Safford. Dr. Newberry remarks that the course of it "is marked by no conspicuous topographical features, but throughout its whole length the rocks are raised in a distinct arch, from which they dip away, on one side, under the Alleghany Coal field; on the other, beneath the Coal basin of Indiana and Illinois." To a great extent, the rocks of the central portions of the arch have been removed by denudation—so that these portions are now basins surrounded by elevated margins composed of later and more resistant strata once deposited in the sea around them when they stood as islands. These strata very generally thin out toward the arch, proving thus their subsequent origin. Besides presenting his own observations on the subject, Dr. Newberry appeals to facts obtained by Prof. Orton in his careful investigations of the Cincinnati region. Dr. Newberry describes also the special geology of Cuyahoga County, treating of its rocks, fossils, lake ridges or shore terraces, drift, economical productions, including coal, etc.; and adds a briefer account of the geology of Summit County.

The geological structure, products, and general relations of the second geological district are discussed at length, and with much that is new and important, by Prof. E. B. Andrews. It includes Gallia, Meigs, Allen, Morgan and part of Muskingum Counties, and embraces a large part of the Coal formation in Ohio. Prof. Andrews closes with "some conclusions theoretical and practical" on the structure of the district and especially on its Coal measures, coal beds and coal. Were it within the compass of this Journal we should like to introduce here the whole chapter. He shows that the Coal marshes were but little above the sea level, and were therefore flooded with salt water at slight changes of level. He states that the occurrence of broken down trees of *Sigillaria*, *Lepidodendron*, etc., sometimes show the effect of the incoming sea attending a subsidence; and observes that "he once traced the trunk of a *Sigillaria*, in the roof of the Pomeroy seam of coal, for over forty feet;" and also that thousands of the trunks of what Mr. Lesquereux takes to be *Pecopteris arborescens* are found in the slates over the same coal lying in horizontal burial as they were bent or broken down by the waters which brought in the sediments that cover them. As a general thing, the subsidence was so regular that two beds of coal, each formed at the water level, are almost perfectly parallel. The Nelsonville bed in Ohio, for example, is about 420 feet below the Pomeroy bed (the equivalent of the Wheeling and Pittsburgh bed) through many counties in the State; and the same is true of the other well-defined beds. Prof. Andrews says that he has not found any instance in which two distinct beds of coal coalesced in one.

Prof. Edward Orton had charge of the third geological district, including Hamilton, Clermont, Warren and Butler Counties. He gives a full and able account of the region with regard to all its ranges of formations from the Lower Silurian to the Drift, and the soil and its productions at surface. The Cincinnati group is described at length, and the various facts bearing on the fact and era of the Cincinnati uplift are presented in detail, and illustrated by a map.

The geology of Ashtabula, Trumbull, Lake and Geauga Counties is reported on in the following pages of the Report by M. C. Read; of Williams, Fulton and Lucas Counties, and West Sister Island, and the surface geology of the Maumee Valley by G. K. Gilbert; and the geology of Sandusky, Seneca, Wyandot and Marion Counties, by N. H. Winchell. In each the region under investigation appears to have been well studied. The study of the drift and terraces of Maumee Valley by G. K. Gilbert, has led Prof. Gilbert to important results—as the readers of this Journal have already gathered from his pages in the first volume of the present series (1871).

Many of the pages of the several reports owe much of their value to analyses and other results of chemical investigations by the chemist of the survey, Mr. T. G. Wormley, some of whose determinations with respect to the condition of the sulphur in the Ohio mineral coal have already appeared in this Journal.*

The State has been ably served by its geologists both in the work performed and in the preparation of the Reports presenting its results. The geology of the several districts are separately illustrated by colored geological maps; and the style of the volume is well adapted to give intelligible ideas of the geology and mineral productions of the State to its people. This volume is soon to be followed by another on the Paleontology, by Mr. Meek and Prof. Newberry, which will contain, besides descriptions, numerous excellent plates of fossil plants, shells, crinoids, etc.

7. *The Coal-Regions of America:* their Topography, Geology, and Development, with a colored geological map of Pennsylvania, a railroad map of all the coal-regions, and numerous other maps and illustrations; by JAMES MACFARLANE, A.M. 689 pp. 8vo. New York, 1873. (D. Appleton & Co.)—This volume is a very important contribution to economical geology, by one who has been for sixteen years employed in a large coal business in Pennsylvania. The author has collected with great assiduity the facts respecting the character, structure, distribution, working, economical value, and other points connected with the mineral coal and the coal-regions of the continent. Although a scientific treatise on the Coal formations was not his object, he has brought in much information on the stratification and geological relations of the Coal-measures and their coal beds. The coal-region and products of Nova Scotia are described equally with those of the United States, and those of Cretaceous or Tertiary age in the Rocky Mountains, as well as the true Carboniferous. The geological map of Pennsylvania is by J. Peter Lesley, one of the best of American geologists, who has labored much among the rocks of the State, and especially its coal strata. This and the other maps and illustrations are excellent.

8. *Geological Map of the United States*, compiled for the 9th Census, by C. H. HITCHCOCK and W. P. BLAKE. (J. Bien, New York, lithog.)—The need of a geological map of the United States has been long and urgently felt by all students of the science. The admirable chart of Canada, which, through the liberality of the Canadian government, is made to embrace the northern States to Virginia, and to extend west to the 100th meridian, has supplied the place in part of such a chart. Yet its price—though small considering the size, the amount of detail, and its artistic perfection—is in the way of its general use.† The map now issued by Professors Hitchcock and Blake is a small one (34×22 in.), with no geological details beyond an indication in colors of the grander areas—namely, the Eozoic, with which all the metamorphic areas are united under one color; the Silurian—the Devonian and Subcarboniferous—the Carboniferous and Permian—the Triassic and Jurassic—the Tertiary—the Alluvium—

---

* Third Series, i, 216.

† Its size is 8 feet by 3½, and it is sold by Dawson Brothers, Montreal, for $18 in sheets, and $24 on cloth in portfolio.

the Volcanic. Even these subdivisions are enough to make a chart of the kind valuable to the general reader.

It is a little puzzling to us to explain why such a chart should have been compiled for "the 9th Census." There is nothing in or on it to indicate that it was intended to illustrate the geographical distribution of mineral products of economical importance. The 9th Census Reports claim to represent the known condition of the country in the year 1870, and this they do with great fullness both in the text and the various excellent maps issued by General F. A. Walker. A geological chart fit to be associated with such work, or to be a part of the publications relating to the 9th Census, should present to the people an exact exhibition of the present knowledge with regard to the geology of the United States, or if not for all its formations, at least for all its varied mineral materials; the agriculturist would say for all its formations with their fullest details; for only on such a map could the particular rock underlying the soil of a region be indicated. At a time when other nations, and Canada among them, are issuing national geological charts that are most admirable productions both of art and science, it is not a little discreditable to the United States for the government to publish so meagre a production. A general U. S. geological chart ought to be published by the General Government, and it should combine all that is contained in the maps that have been made in the course of the various State surveys, and be issued in the best possible style. It would be a great thing for the nation's industry as well as its science if the work could be soon begun, and the best of American art and science be engaged upon it.

The lithographer has done his part on the 9th Census map badly. The glaring colors are selected without taste, and are so unskillfully put on that those of adjoining areas often overlap some miles, and sometimes to the obliteration of a narrow intermediate area that was in the original copy. As one example, the Connecticut River Red Sandstone formation, besides being narrowed in places, is in this way stopped off at Northampton, the remaining 25 miles to the north, which the engraving faintly indicates, being buried beneath the overlapped colors of the areas adjoining. Such careless work does not appear on the Canada geological chart, or those published abroad.

There are a number of improvements—improvements in our view—that may be made in the map in preparing it for another issue. Some of these are: Not to put the carmine color of the Eozoic over all the metamorphic areas of the country whether Eozoic or not, that thus positive knowledge may be kept apart from the doubtful; to take the Sierra Nevada, and some other areas on the Pacific slope, out of the Eozoic carmine, and substitute the color of the Triassic and Jurassic; to leave the metamorphic areas of uncertain age in white, as an acknowledgement of doubt or ignorance; to omit the bands of Lower Silurian around the metamorphic areas of the Rocky Mountains, except so far as specially observed facts have shown that they exist there; to take away the green color, which means Cretaceous, from the whole of the north side of Long Island, no facts making the region Cretaceous; to put no color over regions "west of the 100th meridian" where "the Paleozoic and Cenozoic systems cannot be subdivided."

9. *Sternbergia.*—Dr. DAWSON states that the pith of the balsam fir (*Abies balsamea*) has the same curious structure of pith that he years since found in Sternbergia, the pith of a Devonian Conifer. It is well seen in young twigs one or two years old, and closely resembles that of *Dadoxylon Materiarium* of the upper Coal formation of Nova Scotia. The structure is in each case an "organic partitioning of the pith by diaphragms of denser cells opposite the nodes."—*Nature*, May 15.

10. *The Story of the Earth and Man;* by J. W. DAWSON, LL.D., F.R.S., F.G.S., Principal and Vice Chancellor of McGill University, Montreal. 404 pp. 12mo. London. (Hodder & Stoughton).—This work is a popular history of the earth, from its genesis to man. The wonderful story is told by an able geologist, and one sound in the faith both of nature and of the Bible. The progress of the continents, mountains and climates, and of life both vegetable and animal from its beginning, is described in a way to interest and instruct. The author brings out the difficulties which geology presents to the theory of natural selection, and takes strong ground against its sufficiency as a means of accounting for the origin of the kingdom of life. Several plates are introduced intended to represent ideal landscapes with their plants and animals, such as it is imagined may have been realities in the successive ages, in order to impress the characteristics of these ages on the minds of the uninitiated. They subserve a good purpose if the reader takes from them only the most general impressions. The known learning and high character and position of Dr. Dawson, as well as the interest of the subject, will command for his work and his arguments attentive consideration and a wide range of readers.

11. *Revue de Géologie pour les Années* 1869 *et* 1870, par M. DELESSE, Ingénieur en Chef des Mines, etc., and M. DE LAPPARENT, Ingenieúr des Mines. 188 pp. 8vo. Paris, 1873. (F. Savy).—This volume is the ninth in the series of valuable annual reports on the progress of geology by Delesse and Lapparent. Abstracts are given of papers in all departments of geology, both theoretical and applied, excepting that of paleontology.

12. *On the Siliceous deposit of the Upper Geyser Basin of Firehole River;* by F. M. ENDLICH. Sixth Annual Report Hayden's U. S. Geol. Survey.—An analysis of a variety, of milk-white color, cryptocrystalline structure, semi-vitreous aspect, and G.=2·4903, afforded Dr. Peale—

$\ddot{\mathrm{Si}}$	$\dddot{\bar{\mathrm{Al}}}$	$\dddot{\bar{\mathrm{Fe}}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Ca}}$, $\dot{\mathrm{Na}}$, $\dot{\mathrm{Li}}$	ign.
95·84	tr.	2·68	tr.	tr.	1·50=100·02

Another kind, of a light greenish-brown to greenish-white color, amorphous structure, vitreous luster and G.=2·0816, contained

6·3 of water. The mineral, a variety of opal, was collected by Dr. A. C. Peale, and is called by Mr. Endlich *pealite.*

13. *Mineralogia della Toscana;* Studii di ANTONIO D'ACHIARDI, Ajuto al Prof. Min. e Geol. nell Univ. di Pisa.—The second volume (404 pages, 8vo) of this very thorough work on Tuscan mineralogy and crystallography has been issued.

14. *Aragotite, Metacinnabarite.*—F. E. DURAND, in the Proceedings of the California Academy of Sciences, iv, 218, has given the name Aragotite to a bright yellow substance, impregnating a crystalline siliceous dolomite, and occurring with cinnabar. It volatilizes easily, after becoming dark red, but is not acted on by strong acids, or by oil of turpentine, alcohol or ether. It is supposed by the describer to be a volatile hydro-carbon related to idrialine.

Mr. Durand, on p. 219, figures two crystals of metacinnabarite, and states that the form is probably orthorhombic. The figures represent a rectangular prism with replaced angles.

III. ZOOLOGY AND BOTANY.

1. *The Megalops stage of Ocypoda;* by S. I. SMITH.—The *Monolepis inermis*, long ago described by Say,[*] and partially figured by Dana,[†] is undoubtedly a stage in the development of *Ocypoda arenaria.* The large size and peculiar structure of this megalops render it one of the most interesting forms of the group of larvæ to which it belongs. It is closely allied to the *Monolepis orientalis* Dana, from the Sooloo Sea, figured in detail on plate 31 of the Crustacea of the Wilkes' Exploring Expedition. The carapax is very convex above and narrowed toward the front. The front is deflexed and the extremity tricuspidate, the median tooth being long and narrowly triangular, while the lateral teeth are small and obtuse. The sides are high and impressed so as to receive the three anterior pairs of ambulatory legs. The third pair of ambulatory legs are closely appressed along the upper edge of the carapax, and extend forward over the eyes, the dactyli being curved down over the eyes and along each side of the front. The posterior legs are small and weak, and each is folded up and lies in a groove on the latero-posterior surface of the carapax. The external maxillipeds have almost exactly the same structure as in the adult *Ocypoda*, and, as in the adult *Ocypoda*, there is a tuft of peculiar hairs between the bases of the second and third ambulatory legs. This megalops is common upon the coast of the Southern States, it has been found at Block Island, and I have myself collected it, late in August, at Fire Island Beach, Long Island. In the largest specimen from the last locality the carapax is 9·4^{mm} long and 5·6 broad.

A large number of young specimens of the *Ocypoda*, collected at Fire Island Beach, indicate plainly that they had only recently

---

[*] Journal Acad. Nat. Sci. Philadelphia, vol. i, p. 157, 1817.

[†] Crustacea Wilkes' Expl. Exped., plate 31, fig. 6.

changed from this megalops. Some of the smallest of these specimens, in which the carapax is 5·6 to 6·0^{mm} long and 6·1 to 6·5 broad, differ from the adult so much that they might very easily be mistaken for a different species. The carapax is very slightly broader than long and very convex above. The front is broad, not narrowed between the bases of the ocular peduncles, and triangular at the extremity. The margin of the orbit is not transverse but inclines obliquely backward. The ambulatory legs are nearly naked, and those of the posterior pair are proportionally much smaller than in the adult.

The adult *Ocypoda* is terrestrial in its habits, living in deep holes above high water mark on sandy beaches; but the young in the zoëa state are undoubtedly deposited in the water, where they lead a free-swimming existence like true pelagic animals, until they become full grown in the megalops state. Say mentions that his specimens were found cast upon the beach by the refluent tide and "appeared desirous to protect themselves, by burrowing in the sand, in order to wait the return of the tide," but they were more likely awaiting the final change to the terrestrial state. The tufts of peculiar hairs between the bases of the second and third ambulatory legs, and in the adult connected with the respiration, are present in the full grown megalops, and are undoubtedly provided to fit the animal for its terrestrial existence as soon as it is thrown upon the shore. The young in the megalops stage occur on the shore of Long Island, in August, and perhaps earlier. At Fire Island Beach, in 1870, no specimens of *Ocypoda* were discovered till the last of August, and those first found were the smallest ones obtained; by the middle of September, however, they were common on the outer beach, and many of them were twice as large as those first obtained. Although careful search was made along the beach for several miles, not a specimen of the adult or half-grown crab could be found. Every individual there had evidently landed and developed during the season. Probably all those living the year before had perished during the winter, and it is possible that this species never survives long enough to attain its full growth so far north.

New Haven, June 1, 1873.

2. *Corals and Coral Islands, by J. D. Dana. Reply to the criticism of P. Martin Duncan.**—In a criticism of Prof. Dana's work on Corals and Coral Islands, printed in a recent number of "Nature," (vol. vii, p. 119), Mr. Duncan saw fit to mention my name and certain of my views, adopted by Dana, in a somewhat discourteous manner. I therefore offer the following reply to some of his strictures, which are both erroneous and unjust.

Concerning the general character and plan of Dana's book it is not my intention to say anything, for these are matters which chiefly concern the author and publisher. It is to be presumed that they know, quite as well as any critic, the kind of book de-

---

* This "reply" was published in nearly the same form in "Nature," vol. vii, p. 423, but the present article was in type before the publication of the former.

manded by the public—at least by the American public—and experience every day shows the errors of critics in this respect. Certainly few authors have had more extensive and successful experience in writing strictly scientific books for the public than Professor Dana.

Mr. Duncan criticises the introduction of brief notices and descriptions of "animals which are not corals, and which in no way affect or produce coral reefs or islands," evidently alluding to the Actiniæ, Hydroids and Bryozoa; for he says, "all the notices and descriptions of the Actiniæ and Hydroidea might have been omitted, as they only confuse the subject." Surely Mr. Duncan ought to know, and if he does, should not ignore the fact, that *Millepora* and allied genera are true Hydroids, and at the same time form large and abundant corals, which contribute very largely to the formation of coral reefs, both in the Atlantic and Pacific Oceans. Moreover, this important fact is clearly stated by Professor Dana, on page 104, and its discovery is correctly attributed to Agassiz, and the animals are illustrated by a cut copied from his figures. It should be added that a confirmation of this discovery, made twenty-five years ago, has recently been published by Pourtales, (Deep Sea Corals, p. 56). That many of the ancient fossil corals were of the same nature scarcely admits of doubt, though I have elsewhere shown that this was not the case with all the so-called "Tabulata." Why, then, should this important class of corals be omitted from such a work? As for the Actiniæ, their relationship to the ordinary stony corals is so close, and their anatomy so nearly identical, that any general work upon recent corals would be very defective without some description of them. Moreover, they are the only near relatives of the corals that the majority of the readers of the book will ever be able to see alive.

The Bryozoa are also quite entitled to the page and a half allowed them in this work, for that they *do* contribute something to the existing reefs, can be easily demonstrated. A single species, (*Escharella variabilis*), abundant on the southern coast of New England, accumulates in vast quantities over extensive districts—enough even to form beds of limestone under favorable circumstances. It forms solid coral-like masses, two or three inches in diameter. Some coral-reef species grow even larger. And in Palæozoic times, the Bryozoa were relatively of still greater importance, some of the so-called "true-corals," evidently belonging to this group, in addition to those generally referred to it. The stony Algæ, also, are not to be ignored in treating of coral-reefs, and the half page devoted to them, might well have been extended, rather than omitted. Darwin, Agassiz, Major Hunt and others, besides Dana, have recognized their agency in affording calcereous matter to the reef limestones. Fine specimens of such limestones, composed almost entirely of their remains, may be seen in many American museums.

Mr. Duncan, in criticising Dana for adopting the classification that he prefers, makes this remark: "The introduction of American novelties to the exclusion of well-recognized European classifications is neither right nor scientifically correct." Are we to understand from this that "American novelties" are less valuable than French or English ones, providing they be equally true to nature? Or, that an erroneous European classification is more valuable than an American one that is correct? Certainly no one has contributed more, in the way of original investigations and discoveries, to a true classification of the corals, than Professor Dana, in his great work on the Zoöphytes of the U. S. Exploring Expedition, which was far in advance of any work on this subject that had been written in Europe up to that time (1846), and in some respects, his classification was far more natural than that proposed afterwards by Edwards and Haime.

Unfortunately, at that period the corals and polyps in European museums had not been described or figured by European writers in a manner accurate enough to make their identification possible, or even, in many cases, to show their generic and family relations. That Edwards and Haime, having access to those collections, and, having the benefit of Dana's great work, should have been able to make corrections and improvements was natural. Nor was it less natural, that, after the publication of the more accurate descriptions by Edwards and Haime, an American, with these and all other works at hand, and the freest possible access to the original types of Dana, the unrivaled collections brought together by Agassiz, and all the other collections (by no means few or small) in the United States, should, after twelve years devoted largely to the study of these corals, be able to make a few corrections and improvements, even in opposition to the views of certain European writers. But several European authors have also made numerous changes in the system of Edwards and Haime, and are likely to make many more. Certainly the time has not yet come when we can consider the classification of corals permanently fixed, any more than that of other classes of animals. Whether the "novelties" to which he refers be "scientifically correct," is quite another question, and one that must be settled in the scientific way, by the evidence of facts observed, not by denunciations, nor by dogmatic assertions. In my opinion, Mr. Duncan is very unfortunate in selecting the examples, which he gives, of the supposed inaccuracy of my views, as adopted by Dana. He cites the "Oculina tribe," which the writer has proposed to extend so as to include certain families referred by Edwards and Haime to the Astræa tribe, or suborder, and says, "the admission of Orbicella, which is really the old Astræa of Lamarck [a mistake,—not of 1801], and of Caryophyllia, into this well differentiated tribe, is simply absurd, for they possess structural characters sufficiently diverse to place them in different families." As a matter of fact, the writer, in several papers, has placed these same corals in different *families*, but has united these families, together with the Oculinidæ, Stylasteridæ, Stylophoridæ, Pocilliporidæ, etc., into *one* higher group, (suborder), called Oculinacea, and this is the view that Dana adopts, so that the argument quoted is of no value, and becomes "simply absurd." Again, he says that "*Astrangia* was well differentiated long before Prof. Verrill was heard of," and states that Conrad, Lonsdale, and the distinguished French zoöphytologists, "consolidated the genus, which has nothing in common with the Oculinidæ." What he means by "consolidated," in this connection, it is difficult to understand, for all that Conrad and Lonsdale did, was to describe, very poorly, as species of "Astræa," a few fossil species, which were afterwards referred, doubtfully, to Astrangia by Edwards and Haime. The genus itself was first pointed out by Dana himself, in 1846, and named Pleiadia, (as stated in his book, p. 68), but it was not strictly defined at that time, as there were no species belonging to it in the collection of the Exploring Expedition, so that the name given by Edwards and Haime, two years later, has been universally adopted. But what my own age or reputation in the year 1848 has to do with it, is not obvious. That I have since carefully studied sixteen species of this genus, and described a considerable number of new ones, while but three were known to Edwards and Haime, is true; and that I have shown that the genus is closely related to Cladocora and Oculina, is equally true; and I presume that had Mr. Duncan enjoyed as good opportunities as I have had for studying this and all the related genera, he would long ago have arrived at the same conclusions, unless blinded by prejudices. It is certain that the soft parts of Astrangia, Cladocora, Oculina, and Orbicella are almost identical in all essential points of structure and form. Moreover, there are species of *Astrangia* that bud laterally, and finally grow up into branched forms not unlike Oculina; while the species of *Oculina*, when young, are encrusting, and bud like the ordinary Astrangiæ, some of them always remaining nearly in this condition; and as for the internal structure, there are Oculinæ in which the cells are but slightly filled up below, while there are Astrangiæ in which this also takes place to a certain extent. Nor does the existence of the cœnenchyma in the former afford more reliable characters for their differentiation; for it often occurs in Astrangia, having even the superficial radiating lines so characteristic of Oculina, and it is often nearly wanting in the latter. In fact, it is in some cases, quite difficult to say to which genus some specimens of certain species belong (*A. Haimei* V. and *A. Danæ* Ag., for example). Such are the genera that have "nothing in common," according to our critic. If any one should doubt the close resemblance of the soft parts, he can easily satisfy himself by studying the published figures of these genera; but the living animals resemble each other even more than do the figures. It would, in fact, be very difficult to write a diagnosis of the Oculinidæ which would include all the species, and at the same time exclude certain well-characterized Astrangiæ. These amimals should then be compared with those of *Astræa*, (*Favia*), or any other true Astræans, when the contrast will be sufficiently apparent. The relations between Caryophyllia and Astrangia, through Paracyathus, Phyllangia, etc., are sufficiently obvious; but as I have elsewhere fully discussed all these relations (Trans. Conn. Acad., I, pp. 512 to 540, 1869), it is unnecessary to say more at this time upon these points.

What Mr. Duncan means by saying that "*Caryophyllia Smithii*" was first discovered in the European seas by the Porcupine expedition is unintelligible, if by the name he intends the well-known species which has for many years passed under that name in England, and which Dana illustrates by a figure copied from Gosse's Actinologia Britanica, (the only figure, by the way, which Mr. Duncan specially criticises). The remark that *C. cyathus* is widely distributed in the Atlantic, extending "even as far north as the British Isles," was probably based on the discovery of the well-known *C. clavus* in the Straits of Florida, by Pourtales, coupled with the assertion of Mr. Duncan, in a former paper, that the latter and *C. cyathus*, and all other European forms, are only "varieties" of "*C. borealis*." So Mr. Duncan's remark that "had Dana waited a little longer he would have had the opportunity of quoting correctly," was, to say the least, quite uncalled for, and unbecoming to him, since the alleged error originated with Mr. Duncan himself.

But the peculiar injustice of the critic is, perhaps, best seen in his failure to give Dana credit for his extensive original investigations upon the structure of coral reefs and islands, and his intimation that the facts and theories are mostly borrowed. He says, "the chapters on the structure of coral reefs and islands add little to the knowledge which Darwin, and Jukes, and Hochstetter have given us; but Dana's great powers of illustration enable him to reproduce the details with which we are so familiar, thanks to these authors, in very engaging forms." Professor Dana has given Darwin full credit and well merited praise, both in the preface and in many places in the body of the book, for his observations of facts and his discovery of the true mode of formation of coral reefs; but he also states the well-known fact, that his own observations had been made and his report written in 1842, before Mr. Darwin's report was published. The report of Mr. Jukes was published still later (1847); Dana's observations were, therefore, wholly original, and the chapters upon this subject are, as they purport to be, mainly a reprint of his original report, with such additions from other and later sources as seemed necessary or useful, all of which are credited to the various authors who have written upon this subject. In the preface the author says, "The observations forming the basis of the work were made in the course of the Wilkes Exploring Expedition around the world, during the four years from 1838 to 1842," and had Mr. Duncan taken the trouble to examine the original report, he would have found there the true source of most of the facts narrated.

The figures of corals are also mostly copied from those in the atlas of Dana's Zoöphytes, which were originally drawn from nature by Dana himself, so that it is not strange that "some of them are very correct representations of nature." When the figures are not original, the source is invariably given. The charge that Dana does not give credit to others, is simply ridiculous, and in no case more so than when he is accused of treating the works of Edwards and Haime with "supreme contempt, inasmuch as he rarely gives them credit for their good work," for in the list (p. 379), of the species of corals described in his great work on Zoöphytes, prepared by the writer at his request, he has adopted, without hesitation, all the numerous rectifications made by them, as well as those made by the writer and others. A considerable number of rectifications also appear in this list for the first time, and it must therefore be quoted as the original authority for such changes. Nothing less than the complete absence of personal pride and vanity, and entire devotion to scientific truth, for which Professor Dana is so justly distinguished, could have induced him to have published such a list in this book. No doubt instances in which he has overlooked writings of more or less importance may occur, and the authorities for well-known facts may not always be given, for such references would uselessly encumber the book. In other cases, when to refer to another would be only to condemn, such references have been intentionally omitted, since they would serve no useful purpose. Such was the case in respect to the various erroneous classifications of European writers, which are not adopted. Such was the case, also when, in describing the extensive coral reefs of Brazil, so well explored by Prof. Hartt, and which have been shown by the writer* to consist of corals similar to, and partly identical with, those of the West Indies, he does not refer to Mr. Duncan's assertion (Quart. Jour. Geol. Soc., xxiv, p. 30), that "The Orinoco drains a vast tertiary region, and shuts in the coral-life of the Carribbean on the south;" or that "the Florida reefs consist of few species," when at least 45 had even then been recorded from them (others have since been added), which was a greater number than Mr. Duncan, in another place, admits from any existing reefs. Other statements and theories in the same paper, concerning the fossil and recent corals of the West Indies, have become, in consequence of the later discoveries of Pourtales, equally absurd, and needed no exposure. His assertion that the Isthmus of Panama was deeply submerged in the Miocene, reiterated in his criticism of Dana, may rest on no better foundation than the other assertions quoted from the same paper, notwithstanding the careless way in which he misquotes as to place of publication,† and misrepresents as to the contents, a brief article upon the same subject by the writer, who still looks in vain for such evidence as would be afforded by elevated coral

---

* Transactions of the Connecticut Academy, vol. i, p. 351, 1868; and this Journal, vol. xlv, p. 415, 1868.

† Mr. Duncan referred to my paper as published in the Proceedings of the Essex Institute, but it was published in the Proceedings of the Boston Society of Natural History, vol. x, p. 323.—A. E. V.

reefs related to those of the West Indies, but situated upon the Pacific side of the Isthmus, or upon its highest parts, or even by fossiliferous beds containing other fossils, thus situated. The well known existence of elevated coral reefs in the East Indies and Polynesia, and in the West Indies, proves nothing of the sort, for what little relationship exists between the corals of those regions can be explained in other ways. We think it singular that while certain geologists find it necessary to force the Gulf Stream across the Isthmus during the warm Miocene period, others find it quite as important to have it turned out of the Atlantic across the Isthmus during the Glacial period. Both assumptions seem equally gratuitous. A. E. VERRILL.

3. *Principles of Animal Mechanics;* by the Rev. SAMUEL HAUGHTON, F.R.S., Fellow of Trinity Coll. Dublin. 8vo. London, 1873. (Longmans, Green & Co.)—This volume is the result of observations and calculations made by the author during the last two years. The scope of the work is seen by a statement of a portion of the subjects treated, viz: the nature of muscular contraction; statical work done by muscles; dynamical work done by muscles; the absolute force of muscles; mechanical work done by the human heart; classification of muscles and their mode of action; theory of the hip and shoulder joints: principle of least action applied to the arrangement of the muscular fibers of the heart, etc.

The author has throughout reduced his elaborate observations made in the dissecting room to numbers, and then has availed himself of the principles of geometry and mechanics in their further discussion. Especially in his treatment of muscular curved surfaces, both ellipsoidal and skew surfaces, has the author made full use of the mathematics.

As a result of many calculations for the hip, shoulder, and other joints of many animals, Dr. Haughton states that he has "never met with any exception to the following propositions, which may be regarded as summing up my results:"—

1. Each muscle is constructed in relation to its joint in such a manner as to perform one kind of work only: and it performs that work to maximum advantage.

2. The number of muscles employed is determined by the number of distinct actions required from the limb.

3. The shape and form of the bones employed are the necessary consequence of the shape and power of the muscles in action.

4. The smallest muscle in the combination is as carefully adapted to its conditions of maximum work as the largest muscle.

From these propositions, supposed to be extended to the action of every muscle and joint, it appears to me to follow as necessary consequences:—

1. That a foreseeing Mind planned the type of the limb, and of its actions.

2. The idea of the limb and of its necessary actions being given; the number, shape, and arrangement of the necessary muscles

can be calculated and predicted with as much certainty as an astronomer can predict an eclipse.

3. That the shape and arrangement of the bones follow, of necessity, from the necessary arrangement of the muscles.

4. That any alterations, however slight, in any part of the combination of bones, muscles, and joints, would entail a loss of work, and lead to a less perfect mechanism.

5. Hence, the permanence and stability of each species (so far as relates to bones, muscles, and joints) is absolutely secured on the principles so admirably laid down by Mr. Darwin.

5. The profound study of the mechanism of joints lends no support to the postulate, that the similarities found to exist in the bones, muscles, and joints of animals may be explained by common descent fron a supposed common ancestor.

With respect to muscular action Dr. Haughton lays down these three laws:

Law I.—In comparing together different muscles, the work done in contracting is proportional to the weight of each.

Law II.—In comparing the same muscle (or group of muscles) with itself, when contracting under different external conditions, the work done is always constant in a single contraction.

Law III.—When the same muscle (or group of muscles) is kept in constant action until fatigue sets in, the total work done multiplied by the rate of work is constant. H. A. N.

4. *Check-list of the Ferns of North America north of Mexico.* Prepared and published by JOHN ROBINSON, Salem, Mass. April, 1873.—This check-list is published in two forms, 1st, on a thin sheet of folio-post for use in marking desiderata, etc., and 2d, in an ordinary 8vo pamphlet, this edition having some English names, and as it is printed on alternate pages, the names may be cut out and used as labels. The same numbers are used which appeared in Mann's Catalogue, the additional species being marked by letters added to the nearest number. The whole number of distinct species recognized is 126, besides which there are given 12 named varieties. Since the list was printed an additional species has been reported, viz: *Aspidium unitum* Mettenius, found near Enterprise, Florida, by Mr. C. E. Faxon of Cambridge, Mass. Doubtless there are yet undiscovered West Indian ferns in Florida, Mexican ferns in Arizona, and possibly undescribed species in California and along the Cordilleras. D. C. E.

5. *Flora Brasiliensis* of von MARTIUS, continued by Prof. EICHLER.—Fascicle 60, published in December, 1862, is a small one, containing three limited families, which are neatly elaborated by Dr. Engler of Munich; viz: *Olacineæ*, with 8 plates, one of them illustrating the new genus *Tetrastylidium*; *Icacineæ*, regarded as a distinct order, 4 plates (one of *Kummeria* of Martius, which is *Discophora* of Miers); and *Zygophylleæ*, with a single plate of *Kallstrœmia maxima*, which is a reproduction of that of *Ehrenbergia tribuloides* of Martius and Zuccarini's Nova Genera.

Fascicle 61, issued February, 1873, is much more ample. It takes in only two tribes (*Phyllantheæ* and *Crotoneæ*) of the vast order *Euphorbiaceæ*, by Dr. J. Müller, who most creditably elaborated this family (*Euphorbia* excepted), in the Prodromus. We have here 42 plates and letter-press up to p. 292; so that the order will fill a volume, the second part of which, it is said, will appear before the close of the current year. The Brazilian species of *Phyllanthus* amount to 71, of *Croton* to 275. A. G.

6. *A Monograph of Ebenaceæ*, by W. P. Hiern, M. A. (Trans. Cambridge Phil. Society, vol. xii, part 1.) Cambridge, Eng., 1873, 4to.—The letter-press fills 300 pages; the illustrations are 11 lithographic plates; and there is a lithographed "plan exhibiting the affinities of *Ebenaceæ*." Mr. Hiern is very favorably known by two or three botanical papers, one of them on the *Batrachium* group of *Ranunculus*. He comes now to take a position among the few British botanists of the day who will undertake to elaborate an exotic order; and he has chosen one which has much needed a monographer. In the notice of the collections consulted, the herbarium of "*Lehmann*," now belonging to Cambridge University, is mentioned. That of the late *Dr. Charles Lemann* (to whose memory Bentham dedicated the genus *Carlemannia*) is doubtless the one intended.

In a brief account of the economical products of the order, 18 species of *Diospyros*, 2 of *Maba*, and one of *Euclea* are said to supply ebony; not to speak of other hard woods, such as boxwood and pear tree, which are artificially dyed black and used in commerce as ebony, nor of the ebony of the ancients, which according to Bertoloni, was furnished by a *Leguminosa*. Fourteen species of Diospyros yield edible fruits. Much the best, no doubt, is that of the Japanese *D. Kaki*—perhaps because it has been immemorially cultivated; the next may be our N. American *persimmon*, which is said to be better fit to eat after it has suffered frost. It is hardly edible without it. Characters are assigned for distinguishing *D. Virginiana* from the Asiatic *D. Lotus;* but it is added that some specimens, of which the native country is unknown, are extremely difficult to assign with certainty. For his very full list of the numbered collections, with names assigned to the numbers, our author has earned hearty thanks. Only five genera are admitted; and one of these is a new one, of a single species, from Madagascar, *Tetraclis*, well marked by the valvate æstivation of the corolla. Not only are lists given of the species of each geographical region, but a complete chronological enumeration of all the published species. The treatment of the systematic part of the monograph, the Latin diagnoses and the English descriptions, and the displayed synonomy, &c., seems wholly creditable; but there is a surplus of punctuation in the diagnoses, each adjective being isolated by a comma. The fossil species are all described in an appendix, but the author disclaims responsibility for them. A. G.

7. *Dodecatheon Meadia* germinates after the fashion of *Delphinium nudicaule*, &c., according to Naudin (Jour. Soc. Hort.,

France, 1872, p. 153), i. e., has petioled and connate cotyledons, from the base of which false radicle the succeeding leaves come forth. A. G.

8. *E. Regel: Animadversiones de Plantis vivis nonnullis Hort. Bot. Imp. Petropolitani.*—An undated pamphlet, issued this spring. It contains several Californian plants raised from seeds collected by Rœzl,—all but one of which we can identify. Regel's *Aster scorzonerifolius* is *A.* (*Xylorhiza*) *Andersonii* Gray. His *Callirrhoe spicata* (figured in his Garten-Flora, 1872, t. 737), is *Sidalcea malvæflora* Gray. His *Campanula Rœzli* is *C. prenanthoides* Durand and *C. filiflora* Kellogg. *Pentstemon Rœzli* remains unrecognized; but, except that the cells of the anther are said to be distinct, it might well be a form of *P. azureus* Benth. A. G.

IV. ASTRONOMY.

1. *Astronomical and Meteorological Observations made during the year* 1870 *at the U. S. Naval Observatory;* Rear Admiral B. F. SANDS, Sup't.—This thick volume gives the results of the routine work of the Naval Observatory for the year 1870, and is followed by four appendices. Three of these have been before noticed (vol. v, 320). The first appendix gives the result of the determination of the longitude of St. Louis, from observations made by Prof. Harkness of the Observatory and Prof. Einsbeck of the Coast Survey.

The final result is that the observing station at St. Louis, in the Washington University grounds, on St. Charles street, between 17th and 18th streets, is west of the center of the dome of the United States Naval Observatory at Washington by $0^h\ 52^m\ 36^s\cdot90 \pm 0^s\cdot026$.

2. *Aurora Australis.*—The Aurora was visible at Melbourne, S. Australia, on the evening of the 8th of July, 1872. It was first seen at $6^h\ 50^m$, and at $6^h\ 55^m$; there were for a short time shifting streams. It brightened again at $10^h\ 55^m$, reaching an altitude of 25°; and again at 11° 30′. It was seen also at Cape Otway. Coincident with the Aurora there were magnetic disturbances; the minimum easterly declination occurred at $8^h\ 45^m$, the maximum at $9^h\ 20^m$. On Nov. 25 traces were seen at $11^h\ 30^m$; the same again on December 9th.—*Monthly Rec. Melbourne Observatory.*

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Earthquake wave of August* 14, 1868, *and depth of the Pacific.*—J. E. HILGARD, of the Coast Survey, has calculated the depths indicated by the observations on the rate of transmission of the earthquake wave of Aug. 13, the shocks of which were nearly vertical at Arica, Peru. The first shock began at $5^h\ 05^m$ and lasted till $5^h\ 15^m$, and the first wave at $5^h\ 32^m$. We cite from an abstract of his paper in the Coast Survey Report for 1869, recently issued (p. 233), the table containing his results.

	Dist'nce from Arica.	Local time, first wave.	Long. from Arica.	Arica time, first wave.	Time of trans-mission.	Nautic. miles pr.hour.	Mean depth of ocean.
	Miles.	*d. h. m.*	*h. m.*	*d. h. m.*	*h. m.*		*Feet.*
Arica	------	13 5 32	------	--------	------	------	--------
San Diego	4,030	13 14 00	2 27	13 16 27	10 55	369	12,100
Fort Point	4,480	13 15 00	3 28	13 18 28	12 56	348	10,800
Astoria	5,000	13 20 50	3 33	13 24 23	18 51	265	6,200
Kodiak	6,200	13 22 00	5 32	13 27 32	22 00	282	7,000
Rapa	4,057	13 11 30	4 56	13 16 26	10 54	372	12,200
Chatham Island	5,520	14 13 30	7 03	13 20 33	15 01	368	12,100
Hawaii	5,460	13 14 00	5 42	13 19 42	14 10	385	13,200
Honolulu	5,580	13 12 00	5 50	13 17 50	12 18	454	18,500
Samoan Islands	5,760	14 14 30	6 40	13 21 10	15 38	368	12,100
Lyttleton	6,120	14 16 45	7 48	14 00 33	19 01	322	9,200
Newcastle	7,380	14 18 30	9 12	14 03 42	22 10	332	9,800
Sydney	7,440	13 20 00	9 13	14 05 13	23 41	314	8,800

Mr. Hilgard states that the superior depth of the Pacific in its eastern equatorial part, which there was otherwise good ground for believing in, is here made manifest, and that the depth in the northern part also seems to be small.

2. *The Challenger Expedition.*—Crossing the ocean to the West Indies, the expedition made several deep soundings. March 4th, in 21° 38′ N., 44° 39′ W., 1,900 fathoms; the bottom gray ooze and the bottom temperature 1·9° C. A crustacean related to the Astaci (and named by Dr. Suhm *Deidamia leptodactyla*, was brought up, which had no eyestalks or eyes. March 6th, 2,325 fathoms, bottom temperature 1·7° C.; brought up a little red mud, containing a single valve of a lamellibranch, and some sharks' teeth of two genera, with nodules that appeared to be coral altered to manganese ore: position 19° 57′ N., 53° 26′ W., 558 miles from Sombrero. March 10th, 2,675 fathoms, bottom temperature 1·6° C.; brought up some red clay with very little calcareous matter. March 11th, the line run out "over 4,000 fathoms or nearly five miles"; brought up the same red mud, containing some long cases of a tube-making Annelid (related to the shallow-water Clymenidæ and closely allied to Owenia), made out of the gritty matter, which occurs sparingly in the clay, and very few foraminifera; the depth was 2,975 fathoms, "a depth which does not appear to be greatly exceeded in any part of the ocean." March 13th, lat. 18° 54′ N., long. 61° 28′ W.; March 14th, still 35 m. from land, sounded in 1,420 fathoms; brought up material consisting chiefly of foraminifera, with spicules of sponges.

"The expedition sailed thence to Bermuda and Halifax, arriving at the latter place May 9th."—*Nature*, May 15.

3. *Michigan University.*—Prof. E. W. Hilgard, for many years connected with the University at Oxford, Mississippi, has recently entered upon the duties of Professor of Geology in the Michigan University. The change takes him to a new field, where he will be able to connect his very valuable work in the Gulf region with observations over that of the Great Lakes and the northern United States.

4. *British Association.*—The next meeting of the British Association will be held at Bradford, England, commencing on the 17th of September, and be under the Presidency of the distinguished physicist, James P. Joule.

5. *Report of the Superintendent* (Prof. BENJAMIN PEIRCE) *of the U. S. Coast Survey, showing the progress of the Survey during the year* 1869. 260 pp. 4to, with 28 maps. Washington, 1872.—Besides the Report of the Superintendent on the movements, researches and results of the Coast Survey, this volume contains several valuable papers in an Appendix: among them Prof. Agassiz, on the coral reef regions and deep sea-bottoms of Florida and the adjoining region; on observations by Coast Survey officers, on the eclipse of the sun of Aug. 7th, 1869; on the reclamation of tide lands, and its relation to navigation, by Assist. Henry Mitchell; on the earthquake wave of Aug. 14, 1868, by J. E. Hilgard.

6. *Year-book of Nature and Popular Science for* 1872; edited by JOHN C. DRAPER, Prof. Nat. Hist. and Physiology in the College of the City of New York, and of Chem. in the Univ. Med. College. 334 pp. 12mo. New York, 1873. (Scribner, Armstrong & Co.)—So small a work can of course contain only brief excerpts from some of the scientific articles of the year. This volume, besides its many short paragraphs of this kind, has scraps of information and opinions on a large variety of subjects, many of them not 1872 in origin, or of any particular year.

7. *Annual Record of Science and Industry for* 1872, by SPENCER F. BAIRD. 652 pp. 12mo. New York, 1873. (Harper & Brother.)—The readers of Harper's periodical publications and others will gladly welcome a volume containing the various scientific notices contributed to them by Prof. Baird. The Record embraces a large amount of information with regard to discoveries during the year in the various branches of science; the movements and explorations of expeditions; and the developments in many branches of industrial science. Besides the names of the several physical and natural sciences, it has the heads of Agriculture, Pisciculture and the Fisheries, Domestic and Household Economy, Mechanics and Engineering, Hygiene and Sanitary Science.

The book opens with an introductory chapter having the title "General Summary of Scientific and Industrial Progress during the year 1872," the most of which was evidently prepared for Prof. Baird by other hands. In general the chapter appears to be satisfactory. But in the geological part the writer cites very one-sidedly from the papers of 1872 (and 1871), putting among established truths the view that the Green Mountain rocks are Huronian; and that the metamorphism of Paleozoic and Mesozoic rocks is no longer to be believed in—making the old idea "an hypothesis based on very slender grounds." A little deeper look into the articles of 1872 would have brought to light evidence that the formations to which the great limestones (marbles) of the Green Mountains belong, and which all Canadian geologists have pronounced Paleozoic, include gneisses, mica-shists, chloritic mica slates, garnet rock, and other metamorphic rocks which are as completely metamorphic as any of pre-Paleozoic time;* and that some of the kinds so closely resemble rocks of the Green Mountain series, that if lithological evidence is worth any thing, Mount Mansfield, the highest peak in these mountains, in Northern Vermont, is of the same age with some of the *Paleozoic* summits of Berkshire. An actual comparison of rocks has proved that the lithological evidence for the Huronian age of the Green Mountains will not hold, and that the denial of the existence of Paleozoic gneisses and mica slates connot be sustained by an appeal to Green Mountain facts.

8. *Reptiles and Birds:* a popular account of their various orders, with a description of the habits and economy of the most interesting. From the French of Louis Figuier. New edition, revised by Parker Gilmore ("ubique"). 624 pp. 12mo, with 307 illustrations. New York, 1873. (D. Appleton & Co.)—Figuier's popular works in science are well known. The figures are very good.

9. *Views of Nature, and of the Elements, Force and Phenomena of Nature and of Mind;* by EZRA C. SEAMEN. 140 pp. 12mo. New York, 1873. (Scribner, Armstrong & Co.)—This little volume contains many sound ideas. But the author is not sufficiently versed in science to criticize its principles, or to produce arguments on scientific points that have much weight.

10. *A Manual of Photography founded on Hardwick's Photographic Chemistry;* by GEO. DAWSON, M.A., Ph.D., of King's College, London. 8th edition. 276 pp. 12mo. Philadelphia: 1873. (Lindsay & Blakiston).—Hardwick's Photographic Chemistry has long been a standard work with photographers. Mr. Dawson has condensed it by wisely omitting much irrelevant matter—as the compend of elementary chemistry—theoretical speculations on light, &c.—thus making his manual more convenient than the original. The historical sketch very naturally omits all allusion to the contributions of American photographers to the art. But this does not much impair its value. The book is an eminently practical and useful treatise, not too learned for the unscientific reader, and exact enough for all useful purposes in the practice of this important art. B. S.

OBITUARY.

CHRISTOPHER HANSTEEN, for many years Professor of Astronomy and applied Mathematics at the University of Christiania, Norway, and Director of the Observatory there, died on the 15th of April last, at the age of 88. He made many valuable contributions to our knowledge of terrestrial magnetism, and was sent by his Government on an expedition into Siberia, with that object, in the year 1828. To him we principally owe the establishment of 11·1 years as the length of the periodicity of the magnetic declination, a period which also agrees with that of the maximum and minimum frequency of the solar spots, and which appears to be connected with that of many other terrestrial phenomena.—*Athenæum*, May 24th.

---

* This Journal, III, iv, 362, 450.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XIII.—*On the effects of Magnetization in changing the Dimensions of Iron and Steel bars, and in increasing the Interior Capacity of Hollow Iron Cylinders;* by ALFRED M. MAYER, Ph.D., Professor of Physics in the Stevens Institute of Technology.

PART II.

(Read before the National Academy of Sciences, in Cambridge, Nov. 22, 1872.)

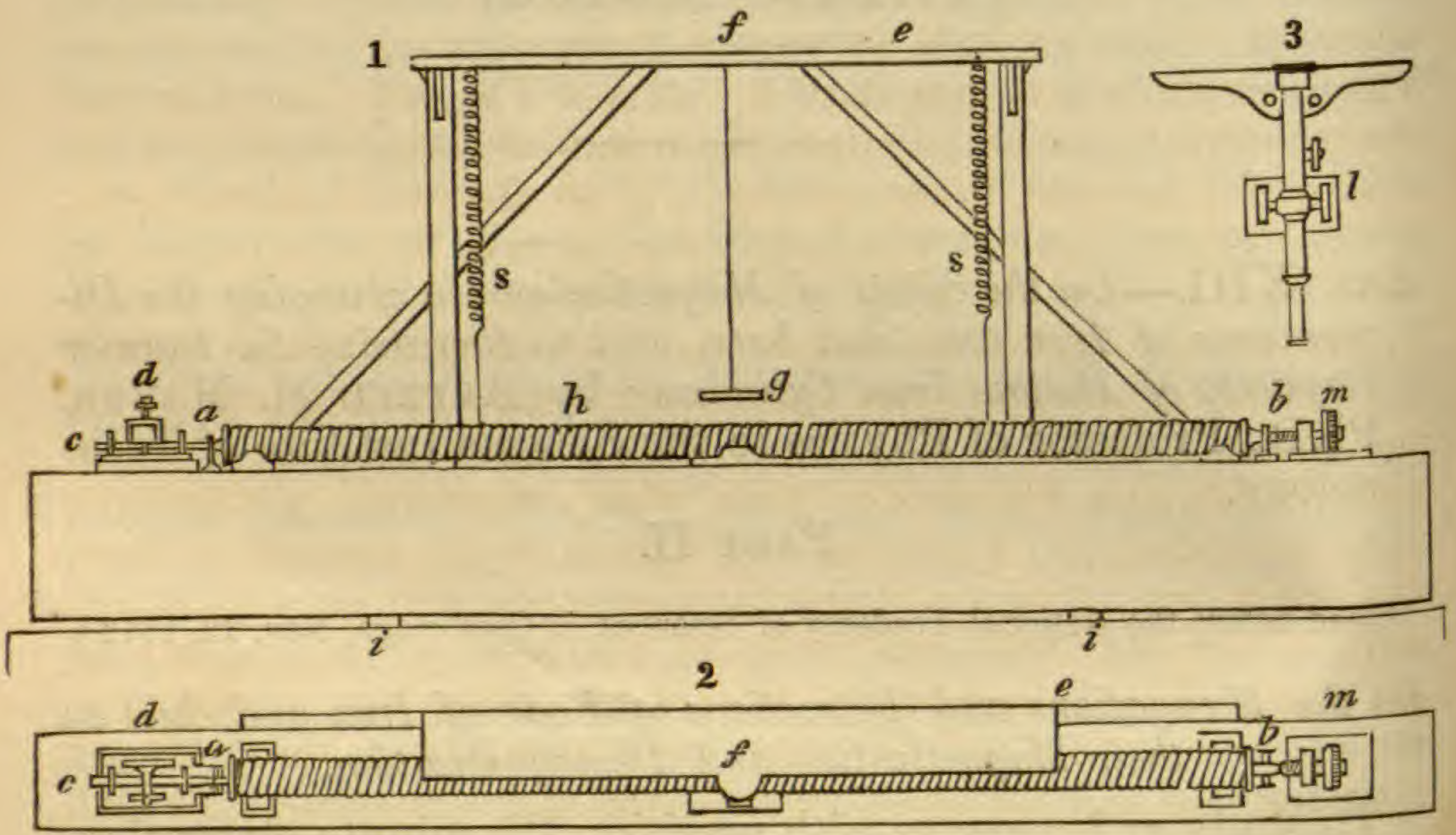
On the Elongations and Retractions of Rods of Iron and Steel on their Magnetization and Demagnetization.

To study and measure with precision the minute elongations and retractions which rods of iron and steel undergo on their magnetization and demagnetization, it is necessary that the motions of the part of the measuring apparatus which records these changes in length should not be in the least affected by outside vibrations transmitted to the apparatus, but should be controled alone by the molecular motions in the rods which take place on changes in their magnetic conditions; also the motions of this indicating part of the apparatus should be synchronous with the motions in the rods, so that we may be able to study the character as well as the amount of these elongations and retractions.

Several instruments have been devised by me which fulfill these essential conditions, but they were all abandoned (except one to be described in detail in Part IV of this memoir), and preference given to "The Reflecting Comparator and Pyrometer" of our esteemed colleague, Mr. Joseph Saxton; this simple and precise instrument is well known to American scientists as the apparatus which has greatly aided in giving to the geodetic work of our National Coast Survey its renowned precision, and in rendering accurate the comparisons and constructions of our office of Weights and Measures. A detailed description, with drawings, of this instrument will be found in the "Report on the Construction and Distribution of Weights and Measures, Washington, D. C., 1857," written by Dr. A. D. Bache, the late President of the Academy.*

The Measuring Instrument.

I will now describe the actual adaptation of this instrument to our research. The drawings 1 and 2 give respectively an elevation and plan of the apparatus. A beam of Georgia pine, well seasoned, dried and then soaked with shellac varnish, formed the base on which the instrument was lined and firmly attached. This beam is 7 feet long, 8¼ inches deep, and 5¾ inches wide. It rested on slips of hard wood at *i*, *i*, placed at distances from the ends of the beam equal to one-fourth of its length. At *a* and *b* are two Vs of brass which supported the terminal brass caps of the rods experimented on. These rods were all 60·1 inches long, ·5 inch in diameter; and each rod weighed, on the average, 1520 grams. While the ends of a rod rested in the Vs, 1100 grams of its weight was supported by the two springs, *s s*, which took hold of the rod at distances from its ends equal to ¼ of its length. The flexure of the rod was thus in great part avoided, and it could therefore be accurately cen- against its agate terminal. This operation was performed as



---

* To my friend and colleague, Dr. J. E. Hilgard, of the U. S. Coast Survey office, I am indebted for the loan of the comparator used in these researches.

tered in the helix *h*. This helix is 60·25 inches long, and has an outside diameter of 1·75 inch. It is wrapped on a tube of brass of ·8 inch internal diameter, slit longitudinally throughout its whole length. At *m* is the micrometer abutting-screw, against which the end of the rod is firmly pressed by two heliacal springs, which are stretched between hooks on the brass mountings of the screw and a rod which passed through the terminal brass caps of the rod. The brass caps, at both ends of the rod, are terminated by pieces of agate. The other end of the rod is in contact with a slide *c*, with triangular section which accurately moves, between guides, in a direction which is the axis of the rod prolonged. To this slide is attached a delicate fusee-chain, which is coiled once around the vertical axis of the mirror *d*. This chain is prevented from slipping by a steel pin which securely attaches it to the axis. The slide carrying the chain is firmly pressed against the terminal agate of the rod by means of a heliacal brass spring. Thus the rod is, at one end, firmly pressed against the micrometer screw, while against the other end presses the slide which is connected with the mirror by the intervention of the fusee-chain; which latter is also tightly stretched. The well-joined framework *e* supports the springs *s s*, and also a divided circle *f*, from whose center dropped either a fiber of silk, or a filament of glass, which supported a magnet of very hard steel *g*. From the oscillations of this magnet, or from its deflections by means of the divided circle and glass filament, were determined the intensities of the residual magnetism of the rods. The deflections of the mirror, caused by the elongations or retractions of the rods, were determined by means of the telescope and the scale, represented at *l*. The telescope and scale were placed between 5 and 6 meters from the mirror, and the scale was divided into millimeters. Each unit of the division given in the experiments corresponds to one centimeter of the scale. The above apparatus was placed in a cellar room, without windows and entirely under ground; and the room was always entered by a door, the bottom of which was on a level with the ceiling of the room. During the course of the experiments the range of variation of temperature of this room did not exceed 0·1° C. in twenty-four hours.

Examination of the stability and degree of precision of the apparatus.

A rod was accurately centered in the helix, and the micrometer screw and the slide of the mirror were brought in contact with its ends. After the heat imparted to the rod and apparatus by handling had been dissipated, and the scale-reading had remained constant for an hour, I pushed the mirror-slide away from the rod and then again allowed it to come expeditiously as was consistent with the careful avoidance of shocks to the apparatus. The thermometers which were placed near various parts of the apparatus were now read, and it was ascertained that they gave the same readings as before the apparatus was touched. The scale was now read in the telescope, and it was ascertained that the cross-threads bisected the same division observed before the slide was moved; thus showing that the mirror returned to the position it had before its rotation. This important fact was repeatedly confirmed with all the rods and at various stages of the research. Indeed, the measures of hundreds of experiments made on the elongations and retractions of rods also confirmed the confidence I obtained in the indications of the apparatus arrived at by the preceding experiments. Jumping on the floor of the room, and the passage of carriages and carts in the streets, had not the slightest effect in disturbing the scale-readings.

To ascertain whether the mirror accurately followed the changes in length of the rod, I repeatedly made the following observation. The readings of the screw-head and the scale were noted; then the screw was rotated by an assistant, so as to push before it the rod. The scale-readings ran up steadily with the rotation, and when the screw was rotated backward the scale-readings ran smoothly down, and when the screw-head had reached the same position it had before it was touched I found that the scale-reading corresponded to that noted when the screw previously had this position. This observation repeatedly made gave me the means of testing the precision of the instrument during the progress of the investigations.

It will be seen below that one division of the scale, or centimeter, corresponded to a change of ·00011 inch in the length of the rod; but $\frac{1}{2}$ millimeter, or $\frac{1}{20}$ of a division, could be precisely read in the telescope; I am therefore justified in believing that the measures I will give in this memoir can be relied on to the $\frac{1}{200000}$ of an inch.

Determination of the value of one division of the scale in changes of length in inch-measure of the rods.

Pasted on the inside of the box in which the mirror, telescope and micrometer-screw came to me, was the following: "Abutting-screw of field-pyrometer. By 7 comparisons of 5 turns with 0·1 inch on Troughton-scale, in June, 1857, by Mr. Saxton, 1 turn=0·01912 inch."

As the result of numerous determinations, made on various parts of the screw, I found that $\frac{1}{100}$ of a rotation of the screw equaled 1·737 divisions of the telescope scale; which gives 0·00011 inch as the value of one division of the scale. This value, however, applies only to the experiments on the rods of iron, Nos. 1 to 6 inclusive. Before commencing the experiments on the rods of steel, the distance of the scale from the mirror was changed, and in this new position I found that one division of the scale corresponded to 0·000146 of an inch.

Description of the helix and measures of the resistances of its wires.

The helix was a compound one, formed of four layers of copper wire. The two inner layers formed 1069 turns of one length of 303 feet of wire ·087 inch in diameter. The two outer layers were formed of another length of 330 feet of ·112 inch wire wrapped in 850 turns. These two helices could be used separately, or joined into one helix of 633 feet having 1919 turns.

The resistance of the inner helix was ·44 ohm; the outer had a resistance of ·31 ohm; together giving a resistance of ·75 ohm. The latter resistance, added to that of the wires leading from the battery through a Gaugain galvanometer to the helix and back to the battery, brought up the resistance to nearly one ohm.

A battery of 25 cells of Bunsen was used in the determinations of the coefficients of elongation and retraction; and the above interpolar resistance showed that the maximum effect of magnetization would be given by connecting the 25 cells, 5 in couple and 5 in series.

Whenever in this research we speak of the effect of 25 cells, it is to be understood that they are connected as just described.

The iron and steel rods used in the experiments were prepared for me with the well-known skill and fidelity of Mr. William Wallace of Ansonia, Ct. He carefully selected the material, and annealed the iron rods by packing them with iron scales from a rolling mill, in a wrought-iron covered box, and exposing the box to a red heat for three days; the box was then allowed to cool very slowly. The steel rods were tempered as uniformly as possible throughout their lengths

Arrangement of the Apparatus, and general description of the phenomena which take place on the magnetization and demagnetization of the rods of iron.

The beam supporting the apparatus was so placed that the axis of the helix was in the magnetic meridian. Each rod, before it was introduced into the helix, was tested, as to its magnetic condition, by placing its length at right angles to the magnetic meridian and pointing it toward the center of a magnetic needle. When the rod, thus directed, gave indications of polarity, its S end was placed downward with the axis of the rod in the line of the dip, and its upper end was struck with a light mallet. The rod was tested, until after one or more operations of this kind it gave no indications of polarity. But on placing the rod in the helix, it of course was again magnetized, but feebly, by the earth's induction. This fact serves to determine the distance at which the magnet, which determined the residual polarity, had to be suspended above the rod. If this magnet is placed too near the rod, an interaction between it and the soft iron of the rod takes place by the inductive action of the magnet, and the vibrations of the latter are more frequent than when it is alone acted on by the earth; but if it be removed to a certain distance above the rod, then the magnetism of the rod acts as a "damper" on the magnet, and its vibrations are slower than when it is only under the earth's influence. There is, therefore, an intermediate position at which the magnet vibrates the same, whether the rod remains under it or is taken away. This distance, of course, varies with the rod used, but on an average it was about 3 inches.

Thus arranged, the rod was allowed to remain until its temperature had become constant, and the scale reading in the telescope was stationary.

The interpolar connections with the battery were made so that the helix, on closing the circuit, would magnetize the rod with the same direction of polarity it already had from the earth's action. The current was now passed from the 25 cells by plunging the amalgamated wire of the open part of the circuit into a cup of mercury; then the scale-reading was immediately noted; the circuit was at once broken, and another reading obtained. The thermometers which were placed on various parts ol the apparatus, and which had been read just before closing the circuit, were now again observed, and the room vacated and closed. At intervals of a half hour during the three to six subsequent hours the room was entered, and readings of scale and thermometer obtained.

It may be well to give here a general account of the phenomena which the rods exhibit when the voltaic circuit is successively closed and opened. When the rod has, for the first time, the heliacal current passed around it, a sudden elongation takes place, and this elongation remains steadily of the same amount as long as the circuit is closed and the temperature of the rod remains constant. Now, on breaking the circuit, the rod retracts, with a less velocity than that with which it elongated, but the retraction does not equal the elongation.

The temperature of the rod remaining constant, it has been found that the rod retains the length it attained on the breaking of the circuit; that is, the rod has received, with its permanent magnetic charge, a permanent elongation. On passing the current a second time the rod again elongates, but the elongation is now less than that which took place when the current was first passed around it. On now breaking the circuit the rod retracts to the length it had before the current was passed for the second time. That is, after the first magnetization and demagnetization of the rod, the successive elongations and retractions are equal. These conditions exist until four or five subsequent make and break-circuits have been made; but now a change takes place in the phenomena, for on making the circuit the rod elongates about the same as in the preceding experiments, *but on breaking the circuit* the retraction does not equal the elongation; so that after each experiment the rod is slightly longer than before the preceding experiment was made. Continuing the experiments, the scale gradually passes over the cross-threads, and I have thus repeatedly caused the entire scale to traverse the field of the telescope. On now allowing the rod to remain at the temperature it had when the current was for the first time passed around it, the rod slowly retracts until, after several hours have elapsed, the rod has the length which was observed after the first experiment made upon it.

Heat developed in the rod at the instant of its demagnetization.

The above described experiments show conclusively that the minute elongations which take place on breaking the circuit are due to the heat developed in the rod at the moment of its demagnetization; for, in the preceding experiment the current did not heat the helix sufficiently to cause radiations from it to elongate the rod; therefore, to obtain the results described above, it is important to ascertain beforehand that when the current has traversed the helix for a time equal to that occupied in the experiments, the rod during this time does not elongate.

If the current is sufficiently intense to heat directly the helix and rod, the above phenomena of heating on demagnetization nevertheless manifests itself and can readily be disentangled from the combined effects, as will be seen further on.

These interesting results proving the development of heat on demagnetization, were obtained a year ago without any knowledge of the recent work of Jamin and Roger, and the measures made directly on the changes in length of the rods, tend to confirm the result arrived at by these experimenters.* Recently Cazin (Compt. Rendus, t. lxxv, p. 1265), has shown that "the heat thus produced is proportional to the square of the intensity of the magnetism and to the polar distance;" and Moutier,

---

* I have not been able to find the paper containing Jamin and Roger's experiments, either in the Comptes Rendus or in the Ann. de Ch. et de Phys. I have obtained the information of their results only from the following passage in the paper of M. Cazin, C. R., t. lxxv, p. 1266. "When we pass an intermittent current in the wire of an electro-magnet, the recent experiments of MM. Jamin and Roger have demonstrated in a definite manner that the core is heated." The method by which they discovered this fact is not stated by Cazin.

(Comptes Rendus, t. lxxv, p. 1620), deduces this result from a thermodynamic theorem established by Clausius, and thus concludes his paper: "The increase of *vis viva* which the bar experiences from the effect of magnetization is therefore proportional to the square of the intensity of the magnetism and to the polar distance. The effects of the demagnetization correspond to an equal loss of *vis viva*, which is the measure of the thermal effect produced, and this effect is the only one which accompanies the demagnetization."

The fact that an iron bar is heated by successive magnetizations and demagnetizations has been known for a long time, but only recently have experiments been made which indicate that this heat is produced at the moment of demagnetization. In a paper "On the Calorific Effects of Magneto-Electricity, and on the Mechanical Value of Heat," (L. E. and D. Phil. Mag., vol. 23, 1843), Dr. Joule first showed that heat was developed in an iron bar when it was rotated between the poles of a powerful magnet, and also determined that the heat thus produced was proportional to the square of the inductive force. These experiments will ever be regarded with interest, for they led Joule to the first experimental determination ever made of "the mechanical value of heat."

It may be of interest to present the following account of the experiments made by Van Breda and Grove, taken from Daguin's Traité de Physique, 1861, vol. III, p. 621. "M. Van Breda having enveloped a tube of iron with a helix through which he passed an intermittent current, found a heating of the iron due to the alternative displacement of the molecules,* the heat being shown by the dilatation of the air contained in the tube, which formed a reservoir of an air thermometer. Grove subsequently determined the heating of an armature of soft iron, on passing an intermittent current in the wire of an electro-magnet on which the armature was placed, or in turning near it the poles of a strong electro-magnet. The heating effects were indicated by a thermo-electrical couple. Cobalt and nickel gave similar results, but less marked; while non-magnetic metals were not heated in the same circumstances. I have made many experiments on a tube of iron, weighing two hundred weight, which confirm these results. The experiments will be given in Part III. of this memoir.

I here present two tables of experiments on rod No. 2, of Ulster iron. The successive discussion of these two tables will give to the reader a clear physical conception of the phenomena, and serve to elucidate the account I have above given of the heat developed on demagnetization.

---

* The heat observed, however, may not be entirely due to these motions, for the thermal effects may in part be due to the currents induced in the iron on magnetization and demagnetization.

TABLE I.

No. of Expt.	Scale, circuit open.	Scale, on closing circuit.	Scale, on breaking circuit.	Elongation.	Retraction.
1	37·6	39·2	38·0	1·6	1·2
2	38·0	39·2	38·0	1·2	1·2
3	38·0	39·2	38·0	1·2	1·2
4	38·0	39·2	38·0	1·2	1·2
5	38·0	39·2	38·0	1·2	1·2
6	38·0	39·2	38·1	1·2	1·1
7	38·1	39·3	38·1	1·2	1·2
8	38·2	39·4	38·3	1·2	1·1
9	38·3	39·5	38·4	1·2	1·1
10	38·4	39·55	38·6	1·15	0·95
11	38·6	39·6	38·6	1·0	1·0
12	38·6	40·0	38·85	1·4	1·15
13	38·85	40·1	39·0	1·25	1·1
14	39·0	40·2	39·1	1·2	1·1
15	39·1	40·2	39·2	1·1	1·0
16	39·2	40·3	39·2	1·1	1·1
17	39·2	40·4	39·3	1·2	1·1

In experiment No. 1, we passed the current for the first time around the unmagnetized rod, and observed an elongation of 1·6 divisions of the telescope-scale. Immediately after the observation we broke the circuit, which had remained closed about 5 seconds, and observed a retraction of 1·2 div.; the rod now remained at a constant temperature for three hours and the scale-reading remained steady at 38·0; thus showing that the rod had received a permanent elongation of ·4 of a division on receiving its charge of residual magnetism. On repeating the experiment, we find an elongation and retraction of 1·2 div., which is the quantity the rod retracted on the first break-circuit. Experiments 2 to 5 inclusive give the same result; but on the 6th and subsequent break-circuits, we observe a retraction less than 1·2, and this effect we attribute to the heat produced in the rod at the instant of its demagnetization. It is also noteworthy, that from the moment of breaking the circuit in an experiment until the forming of it in the succeeding one, the scale remained immovable. Taking 1·2 div. as the amount of elongation and retraction due alone to magnetization and demagnetization, we can determine the mean amount of elongation at the moment of demagnetization as follows: The mean elongation in experiments 6–17 is 1·18 div. This is only ·02 of a div. less than 1·2, and can candidly be attributed to the errors of observation, but the mean retraction of the same experiments is 1·08 div., which is ·12 of a division less than 1·2, and gives us the measure of the effect due to the heating of the rod at the moment of its demagnetization; for, on keeping the rod at the temperature it had during experiments 1–5, we found that it gradually retracted until the scale again remained steady at 38·0.

Table II is here given to show that nearly the same effects of elongation and retraction are observed when the rod is gradually elongating under the effects of heat radiated from the helix, when the latter has passed through it a powerful current.

TABLE II.

No. of Expt.	Scale, circuit open.	Scale, on closing circuit.	Scale, on breaking circuit.	Elongation.	Retraction.
18	51·4	52·8	51·8	1·4	1·0
19	51·8	53·2	52·2	1·4	1·1
20	52·2	53·4	52·4	1·2	1·1
21	52·5	53·8	52·7	1·3	1·1
22	52·8	54·0	52·9	1·2	1·1
23	53·0	54·3	53·2	1·3	1·1
24	53·2	54·5	53·5	1·3	1·0
25	53·5	54·7	53·6	1·2	1·1
26	53·8	55·2	54·2	1·4	1·0
27	54·2	55·4	54·4	1·2	1·0
28	54·4	55·6	54·5	1·2	1·1
29	54·5	55·7	54·7	1·2	1·0
30	54·8	55·8	54·75	1·0	1·05
31	54·8	56·0	55·0	1·2	1·0
32	55·0	56·2	55·2	1·2	1·0
33	55·2	56·3	55·25	1·1	1·05
34	55·25	56·4	55·4	1·15	1·0
35	55·4	56·45	55·5	1·05	0·95

The experiments in this table were made on the same rod used in the experiments in Table I, but before this new series was commenced I passed around the helix a stronger current than previously used, so that the rod was elongated, by the heated helix, from 39·2 divisions of the scale to 51·4 divisions, and while the scale was advancing to this reading I determined its rate of progress and found it to be 3·6 divisions in 10 minutes. Therefore these experiments were made on the rod while it had a slow motion of elongation. The mean of the elongations is 1·22 divisions. The mean of the retraction is 1·04 div., which subtracted from 1·20 gives ·16 of a division for the effect of the heat of one demagnetization. The reduction of Table I gave ·12 of a division for this effect. The difference in the two results I thus account for. While the bar was slowly expanding from the heat radiated from the helix, the circuit was made and the elongation was immediately observed, but about five seconds elapsed before the reading could be made, and the circuit broken, and during these five seconds the rod was expanding, but so slowly that its amount could not be read, but was often visible. That this minute expansion could not be determined was to be expected, for if the rod elongated from heat 3·6 divisions in 10 minutes, it elongated only ·03 of a division in five seconds, and ·03 of a division was a quantity too small to be measured on the scale, but it nevertheless existed there, and during the continuance of 18 make-circuits would amount to ·03 × 18 = ·54 of a division; quite an appreciable quantity when we come to calculate the mean with this fraction contained in the sum of retractions given in the last column of the table. Therefore, to obtain the effect of the heat developed at the moment of demagnetization, we should subtract ·03 from ·16, the heating effect of demagnetization determined without this correction. This gives ·16 − ·03 = ·13 of a division; while from Table I we deduced ·12 for the value of the same effect. The difference of only ·01 division in the two results is not, however, to be taken without some reserve, for in the calculations I assumed that the rod had the same rate of expansion under a closed circuit as under an intermittent one, and this I did because I had no means of determining the difference, if any exist. Experiments similar to those just given were made on all the iron rods, and similar results were obtained.

Relations existing between the number of break-circuits, the heating of the rod, and its elongations.

At this stage of the investigation, it became of interest to determine the above relation. For that purpose I drilled a hole six inches deep in the direction of the axis of rod number 3, of Norway iron, and inserted into this hole a thermo-electric couple, formed of two wires, one of copper, the other of iron. This compound wire was wrapped, first with two layers of waxed silk, then with twelve layers of floss-silk, and over these layers I coiled two more layers of waxed floss-silk, leaving, however, the point of junction of the wires exposed.

This apparatus was introduced into the rod so that the uncovered point of the wire was about one millimeter from the bottom of the hole, and the space included between the point of the wire and the bottom of the hole was filled, in some experiments with fine iron filings, in others with mercury. The terminals of the thermo-electric couple were connected with a delicate galvanometer. With the apparatus thus arranged, I successively made 50, 100, 200, 300, and 400 break-circuits, taking care that the closed circuits, preceding the break-circuits, should all be of the same duration.

After each series of break-circuits the elongation produced in the rod and the permanent deflection in the galvanometer-needles were noted, and the observations showed that the elongations and the increments of temperature in the rod were proportional to the number of break-circuits.

On the elongations and retractions observed in the iron rods as the strength of the magnetizing current is gradually increased and diminished, and on the equality in the elongations produced by a definite current when it is gradually and when it is suddenly brought up to its maximum strength.

The observed sudden elongations taking place in an iron rod at the moment of its magnetization naturally led me to inquire if the quantity of this elongation was in any way due to the suddenness of the magnetizing action, and whether the elongation produced by a certain current which is gradually brought up to its maximum strength would equal that produced by the same current suddenly passed with the same maximum strength. This problem was also connected with a proposed simple and accurate means of measuring the changes in dimensions of bodies subjected to magnetization, and I have therefore examined it with care in the following manner. I cut the thick copper wire leading from the battery to the helix and firmly attached one of its loose ends to a support. Between this copper wire and the opposite wall I stretched a fine wire of german-silver. The other loose end of the battery wire was bent into a sharp angle and the vertex of this angle was well amalgamated. Now by sliding this bent copper wire along the fine wire of german-silver toward the other copper wire, I could gradually diminish the resistance, and on touching the other end of the thick battery wire, this interposed resistance vanished and the current gained its maximum strength. On slowly retracing our steps the resistance was gradually increased, until the whole length of the fine wire was interposed, and then the resistance was at its maximum and the strength of the current was at its minimum. But if we brought the two amalgamated ends of the copper wire in contact, either with or without the intervention of a mercury cup, we at once could suddenly send the current with its maximum intensity through the helix.

Mean results of 1st series of experiments. Resistance of fine wire = ·6 *ohm.* One cell in circuit.

On gradually diminishing the resistance.

Fraction of length of fine interposed wire.

	1	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	0
Scale-readings went from 54·8 to	54·85	54·9	55	55·2	55·6	56·1

On gradually increasing the resistance.

Scale-readings went from 55·5 to	54·8	55·6	55·8	55·9	55·95	56·1
Tangent galvanometer,	$4\frac{3}{4}$°	---	---	---	-- -	$29\frac{1}{2}$°

Mean results of 2d series of experiments. Resistance of fine wire = ·9 *ohm.* One cell in circuit.

On gradually diminishing the resistance.

Scale-readings,	54·8	54·8	54·85	55	55·4	56·1

On gradually increasing the resistance.

Scale-readings went from 55·25 to	54·8	55·4	55·65	55·8	55·9	56·1
Tangent galvanometer,		3°	----	---	---	$29\frac{1}{2}$°

Examining the results in the two series of experiments, we see that where the current was passed, with all of the interposed resistance in the circuit, the scale went from 54·8 to 54·85, or moved ·05 of a division in the first series of experiments; but in the second series the current was too feeble to effect a measureable elongation, and it was not until $\frac{1}{4}$ of the fine wire was out of the circuit that the scale-reading began to increase. In both series of experiments the rapid increase in the rate of elongation is noticeable after $\frac{3}{4}$ of the fine wire was out of the circuit; the elongation, in both series of experiments, amounted to 1·3 divisions of the scale. The same amount of elongation always occurred when the ends of the copper wires were brought together, or when the circuit was as suddenly formed by plunging the wires into a cup containing mercury. Therefore, it is well established that a current of a definite strength will produce the same amount of elongation whether that strength is suddenly or gradually attained. Indeed, in some of the experiments over three minutes were occupied in gradually decreasing the interposed resistance, until it was entirely out of the circuit, yet during this very slow increase of the current strength, the scale slowly and smoothly moved upward in its readings, and when all the interposed resistance had been passed over the elongation again equaled 1·3 division.

The establishment of the above fact was of considerable importance, for it rendered applicable the following simple and precise method of measuring the change in dimensions of bodies on their magnetization. Two iron, steel or bismuth bars are placed parallel to each other, in Vs, with their similar ends strongly pressed against a firm support, so that if the rods change their length on magnetization, their free ends will move.

Now imagine a lever so arranged that one end of it carries a plano-convex lens and the other end a micrometer screw. The convex side of the lens is opposite a plane glass, which terminates the end of one of the rods, while the point of the micrometer screw touches the end of the other rod, against which it is pressed by a spring. An inclined piece of plane glass placed in front of the lens, sends the light from a sodium flame down to the lens and plane glass behind it, and by means of a microscope we can look through the inclined glass on to the lens and thus accurately view and measure the Newton's rings, which we will now observe. If around the rods we now pass a voltaic current of gradually increasing strength, we will see the rings gradually displaced, and from the amount and direction of this displacement, together with the knowledge of the wave-lengths of the rays of the sodium light, we can accurately determine the amount and direction of the motion of the ends of the rods.

If, however, the current should have been passed at once with its full intensity, there would have followed a sudden displacement of the rings, but the amount and direction of this displacement it would have been impossible to determine. By making the arm of the lever which carries the convex lens longer than the arm which carries the screw, we can increase the delicacy of the apparatus, for it is understood that, as the rods move in the same direction, the rod carrying the plane glass moves toward the lens, while at the same time the other rod, through the intervention of the lever, pushes the lens toward the plane glass.

The examination of the experiments of the first and second series contained under the heading, "On gradually increasing the resistance," makes known a remarkable phenomenon. In these experiments the current, with its maximum strength, was first passed through the helix and then it was gradually brought down to its minimum strength by sliding the copper battery wire over the fine wire of german-silver until the whole length of the latter was brought into the circuit. At the moment of sending the current with its maximum strength, the rod elongated 1·3 divisions of the scale; but if we now keep the circuit closed, but gradually diminish the strength of the current, we observe that the scale-readings do not correspond to those given when the corresponding strengths of current were reached by going from their mimimum to their maximum, as the following tables, giving the differences of scale-readings in the two cases, plainly show.

First series of experiments.

Fraction of length of fine interpolar wire,	1	¾	½	¼	⅛	0
On gradually diminishing the current,	55·5	55·6	55·8	55·9	55·95	56·1
" " increasing the current,	54·85	54·9	55·0	55·2	55·6	56·1
Differences,	·65	·7	·8	·7	·35	·0

Second series of experiments.

Fraction of length of interpolar wire,	1	¾	½	¼	⅛	0
On gradually diminishing the current,	55·25	55·4	55·65	55·8	55·9	56·1
On gradually increasing the current,	54·8	54·8	54·85	55·0	55·4	56·1
Differences,	·45	·6	·8	·8	·5	·0

We thus see that the rod tends to persist in the elongation it acquired in first passing the maximum current, for it does not retract in proportion to the diminished strength of this current; and the experiments show that even when the current is so far diminished in strength that it would, if suddenly thrown through the helix, be unable to elongate the rod sufficiently to be measurable, yet this feeble current holds the rod elongated ·45 of a division in the second series of experiments, but on breaking the circuit the rod instantly retracts ·45 of a division in the second series of experiments and ·65 of a division in the first series, and regains the length it had before the current was passed around it.

On passing the current with the whole of the fine wire in the circuit, we have, in the first series of experiments, an elongation of ·05 of a division, but on making the circuit without the interposed fine wire, we have an elongation of 1·3 divisions; and if we now do not break the current, but gradually diminish its strength by increasing the interpolar resistance, we find that when the whole of the fine wire is again in the circuit that the elongation is yet ·65 of a division: whereas when the circuit was at once formed with this same interposed resistance the rod was elongated only ·05 of a division.

The discovery of this most remarkable phenomenon was contained in the above experiments, but to be sure that my experiments should not mislead me, I repeated them several times, using every precaution to ensure their accuracy, and obtained results almost identical with those formerly observed. I am therefore confident that I have discovered a phenomenon worthy of minute study, and I purpose to make it the subject of a special investigation.

Unfortunately, during the above experiments, I did not make a parallel series of determinations of the magnetic intensities of the rod during the successive stages of passing a current of increasing and of decreasing strength. Yet I can hardly believe that the magnetic intensity will be kept up with the persistent elongation of the rod when it is slowly demagnetized, but I think that it will be found that the magnetic intensity of the rod depends alone on the strength of the current traversing the helix. The phenomenon indeed shows that the molecules of the rod, on its elongation by magnetization, having been forced into new positions, that either by what might be well called a "*magnetic set*"* or from molecular friction, the molecules retained these new positions with such persistence, that it required the sudden shock of the induced current, produced on breaking the circuit, to cause them to rush to their positions of stable equilibrium.

Effects observed on making and breaking separate currents in the component helices of the compound helix.

In these experiments two batteries were used. In the outer helix I made and broke a current from 16 cells, arranged four coupled and four in series. In connection with the inner helix, I used a battery of 25 cells, connected five in a row and five in series. The experiments are interesting as showing the effects

---

* The term "magnetic set," as appplied above, is from analogy an appropriate name for the phenomenon; but it cannot well be so applied, for Dr. Joule has already appropriated "magnetic set" as designating the residual magnetism an iron rod retains after its electro-magnetization.

of the induced currents formed on making and breaking the circuits in the various manners given in the following experiments.

(1.) Made circuit in inner helix, rod elongated 1·4 division.
" " " outer " " " ·25 "
Broke " " " " " retracted ·25 "
" " " inner " " " 1·4 "

(2.) Made circuit in outer helix, rod elongated 1·5 divisions.
" " " inner " rod suddenly retracted ·4 div., and then suddenly elongated ·4 division.
Broke circuit in inner helix, rod suddenly retracted ·4 div., and then suddenly elongated ·4 division.
Broke circuit in outer helix, rod retracted 1·5 divisions.

(3.) Made circuit in inner helix, rod elongated 1·4 divisions.
" " " outer " " " ·25 "
Broke circuit in inner helix, rod suddenly retracted ·35 division, then suddenly elongated ·35 division.
Broke circuit in outer helix, rod retracted 1·65 divisions.

(4) Made circuit in outer helix, rod elongated 1·5 divisions.
Made circuit in inner helix, rod suddenly retracted ·5 division, then suddenly elongated ·05 division.
Broke circuit in outer helix, rod retracted ·1 division.
" " " inner " " " 1·4 divisions.

On the times occupied in the elongations and retractions of a rod when the two component helices are joined as one helix, and placed in the circuit of one battery.

The determinations I here give were made with the eye and a chronograph, and although not as accurate as the interest of the research demands, yet are near enough to the truth to show that the subject is worthy of a careful investigation. The experiments given under the above heading and the succeeding one, give an insight into the *velocities* of the molecular motions, and therefore these determinations, taken in connection with the measures of the corresponding elongations and retractions, will be of considerable theoretic interest, when they have been determined with the precision which the following proposed apparatus will, in all probability, afford.

I thus propose to attack this problem. The mirror of the apparatus will be made of the minimum weight consistent with stability. The mirror will reflect a pencil of light from an electric lamp to a revolving glass disc coated with sensitized collodion. This converging pencil will form a dot of light on the disc and when the latter is stationary will, on the elongation of the rod, describe a portion of one of its radii, which will appear on developing the sensitized plate. If, however, the disc have an uniform and known rate of rotation, the dot will on the elongation of the rod, describe a curved line which, referred to the appropriate ordinates, will give not only the time of the motion of elongation, but also the mode or law of this motion. Of course the motion of retraction can be studied in like manner.

The following experiments were made on rod No. 3, of English refined iron, and each result is the mean of 50 experiments.

	Time of elongation.	Time of retraction.
(1.) 25 cells,	$\frac{1}{20}$th of a second.	$\frac{3}{10}$ths of a second.
(2.) one cell,	$\frac{3}{10}$ths " "	$\frac{1}{10}$th " "

It is thus seen that, with 25 cells, the duration of the retraction is six times as long as the duration of the elongation, but with a current from one cell the phenomena are reversed and the duration of the elongation is three times that of the retraction.

Determinations of the times occupied in the elongation and the retraction of a rod when the inner or the outer helix forms in itself a closed conductor, while the current is passed, in the respective cases, in the outer and in the inner helix.

(1.) Terminals of inner helix *not* joined. Current passed through the outer helix from 25 cells. Elongation of the rod 1·5 divisions. Times of elongation $\frac{1}{120}$th of a second. Times of retraction, $\frac{1}{4}$ sec.

(2.) Same result as above when the outer helix was open, and the current was passed through the inner helix.

(3.) The terminals of inner helix united; so that this helix formed a closed circuit in itself. Current from 25 cells passed through outer helix. Elongation, 1·5 divisions. Time of elongation, $\frac{2}{10}$ths of a second. Time of retraction, $1\frac{1}{10}$th seconds.

(4.) Same results as above when the terminals of the outer helix were united, and the current passed through the inner helix.

(5.) One cell used. When the terminals of the outer or inner helix were *not* united and the current passed respectively through the inner and outer helix, the elongation was 1·1 divisions. The time of elongation, $\frac{3}{10}$ths of a second. The time of retraction $\frac{2}{10}$ths of a second.

(6.) One cell used. The terminals of inner helix united. The elongation was 1·1 divisions. Time of elongation, $\frac{6}{10}$ths of a second. Time of retraction $1\frac{3}{10}$ths seconds.

(7.) Same result as experiment (6) when the terminals of outer helix were joined, and the current from one cell passed through the inner helix.

To observe a rod slowly retracting during 1·3 of a second was a most remarkable sight, and suggests many thoughts as to the interaction of the induced currents passing in the helices and rod. I may here venture to suggest that the study of these extraordinary phenomena—which I believe I have here first made known—will eventually be of some service in the study of induced currents. For the present, I am content with merely presenting *the facts*, for I have not yet been able to command the time which their investigation will require.

In experiments (3) and (6) the time of retraction was respectively $1\frac{1}{10}$ seconds and $1\frac{3}{10}$ seconds, and the slowness of these motions allowed me to obtain an insight into their character. In each of these experiments the rod retracted with a gradually diminishing velocity, and the motion reminded one forcibly of that pertaining to a body projected vertically upward.

The coefficients of elongation and of retraction of seven rods of different species of iron, and of three steel rods of various degrees of hardness.

It remains to give the determinations I have made of the coefficients of elongation and of retraction. Those measures were made on rods of circular sections, 60·1 inches long and ·5 inch in diameter. As previously stated, the iron rods were thoroughly annealed, and the steel rods were carefully tempered. On the ends of the rods, numbers were stamped, and these marks corresponded to the rods as follows:

1. ——— Scrap Iron.
2. ——— Ulster Iron.
3. ——— Norway Iron.
4. ——— English refined Iron.
5. ——— Low Moor Iron.
6. ——— Fall River Iron.

000. ——— Steel soft.
00. ——— Steel hardened and drawn to blue.
0. ——— Steel hardened and drawn to yellow.

The method of determining the coefficients was as follows: When the rod had attained a fixed temperature, so that the scale-reading remained constant for an hour, I recorded this scale-reading. I then passed the current from the 25-cell battery, and so soon as the new scale-reading then produced was read, I broke the circuit and obtained the corresponding scale-reading. These readings were now written in the note book, and immediately after recording them, I again made and broke the circuit and noted the two corresponding readings of the telescope-scale. I then continued making and breaking the circuit and recording the scale-divisions, until the rod began to elongate from the heat produced on demagnetization.

The tables I here present consist of six columns, A, B, C, D, E, and F. Under A are designated the rods; B contains the elongations or retractions produced on first passing the current;

C the retractions or elongations observed after the first made circuit had been broken; D the permanent elongations or retractions observed in the rod after the first circuit passed had been broken; E the elongations or retractions produced on making the second and subsequent circuits; F the elongations or retractions produced on breaking the second and subsequently formed circuits.

Table of the Elongations and Retractions of the Rods.

TABLE I.

Elongations and Retractions in Units of the Telescope-scale.

A. Rod.	B. 1st make-circuit.	C. 1st break-circ'it.	D. Permanent *e* or *r*	E. 2d make-circuit.	F. 2d break-circuit.
1	1·25 *e*†	·75 *r*	·4 *e*†	·7 *e*†	·7 *r*†
2	1·6 *e*	1·2 *r**	·4 *e*†	1·2 *e*	1·2 *r*
3	2·0 *e*	·9 *r*	1·1 *e*	1·4 *e**	1·4 *r**
4	2·5 *e**	1·15 *r*	1·35 *e**	1·15 *e*	1·15 *r*
5	1·65 *e*	·6 *r*†	1·05 *e*	1·0 *e*	1·0 *r*
6	1·4 *e*	·85 *r*	·55 *e*	·9 *e*	·9 *r*
000	·8 *e**	·6 *e**	1·4 *e**	·25 *r*	·25 *e*
00	·25 *r*	·5 *e*	·25 *e*	·5 *r**	·5 *e**
0	·4 *r*†	·25 *e*†	·15 *r*†	·2 *r*†	·2 *e*†

TABLE II.

Elongations and Retractions in Fractions of an inch.

A.	B.		C.		D.		E.		F.	
1	·0001375	*inch*	·0000825	*inch*	·000044	*inch*	·000077	*inch*	·000077	*inch*
2	·000176	"	·000132	"	·000044	"	·000132	"	·000132	"
3	·000220	"	·000099	"	·000121	"	·000154	"	·000154	"
4	·000275	"	·0001265	"	·0001485	"	·0001265	"	·0001265	"
5	·0001815	"	·000066	"	·0001155	"	·000110	"	·000110	"
6	·000154	"	·0000935	"	·0000605	"	·000099	"	·000099	"
000	·0001168	"	·0000876	"	·0002044	"	·0000365	"	·0000365	"
00	·0000365	"	·0000730	"	·0000365	"	·0000730	"	·0000730	"
0	·0000584	"	·0000365	"	·0000219	"	·0000292	"	·0000292	"

TABLE III.

Coefficients of Elongations and of Retractions.

A.	B.	C.	D.	E.	F.
1	·000002288 *e*†	·000001377 *r*	·000000732 *e*†	·000001281 *e*†	·000001281 *r*†
2	·000002928 *e*	·000002196 *r**	·000000732 *e*†	·000002196 *e*	·000002196 *r*
3	·000003660 *e*	·000001647 *r*	·000002013 *e*	·000002562 *e**	·000002562 *r**
4	·000004575 *e**	·000002105 *r*	·000002471 *e**	·000002088 *e*	·000002088 *r*
5	·000003019 *e*	·000001098 *r*†	·000001921 *e*	·000001830 *e*	·000001830 *r*
6	·000002562 *e*	·000001555 *r*	·000001006 *e*	·000001647 *e*	·000001647 *r*
000	·000001943 *e**	·000001457 *e**	·000003400 *e**	·000000607 *r*	·000000607 *e*
00	·000000607 *r*	·000001212 *e*	·000000607 *e*	·000001212 *r**	·00001212 *e**
0	·000000972 *r*†	·000000607 *e*†	·000000364 *r*†	·000000486 *r*†	·00000486 *e*†

* Maximum. † Minimum.

After the quantities given in the columns, I have written *e* to designate the *elongation* of the rod, and *r* to indicate its *retraction.*

I have given the measures in three tables. Table I contains the elongations and retractions in the actual scale units. It is here to be remembered that one division of the scale equals 0·00011 of an inch for the experiments on rods No. 1 to No. 6 inclusive; while for the remaining rods 000, 00, and 0, one division of the scale equals 0·000146 of an inch. Table II gives the elongations and retractions of Table I expressed in fractions of the inch of "Troughton's scale."*

Table III contains the coefficients calculated from the numbers given in Table II.

Certain numbers of the tables are followed by * or by †; * indicates the maximum effect observed in the iron, or in the steel rods, corresponding to the phase of experiment given in the heading of the columns of Table I, or as subsequently designated by A, B, C, D, etc. An examination of the tables shows that the maxima and minima effects, in the case of the iron rods, are very irregularly distributed. Thus, corresponding to the "first make-circuit," we find that rod No. 4 gives the maximum, while rod No. 1 the minimum. On the "first break-circuit," rod No. 2 is the maximum, while rod No. 5 is the minimum. For the "permanent elongation," rod No. 4 is the maximum, and rods No. 1 and 2 are the minima. In the two columns corresponding to "second make-circuit" and "second break-circuit," we see that rod No. 3 gives the maximum effect observed, while rod No. 1 gives the minimum.

The phenomena of Elongation and Retraction observed in Rods of Steel.

The phenomena observed in the magnetization and demagnetization of the rods of steel have not been referred to. Here we have presented to us remarkable results. On first passing the current around rod 000, of soft steel, it elongated ·8 of a scale-division, behaving like a rod of soft iron; but, on breaking the circuit, to my astonishment, it again *elongated* ·6 of a division, thus leaving this rod with a permanent elongation of 1·4 divisions; and this elongation exceeds the permanent

---

* "Two copies of the new British Standard, viz., a bronze standard, No. 11, and a malleable iron standard, No. 57, have been presented by the British government to the United States. A series of careful comparisons,—made in 1856, by Mr. Saxton, under the direction of Dr. Bache,—of the British bronze standard No. 11, with the Troughton scale of 82 inches, showed that *the British bronze standard yard is shorter than the American yard by* 0·00087 *inch.* So that in very exact measures with the yard-unit, it is necessary to state whether the standard is of England or of the English feet."

"Lecture Notes on Physics," by A. M. Mayer, p. 12. Van Nostrand, New York. 1868."

elongation given to any of the soft iron rods when similarly experimented on. On passing the current around the rod, *for the second time*, the soft steel rod again did not act like a rod of iron, for it *retracted* ·25 of a division instead of *elongating*, as did the rods of iron in like circumstances; and on breaking this circuit the rod *elongated* ·25 of a division, instead of retracting; again exhibiting a phenomenon the reverse of those observed in the rods of iron; and it is here important to remark, that *all* of the steel rods behaved in the same manner on the making and breaking of the second and subsequently formed circuits.

The results just described differ from those obtained by Dr. Joule. Referring to his memoir (Phil. Mag., vol. xxx, p. 85), we find that experiments on a rod of soft steel, one yard long and a quarter of an inch in diameter, showed that the rod elongated on first passing the current; but on breaking this circuit, the rod *retracted*, while in my experiments, the rod again *elongated* on breaking this circuit. Indeed, the experiments of Dr. Joule indicate that a rod of soft steel behaves like one of iron, except that the elongations and retractions are of less extent than in the case of an iron rod. It is important, however, to observe that Dr. Joule did not, in his first experiment on this rod, pass around it a current sufficient to "saturate" it, but gradually increased the intensity of the current in successive experiments; and it is to be remarked, that as the intensity of the current increased, the retractions and elongations came nearer and nearer to equality, but in no instance did he observe a *retraction* on passing a current and an *elongation* on its cessation.

In his subsequent experiments, Dr. Joule worked on a steel rod of the same dimensions as that used in his former experiment, but it was "hardened to a certain extent throughout its whole length, but not to such a degree as entirely to resist the action of the file." On *first* passing the current, and also in subsequently passing the current with successively increased intensities, he obtained results similar to those I observed in the rod of soft steel, but with this rod also he never observed a *retraction* on making a circuit, and an *elongation* on breaking it. The fact that so eminent an investigator as Dr. Joule obtained, on *first* passing a current around a bar of soft steel, results similar to those obtained by me with my bar of soft steel, leads me to suspect that the rod I experimented on may have retained some degree of "hardness" after it had been annealed; but even this fact granted, does not explain why *all* the steel rods I experimented on gave *retractions* on passing the current a *second* time after they had been "saturated" during the *first* passage of the current.

Examining the results of my experiments on rod 00, of hard steel "drawn to blue," we see that the phenomena are exactly the reverse of those occurring in rods of iron in the same circumstances, except in this one particular, viz., that after breaking the first made circuit the rod is permanently *elongated;* and this result agrees with all of those obtained by Dr. Joule.

The experiments on rod 0, of hard steel "drawn to yellow" are noteworthy. On making the *first* circuit, this rod *retracted* ·4 of a division, and on breaking this circuit, the rod elongated, but only ·25 of a scale division, thus leaving the rod permanently *retracted* ·15 of a division; so that this rod of hard steel, which after the experiment remained a powerful magnet, is *shorter* than it was before it was magnetized. On passing the second current around this rod, it, like the two preceding rods, *retracted* ·2 of a division, and on breaking this circuit, it elongated by the same quantity, so that after the second and subsequent passages of the voltaic current, it persisted in the retraction it received after the first made circuit was broken.

The experiments I have just given on rod 0, differ in every particular from any obtained by Dr. Joule, on rods which were *not subjected to tractile strain.* I cannot but regret that this eminent physicist did not experiment on rods of very hard steel freed, as far as possible, from all strains; for then my experiments would have been strictly comparable with his. The experiments which Dr. Joule made on rods of hard steel (except those I have already quoted) were conducted on rods subject to tractions going from 80 ℔s. up to 1,030 ℔s., while my experiments were made on rods so supported by brass springs, that only a fraction of their weight was supported by the Vs on which their ends rested.

Referring to Dr. Joule's experiments on a "soft steel wire, one foot long, a quarter of an inch in diameter, tension 80 lbs," we find that this rod behaved like one of soft iron, free of strain, with currents deflecting his galvanometer 34° 40′ up to 56° 30′; but with currents below 34° 40′ no action whatever was observed to take place in the rod, except its magnetization; but when the same rod was subjected to a tension of 462 ℔s., and a current of 60° 15′, it behaved like my horizontally suspended steel rod 00; that is, it retracted on making the circuit, but it elongated more than it had previously retracted when this circuit was broken. With a tension of 1,680 ℔s. the rod retracted and elongated by equal amounts on making and breaking the circuits. In Dr. Joule's experiments on a "hardened steel wire" one foot long, a quarter of an inch in diameter, tension 80 ℔s., he observed no effect until the current reached an intensity of 45° 40′; then this rod also elongated and retracted by equal quantities on making and breaking the circuits. With a tension of 408 ℔s. and of 1030 ℔s., this rod behaved in the same manner, but the elongations and retractions did not begin to show themselves with the respective tensions until the currents had respectively reached the intensities of 60° 20′ and 48° 33′. Summing up these results, Dr. Joule states: "From the above experiments, we find that the induction of permanent magnetism produces no sensible effect on the length of a bar of perfectly hardened steel, and that the temporary shortening effect of the coil is proportional to the magnetism multiplied by the current traversing the coil. The shortening effect does not in this case sensibly increase with the increase of the tension." We have no reason to doubt the truth of this statement when applied to rods subject to tension, but my experiments show that when the rod 000, of soft steel, and the rod 00, of hard steel "drawn to blue," were not subject to such strains, and indeed freed, as far as possible, from all strain, they were *permanently elongated* after they had received their permanent magnetism; and also, that the rod 0, of hard steel "drawn to yellow," had a *permanent retraction* given to it with its permanent magnetic change.

My experiments have been made with such conscientiousness, that at present I am not able to doubt the reality of these effects; but they should be repeated on fresh bars, and this I intend to do at some future day.

It is important that I should here call attention to the fact, that the coefficients I have given in the appended tables are derived from measures on only *one* rod of each species of metal; and it may be that a considerable range in the elongations and retractions may be found in rods made of the same kind of iron or of steel. I hope to be able to present a new series of determinations of these constants, to be made with the apparatus already described, which employs the displacements of Newton's rings as a means of measuring the changes in the longitudinal and transverse dimensions of the rods.

When it is considered that the greatest motions, which have been the objects of my study, have their existence in the space of $\frac{8}{10000}$ths of an inch, while the smallest space within the limits of visibility of the most powerful microscope, being only $\frac{3}{200000}$th (or ·000005) of an inch, and furthermore, when it is known that the last mentioned quantity equals the change in length of one of the rods caused by a variation of temperature of only $\frac{7}{1000}$ths of a degree Centigrade, the difficulties I have conscientiously met and surmounted in this delicate research become manifest; but the very knowledge of those difficulties has tempered with modesty the confidence I feel in my work, and I will gladly accept any correction my measurements may receive from more experienced hands.

ART. XIV.—*On some resuts of the Earth's Contraction from cooling;* by JAMES D. DANA. Part IV, *Igneous Ejections, Volcanoes.*[*]

IV. IGNEOUS EJECTIONS, VOLCANOES.

THE direct connection of igneous ejections with the movements resulting from the earth's contraction has been briefly illustrated in the course of the remarks on mountain making.[†] It is apparent, without further discussion, that regions of great disturbances embrace the regions of great igneous ejections; that the oceanic slopes of the border mountains, especially around the Pacific, the greater ocean, have been preëminently subject to such eruptions; and that in Tertiary times, when the earth's crust was becoming too stiff to bend much before the lateral pressure, profound fractures, instead of flexures, were a common result of its action, igneous outflows were most extensive, and volcanoes were of increased size and numbers.

The questions remaining are—

(1.) Does the mobile rock owe its mobility in all cases, or any, to the movements of the rocks under lateral pressure—motion transformed into heat being its source, in conformity with the views ably set forth by Mallet?

(2.) Is the ejecting force in eruptions a result of the same lateral pressure?

1. *Source of igneous fusion.*[‡]—The suggestion of Prof. Hopkins, with regard to the earth's interior, which has been sustained on a preceding page,[§] offers for the source of igneous

---

[*] For Part I, see vol. v, p. 423; II, vol. vi, p. 6; III, vol. vi, p. 13.

[†] This Journal, v, 433, 441, vi, 8, 10.

[‡] I say nothing here on the nature or the degree of igneous fusion in plastic rock, as this is foreign to the subject under discussion.

[§] Prof. Hopkins's argument from the amount of precession and nutation, in the Trans. Roy. Soc., 1839, 1840, 1842, led him to the conclusion that "the thickness of the solid shell could not be less than about one-fourth or one-fifth of the radius of its external surface." In his paper in the Report of the British Association for 1847, he repeats his conclusion, and then considers the possible steps in the process of refrigeration. Among the different conditions discussed he supposes as one (the one he favors) the temperature of fusion to be increased much by the pressure—at a rate much more rapid than "1° F. for an increase of pressure equivalent to about five atmospheres," and adds that then "we should probably have the condition under which solidification would commence at the center. In this case, after incrustation had begun at the surface, the earth would consist of a solid central nucleus and a solid shell with fluid matter between them, as already explained, till the solidification should be complete." He then remarks, with regard to the present state of our globe, that "under the condition here assumed, with the observed rate of increase of terrestrial temperature in descending, there could be no reasonable doubt of the earth's entire solidity." He next treats more in detail of the process of solidification, and says, having in view the several conditions discussed, that "the incrustation may have constituted the very first step in the solidification, or it may have taken place after the formation of a solid ejections the old one of viscous rock underneath the earth's crust; but viscous rock at first as a layer, and later as remnants of the same layer, left after the long cooling. This author suggests that these isolated or detached portions may be the source of modern volcanic eruptions, and this view is favored by Scrope, the eminent vulcanologist.*

The theory does not require that the isolated fire-lakes should exist now at the depth of the original viscous layer, for in the movements and flexures of the crust, and the opening of fissures for the escape of the mobile rock, great regions of it may have been pressed up and become isolated fire-lakes at a higher level. Or, as Prof. Hopkins suggests, the subterranean sources of volcanic action may have been in shape like inverted cones extending far up into the crust, and may have finally been divided off into "smaller ones by a process similar to that by which the larger cavities were themselves formed from the general fluid mass, the position of each minor cavity being determined by the points in the roof of the larger one, where previous fractures had left the most perfect volcanic vents." This last explanation holds if regions of volcanic vents date back to early geological time, so that modern volcanoes in an area are successors to indefinitely older ones; but is less applicable where the vents of a region are of Cænozoic origin (as appears to be true of most of them), and a consequence of the later movements of lateral pressure.

The inference that igneous eruptions have generally been derived from a deep-seated source is sustained by the great lithological uniformity of ejections over widely distant ranges of surface. The eruptive rocks (or trap) of the Triassico-Jurassic areas of the Atlantic border, from Nova Scotia to the Carolinas, already many times referred to,† all which belong to

---

nucleus surrounded by a superficial fluid envelope, according as the solidification began at the surface or center; but in either case, as I have already intimated, the superficial crust when first formed must necessarily have reposed on a fluid mass beneath." He next explains his views as to the formation of the crust, and the final obliteration of the viscous layer; and states, with reference to volcanoes, "By a continuation of this process it is obvious that the superficial crust of our globe must at length arrive at what I conceive, for reasons above assigned [in a paragraph on p. 33 speaking of the isolated sources of volcanoes], to be its present condition, that of a solid mass containing numerous cavities filled with fluid incandescent matter, and either entirely insulated or perhaps communicating in some cases by obstructed channels." These cavities are made the sources of the material of volcanic eruptions.

* Volcanos, 2d ed., 8vo, 264, 268.

† These hills and dikes of "trap" (as they are ordinarily called) have great length and breadth in Nova Scotia. In the Connecticut valley they are very numerous, and in many lines,—as laid down, especially for Connecticut, by Percival in his Geological Report. A copy of a part of his very accurate detailed map of the trap region is reproduced in the writer's Manual of Geology, page 20. At the east and west bend in the dikes, south of the middle of the map, are the Hanging Hills of Meriden, 900 to 1,000 feet high, situated about 20 miles north of New Haven

one epoch, are solely varieties of dolerite: rocks made up essentially of labradorite and pyroxene, with more or less of magnetic iron ore in disseminated grains or crystals. Analyses have shown that the trap of this region in Connecticut and New Jersey is essentially identical in constitution; and an examination and determination of the density of specimens of the same rock from North Carolina and Nova Scotia leave no doubt that it is fundamentally alike throughout. The aspect of the ordinary specimens from these widely distant regions is closely the same, and the density varies little from 3. The dolerite of East Rock, New Haven, Conn., gave Professor G. J. Brush for the specific gravity 3·09—3·085; from West Rock, ib., 3·045—3·07; from the vicinity of Raleigh, North Carolina (a specimen received by the writer from Prof. Kerr of Raleigh, and not distinguishable by the eye from an East or West Rock specimen), 3·16. Prof. Cook of New Jersey obtained for the dolerite of the Palisades (Geol. Rep. N. J., p. 215), 2·94. Prof. H. How gives the writer for a similar variety from Nova Scotia, 2·94. Complete analyses have not been made of many of these rocks. The following are analyses of the West Rock (New Haven) dolerite and that of the Palisades, New Jersey (70 miles west of West Rock), the former by W. G. Mixter, Assistant Chemist in the Sheffield Scientific School, and the latter by Prof. G. H. Cook, of the New Jersey Geological Survey.

	S̈i	Ä̶l	Ḟe	Ṁg	Ċa	K̇, Ṅa	ign.	
1. West Rock,	52·37	12·31	13·13	6·03	10·74	2·62	0·94	= 98·14
2. Palisades,	53·9	17·5	8·0	10·3	8·0	[2·3]	----	=100

There are variations in the dolerite of the regions above referred to, depending on the proportion of the feldspar, and also on the presence of water. But they occur in various parts of the several regions, instead of characterizing any one of them. The dolerite of dikes in East Haven, Conn.—the town adjoining New Haven on the east—diminishes in luster as the dike is more remote from the New Haven line; and in

(and 12 miles from the southern margin of the map); and the range which extends from these hills north continues to Mt. Tom, near Northampton, in Massachusetts. The range to the east, south of this bend, continues southward to Lake Saltonstall, east of New Haven. Other lines cut through the metamorphic rocks; one of these lines of trap ejections in the eastern metamorphic region of Connecticut, as mapped by Percival, extends from Long Island Sound, six miles east of New Haven, nearly to the southern boundary of Massachusetts, over seventy miles, with a nearly east-northeast trend, consisting of an interrupted series of dikes, intersecting metamorphic rocks of various kinds. A second independent Triassico-Jurassic trough exists in Connecticut, 15 to 20 miles west of the main one, over part of the towns of Southbury and Woodbury; and this also has its numerous trap dikes. The Palisades of New Jersey, bordering the Hudson River, are the northern part of a complex series that continues southward and westward through New Jersey and Pennsylvania into Virginia, following the course of the Triassico-Jurassic sandstone areas. There is also a series in the North Carolina area.

the ridges near Saltonstall Lake, two miles distant, it is faintly glistening, and of somewhat less hardness, and, although generally solid throughout, it is in some parts vesicular (amygdaloidal). A precisely similar rock in all its characters occurs among the trap hills (dolerite) of Meriden, called the Hanging Hills, and part of it is amygdaloidal. The same is found also in Nova Scotia. An examination of a specimen from the vicinity of Saltonstall Lake, by Prof. O. D. Allen, shows the presence of 4·53 per cent of matter driven off on ignition, after deducting the hygroscopic moisture (0·60). It indicates the presence of some hydrous mineral (chlorite apparently), in place of part of the augite or feldspar. But the percentage of silica is 49·88, 50·10, according to two determinations by S. T. Tyson of the Sheffield Scientific School laboratory, and thus differs but little from that of the anhydrous dolerite of West Rock and the Palisades; the proportion is less instead of greater. There is hence a close similarity to the other dolerite, notwithstanding the presence of water.

Since the dikes of this hydrated dolerite occur as parts of the same series as the others, and in the same regions, and are of the same epoch and system of ejections, and moreover are exceptional instead of the prevailing kind, it is apparent that the hydrous character is owing to some exceptional condition attending or subsequent to the eruption. The source of liquid rock was all one, and the material must therefore have been essentially one in kind; it could not have been locally hydrous. Portions of the erupted viscid material might have encountered water on the way to the surface, and thus have become penetrated with it;* so that the viscid material at the high temperature became altered in part—some of its augite to chlorite, and perhaps some of its feldspar, with the lime of the augite, to zeolites, etc. Or else, this kind of change may have taken place through infiltrating waters. The fact that the *vesicular* trap (now amygdaloidal), is that which is hydrated, renders it rather probable that while zeolites and calcite may have been later made within the rock by superficial action or

---

* On this taking in of moisture by liquid rock, Mallet, speaking of the lava in the conduit of a crater, makes the following remarks: "Within a few years it has been proved that capillary infiltration goes on in all porous rocks to enormous depths, and that the capillary passages in such media, though giving free vent to water—and the more as the water is warmer—are, when once filled with liquid, proof against the return through them of gases or vapors. So that the deeply seated walls of the ducts leading to the crater, if of such material, may be red hot and yet continue to pass water from every pore (like the walls of a well in chalk), which is flushed off into steam that cannot return by the way the water came down, and must reach the surface again, if at all, by the duct and crater, overcoming in its way whatever obstructions they may be filled with. And this remarkable property of capillarity sufficiently shows how the lava—fused below or even at or above the level of infiltration—may become interpenetrated throughout its mass by steam bubbles, as it usually but not invariably is found to be."

infiltrating waters, the chief change was cotemporaneous with the eruption; for the vesicular character was undoubtedly then produced, and it was probably dependent on the same moisture that, penetrating the rock, caused the metamorphism or hydration through the mass. Bunsen, in his well known paper on the igneous rocks of Iceland,* gives various facts illustrating this kind of metamorphism yielding chloritic and zeolitic minerals.

There is hence nothing in the relations of the different kinds of dolerite in the Connecticut valley or any part of the Triassico-Jurassic regions of the Atlantic slope, either as to geographical position or chemical composition, that favors the idea of difference of original subterranean source.

Now such a similarity of product occurring at intervals over a region 1,200 miles long, and in several parallel lines, shows some unity of origin. It evinces that the source must have been either the under-crust fire-sea, like the under-Appalachian as we have termed it, derived from the old viscous layer; or else plastic masses within the true crust, which crust, as it was made from the viscous layer by cooling, would have had like uniformity of mineral constitution.

This example of igneous eruption is grand in scale, since the outflows are from tappings along a line more than a thousand miles long; and it may therefore serve well to test the general application of theories of igneous eruptions. It indicates that the original fire-sea was one of great extent.

Professor T. Sterry Hunt, in his paper on "The probable seat of volcanic action,"† and others of earlier date, while adopting the view of a nucleus made solid by pressure and of an exterior crust, with a viscid layer between, has proposed to substitute for the viscous layer recognized as the source of volcanoes by Hopkins, one made by the "aqueo-igneous fusion" of part of the lower sedimentary beds of the supercrust.‡ The alleged cause of such fusion is (1) pressure due to the accumulation of superficial sedimentary beds; (2) increase of heat, by a rise of the isogeothermals—another effect of the same cause; and (3) the presence of moisture, a common feature of sediments: the moisture becoming, under the heating, super-heated vapor, and so aiding by its great dissolving power in the result.

---

* Pogg. Ann., lxxxiii, 197–272, 1851. The secondary origin of the zeolites and chlorite found to penetrate some dolerite and other kinds of igneous rock, as well as filling the cavities within them, I sustained in an article in vol. xlix of the first series of this Journal (1845); and the various facts I have since observed have tended to confirm me in the conclusion. In the paper referred to, I attribute the change to infiltrating waters. The opinion has many advocates.

† This Journal, II. l, 21, 1870.

‡ I use the term supercrust as it is explained on page 12, that is, for the part of the crust made by the action of exterior agencies over the outer surface of the true crust, the true crust being the part that was formed directly from cooling.

In a later article * he says: "I have taken pains [in former papers] to explain that the deeply buried layers of sediment, together with the superficial and water-impregnated portions of the solid nucleus, constitute a softened or plastic zone from which all plutonic and volcanic rocks proceed, and which allows of the movements observed in the solid crust."

It will be perceived that the hypothetical viscous layer of Hunt lies between a rind made out of sedimentary formations and a solid nucleus which is at surface of sedimentary origin; and the viscous layer which Professor Hopkins regards as belonging to a stage in the process of solidification is supposed to have been closed up, or some way put "hors de combat."

This substitution appears to be quite unnecessary, and the process incapable of producing the result claimed. As has been already explained,† the pressure from the gravitation of sediments cannot produce the heat needed for the fusion, no more than it can cause the plications alleged to attend it. If then no fusion of sediments would have resulted from such a cause, there was no chance for the formation of the deep and extended plastic zone required to meet the demands of the grand system of oscillations the earth's surface has experienced. In fact, the conditions Prof. Hunt's hypothesis appeals to—that is, thick sedimentary accumulations, such as those of the Appalachian region,—are far too local for the production of so vast a plastic zone, even if fusion were a possible result of the accumulation.

Again, the facts mentioned on the preceding page give as positive a declaration against this origin of the material of igneous ejections through the fusion of sediments. The sedimentary strata along the Atlantic border, whether unaltered or metamorphic, deep-seated or superficial, vary every score of miles, and could not yield a uniform quality of fused material for the ejections. In the Connecticut Valley the metamorphic rocks from New Haven, Conn., to northern Massachusetts, a distance of a hundred miles, have *an east-northeast strike obliquely across the region of trap ejections*, and are, on the west side, chloritic mica slate, diabase, chlorite slate, argillite, mica schist, gneiss and other micaceous rocks of various kinds; and the Archæan (Azoic) rocks to the west, in Dutchess Co., N. Y., and in Connecticut west of Winsted, are diverse varieties of gneiss and granitoid gneiss, containing orthoclase and albite or oligoclase with quartz, and sometimes hornblendic, but as far as known without labradorite. Only wide diversity, not uniformity, could come from such varied material. Dolerite is, moreover, the last rock to be looked for from any of it, except it be from the diabase. For it has a low percentage of silica (46 to 52 per cent) and no free quartz, with 8 to 12 per cent of oxide of

---

* Geological Magazine, Feb., 1868.

† This vol., page 13.

iron, about as much of lime and also of magnesia, with very little potash or soda; and in these constituents there is comparatively little variation.

Hunt claims that the presence of moisture in many igneous rocks sustains the idea of derivation from the fusion of sediments, that is, from the fusion of rocks containing water. But it has been shown, (on page 107) that the cases of hydrated dolerite in the region referred to are local and exceptional, and that the ridges are so mixed up with those of the more common anhydrous dolerite, that all must have had one source. His argument would be of some weight if there were no source for the moisture except in the region of fusion. The hydrated rock, moreover, is shown to have the low percentage of silica which belongs to the anhydrous dolerite.

If subterranean fusion were somehow produced and a zone of mobile rock were thus made many scores of miles deep, with the material not simply plastic but of perfect liquidity, and the zone without obstructions in any part so that there could be tidal movements or at least free-flowing currents throughout it, then, if the material entered into fusion were as diverse as the rocks of the Atlantic border, there might be such a mixing up and chemical digestion of limestone and everything else, that the product would perhaps be doleritic—a rock low in silica (or basic). But these conditions are those of the earth's liquid envelope before and after refrigeration began, and of the viscous layer developed out of it, even, probably, to the basic character of the fused material; and further, they are what Hunt's method has no provision whatever for producing.

The facts afforded by other parts of the globe and other periods in its history, add force to this argument. A doleritic or basaltic character is the prevailing one among the igneous eruptions of all ages from Archæan time to the present, and of all continents and oceans. Whitney and Pumpelly have described basic or doleritic rocks of Lower Silurian age from the Lake Superior region, where they are the prevailing igneous rocks. Hunt has described and analyzed others, from Canadian localities, of the Laurentian, the Lower Silurian era and of later Paleozoic time. They are far the most abundant of the igneous products of the Tertiary and Quaternary over the Pacific slope. Similar facts might be cited from other continents.* More than three-fourths of true igneous rocks are probably of this nature. Hence, it is reasonable to pronounce such ejections manifestoes of some kind of community of origin in the earth's ejections, as well as announcements of the kind of ma-

---

* For comparison with the analyses on page 106, I add here others of the dolerite (trap) of (I) the Giant's Causeway, (II) Staffa, and (III) Färöe, by Streng (Pogg. Ann., xc, 110, 114, 1853), all of which are now supposed to be of Tertiary

terial that constitutes to a large degree the deeper regions of the crust.

There is, however, considerable diversity among true igneous rocks. Besides the prevalent doleritic iron-bearing kinds, including dolerite, peridotite, melaphyre, etc., to which the preceding observations relate, there are trachytic or feldspathic rocks whose constitution, especially in the case of the more siliceous varieties, comports with their origin from the fusion of granitic rocks or of sedimentary beds made of granitic material. They occur in the same regions in which doleritic dikes exist, as well as among volcanic products.

Such a composition does not, however, make it certain that the supercrust was their source, for true granite and gneiss and even quartzites occur constituting old Archæan terranes, and it may be that essentially the same kinds of rock are to some extent represented in regions of the infra-Archæan crust and even in the fire-seas.

Basaltic and trachytic rocks often occur so combined in a single volcanic mountain, that we seem forced to find some other explanation of their origin than that of the fusion of *unlike* sedimentary strata. As long since observed by von Buch at Teneriffe, the center of the mountain may be trachytic when the sides around are basaltic. I found a similar fact in a dissected volcanic mountain of western Oahu.* And at Mauna Loa, where the ejections are almost all basaltic, there are feldspathic lavas at the very summit of the dome about the summit crater. A sight of the boiling movements of Kilauea in 1840 led me to explain this association in volcanic moun-

---

origin; and another (IV), of an Archæan (Laurentian) dolerite from Grenville, Canada, by Hunt (Geol. Rep. Canada, 1863):

	I. G.=2·88.	II. G.=2·96.	III.	IV.
Silica	52·13	47·80	49·40	50·35
Alumina	14·87	14·80	14·62	17·35
Sesquiox. iron	----	----	----	12·50[1]
Protox. iron	11·40	13·08	16·27	----
Protox. manganese	0·32	0·09	----	----
Magnesia	6·46	6·84	5·86	4·93
Lime	10·56	12·89	10·34	10·19
Soda	2·60	2·48	2·28	2·28
Potash	0·69	0·86	0·34	0·69
Volatile ($\dot{H}$, etc.)	1·19	1·41	2·41	0·75
	100·22	100·25	101·32	99·04

[1] Hunt says the iron is protoxide, though determined under the form of sesquioxide in his analysis.

Lyell recognizes the occurrence of "trap" in all periods from the Laurentian to the present (Principles, chapt. vii); and Mr. S. Allport announces in a recent article (Geol. Mag., May, 1873) entitled "Tertiary and Paleozoic Traps," that he has nearly ready for publication the results of many investigations sustaining the view which he has "for some time maintained, as to the complete identity in composition and structure of eruptive rocks of widely separated geological periods."

* See on this subject the author's Geol. Report, Wilkes Exp. Exped., pp. 204, 269, 368, 372.

tains on the principle of *liquation*—the feldspathic material being the least fusible, and being therefore left at the center while the more fusible iron-bearing lavas were drawn off by the outbreaks through the different sides of the cone. The diversity, on this view, is not proof of diversity of origin

Again, the two kinds of igneous rocks occur on a majestic scale over the Pacific slope of the Rocky Mountains. The trachytic rocks there appear, as stated by Richthofen,* to be generally the older. Clarence King, in his description of the Shoshone Falls on Snake River, states that out of seven hundred feet in thickness of igneous rocks exposed in the bluff, the lower 300 feet are made up of trachyte, while the upper 400 are of basalt; and that a continuous field of igneous rocks, mainly basaltic at surface, stretches over the country of Snake River for three hundred miles or more. The outflows are of later date than the Miocene Tertiary. The fact of the very wide geographical distribution of the basalt on the Pacific slope appears to be good proof, as in the case of the dolerite of the Atlantic border,—but better because of the wider range of the ejections,—that the source of its material was not local, or dependent on the fusion of sedimentary strata. And if this be true of the basaltic rock, it is probably so also of the trachyte. Whatever doubt may exist, the general argument is made a demonstration by the fact explained,† that a vast undercrust fire-sea was a necessity in order that the great heavings and bendings of the earth's crust essential to mountain-making on the Pacific border should have taken place.

The conclusion arrived at militates not only with the theory of Hunt, but also to some extent with Mallet's, unless the latter is made to appeal to the *true crust* for the material to be fused by the motion attending mountain-making. The motion in the true crust, even in the catastrophic period of mountain-making, is very much less and slower than that which is experienced by the plicating strata above it, and must therefore be a much feebler source of heat and fusion. Still, under the fractures, and shovings, and crushings, which must at times take place, it should be sufficient; and, acting at infra-Archæan depths, it would give uniform results over wide areas, or on the other hand a degree of diversity. Unlike Hunt's hypothesis, Mallet gives a reasonable source for the heat occasioning fusion.

But the sufficiency of the method for all cases of igneous ejections may well be questioned. The subsidence ending in

---

* The Natural System of Volcanic Rocks, Mem. Calif. Acad. Sci., Vol. I, Part 2, 4to, San Francisco, 1868. The trachytes of Auvergne are similarly older than the dolerites of the region. But more recent trachytes occur in Italy, and the rock of modern eruptions in Iceland is trachyte.

† This volume, page 7.

the fissures and trap-ejections of the Atlantic slope from Nova Scotia to North Carolina was extremely slow, and probably nowhere exceeded 5000 feet; and it caused in the end only small displacements of the strata. In such a case as this, the motion would seem to be a wholly inadequate cause of the fusion and ejections. Moreover, if the dependence of the subsidence upon the existence beneath of a great region of mobile rock was a fact, as has been urged,* there was fusion enough without aid from this source.

Further, over the Pacific slope of the Rocky Mountains, the vast ejections in the Tertiary era appear to have had, as I have said, a natural source in an undercrust fire-sea, and the same *that was essential to all the previous oscillations of the crust;* and which, therefore, like that beneath the eastern border of the continent, *must have been continued on from the period of general fluidity.*

Moreover, these Pacific-border eruptions took place in connection with, or as a consequence of, only a slight geanticlinal uplift—that is, slight compared with the extent of the region, although adding 10,000 feet to the height of the Rocky Mountains, since the angle of slope made by it was not over fifteen minutes—and through simple fractures that were unattended by flexings or crushings of the region broken: conditions wholly incapable, it would seem, of generating the heat required for so vast an amount of subterranean fusion as the ejections indicate.

Again, both on the Atlantic and Pacific borders of North America, wherever the plications have been greatest, and the conditions, therefore, favorable for producing the largest amount of heat, there we find evidences of the profoundest metamorphism, and of the *least amount of fissure eruptions;* and, conversely, the regions of gentler plications and feebler metamorphism, or of none, are those of the most numerous fissures and most abundant igneous ejections. The Green Mountains are an example of the former; and the Triassico-Jurassic areas on the Atlantic border, or the Tertiary and Quaternary outflows on the Pacific slope, of the latter. The reverse should be true if the heat for the fusion were transformed motion; for fusion certainly requires a much higher temperature than metamorphism. The evidence appears to be decisive against the making of the vast undercrust fire-sea by this method.

On the other hand, as already stated, there are, in many countries, regions of siliceous trachytes whose ejections may well have come from the local fusion of common granite and the allied schistose rocks, or of sedimentary strata of like composition.

---

* This volume, page 7, and beyond.

Mallet's theory presents us with a true cause; but what are the limits of its action it is very difficult to decide. It relieves the theory of local fire-seas as derivative from the old viscous layer of the chief objection urged against it—that such isolated fire-regions could not long exist surrounded by cooled rock; for, if inadequate to make great undercrust fire-seas one or more thousand miles in length, like the Appalachian, the cause may be sufficient through the generated heat to keep the old fire-seas in prolonged existence.

2. *What are igneous rocks?*—From the preceding discussion we derive an idea of the distinction between eruptive and metamorphic rocks. Since the larger part of eruptive rocks have come from the infra-Archæan region—either the true crust, or the fire-seas within or below it—they are igneous in all their history, and in no sense metamorphosed sediments, whether derived from a second fusion of the rocks where they originated or not.

Again, the plastic rock-material that may be derived from the fusion or semi-fusion of the supercrust, (that is, of rocks originally of sedimentary origin,) gives rise to "igneous" rocks often not distinguishable from other igneous rocks, when it is ejected through fissures far from its place of origin; while crystalline rocks are simply *metamorphic* if they remain in their original relations to the associated rocks, or nearly so.

Between these latter igneous rocks and the metamorphic there may be indefinite gradations, as claimed by Hunt. But if our reasonings are right, the great part of igneous rocks can be proved to have had no such supercrust origin. The argument from the presence of moisture or of hydrous minerals in such rocks in favor of their origin from the fusion of sediments has been shown to be invalid.

3. *Source of the ejecting force.*—When the fractures of the crust giving exit to fissure eruptions are a direct sequence to a long continued subsidence—as, for example, in the case of the Triassico-Jurassic eruptions of the Atlantic border,—there can hardly be a doubt that the lateral pressure causing the subsidence contributed also to the ejection of the plastic rock from beneath. And as the great fissurings of the crust are in all cases incidents in the working of lateral pressure, it is unsafe to deny that this cause has not aided in the great majority of eruptions in non-volcanic regions.

Another cause of ejection appealed to is pressure from the vapors imprisoned in the regions of fused rock. It must have often given efficient aid. But such vapors may not exist to the extent sometimes supposed about the deep sources of the material of fissure eruptions. Non-volcanic igneous rocks are usually solid throughout, without the minutest vesicle, and similar complete compactness characterizes many fissure ejections even of volcanic regions, when they have taken place at a considerable distance from the volcanic vent.* This would hardly be so generally the fact if vapors were abundant about the sources of the ejected material, for such vapors would imply the existence in the mobile rock itself ordinarily of vaporizable ingredients capable of easy vaporization under the pressure there existing. The fact seems to be that the great pressure is in the way of vaporization of the sulphids that may exist in the plastic material; for pyrites is often found in the solid basalt. And, further, the deep-seated sources of igneous rocks must be mostly or wholly below the regions accessible to moisture; for if not they would show its presence by hydration and frequently a vesicular structure.

Volcanoes, in their states of *ordinary* activity and eruption, do not appear to be dependent on the lateral pressure in the earth's crust. As I have long since urged, sustaining the view of Prévost, the force engaged is chiefly pressure from the expansion of vaporizable material rising with the lava. Besides this, there is the hydrostatic pressure of the liquid column raised in the conduit through the expanding vapors. The want of sympathy between the summit crater of Mauna Loa, nearly 14,000 feet in elevation, and the larger crater of Kilauea on the flanks of the same broad mountain only 4000 feet above the sea, I have adduced as evidence that the ordinary volcanic action was here due to movements in the upper parts of the lava columns, probably to portions extending little below the sea-level, and that these volcanoes were therefore mainly dependent for their various phases on the freshwaters precipitated over the mountain slopes. The waters of the ocean take their part in such action; but they are not in Hawaii the chief source of activity.† The effects of hydrostatic pressure have been exemplified in the same volcanic mountain, not only in fractures of the mountain, but also in majestic fire-fountains, in which the lavas were thrown to heights from 100 to 700 feet.‡

Another Part, on the formation of the Continental plateaus and Oceanic depression, will finish this memoir.

---

* It is a great, though common, mistake to suppose that volcanic ejections are slags or scoria. The surface of an outflow is often of this character for a depth of six inches or perhaps a foot. But below this, the layer is usually a compact stony mass with nothing slag-like except that it is somewhat vesicular. About Hawaii part of the rock is as solid and free from vesicles as the dolerite of the Connecticut Valley.

† See further on these points the author's Expl. Exp. Geol. Report, and also various articles in this Journal. Mallet's memoir, already often referred to, has excellent observations on this subject, as on others connected with volcanic action.

‡ This Journal, II, xiv, 219, 254, 1852.

ART. XV.—*Researches on the Hexatomic compounds of Cobalt;*[*] by WOLCOTT GIBBS.

IN the joint memoir of Genth and myself on the ammonia-cobalt bases it was stated that Xanthocobalt is not the only product of the action of nitrous acid gas upon ammoniacal solutions of cobalt. A further investigation of this and other related subjects was then promised. I propose now to resume the study of this class of compounds from the standpoint of the chemistry of the present day. The progress of science has rendered necessary the abandonment of my former theoretical views, as well as the adoption of the new notation. It has also, as I shall endeavor to show, lent a peculiar interest to the study of the ammonia-metallic bases.

In studying the action of the alkaline nitrites upon salts of cobalt, or upon those of the different series of ammonia-cobalt compounds, a principal difficulty arises from the varying nature and relative proportions of the products obtained under various conditions of temperature, concentration of solutions employed and duration of action. I have endeavored to cover the whole ground as completely as possible.

1. *Action of ammonia and ammonic nitrite upon a solution of cobaltic chloride and ammonic nitrate.*—When a warm solution of cobaltic chloride, $CoCl_2$, is mixed with ammonic nitrate, and then with a solution of ammonic nitrite, containing much free ammonia, the solution soon becomes deep orange, and after 24 hours deposits orange-brown crystals in large quantity. The mother liquor of these crystals is olive-green. By re-solution in hot water containing a few drops of acetic acid, and filtration, beautiful orange-yellow needles may be obtained as this filtrate cools. The crystals are perfectly free from chlorine and represent the nitrate of a new series of ammonia-cobalt salts, the formula of the salts being

$$Co_2(NH_3)_8(NO_2)_4(NO_3)_2.$$

The formation of this salt is accompanied by an absorption of oxygen from the air and may be expressed by the equation:

$$2CoCl_2+2NH_4 . NO_3+8NH_3+4NH_4 . NO_2+O=Co_2 (NH_3)_8(NO_2)_4(NO_3)_2+4NH_4Cl+2(NH_4)_2O.$$

2. *Action of a mixture of ammonia and potassic nitrite upon cobaltic sulphate.*—When cobaltic sulphate is dissolved in water and a mixture of ammonia and potassic nitrite is added, the liquid speedily becomes brown upon the surface, and after a few hours orange-yellow crystals form upon the bottom and sides

---

[*] Being Part II of Researches on the Ammonia-cobalt bases, by Wolcott Gibbs and F. A. Genth.

of the containing vessel, while a green flaky matter is at the same time deposited. When large quantities of material are operated upon, the complete oxidation requires several days. On filtering, a bright green mass mixed with orange-yellow crystals remains upon the filter; the filtrate is olive-green, and on standing often deposits small brilliant orange-yellow scales. If the mass on the filter is treated with hot, very dilute, sulphuric acid, it instantly becomes bright orange and on boiling dissolves. The solution then deposits on cooling a splendid salt, which has the formula

$$Co_2(NH_3)_8(NO_2)_4SO_4$$

and which is the sulphate corresponding to the nitrate already mentioned.

3. *Action of a mixture of ammonia and potassic nitrite upon cobaltic nitrate.*—When cobaltic nitrate is dissolved in water and a mixture of ammonia and potassic nitrite is added, the liquid speedily becomes brownish-orange, and after an hour begins to deposit bright orange-yellow crystals, mixed with a green flocky matter, precisely as in the case of the sulphate. By dissolving the orange-yellow crystals in boiling water, a few drops of acetic acid being added to prevent decomposition, a fine sherry-wine colored solution is obtained, which on cooling deposits crystals of two different forms, the larger portion being in octahedrons, the smaller in prismatic forms. By careful mechanical separation and recrystallization these crystals may be separated and the two salts obtained pure for analysis. In this manner I found the octahedral salt to be nitrate of Xanthocobalt, while the prismatic crystals are the nitrate of the octamin series above mentioned. In one experiment:

0·3833 gr. gave 0·1890 gr. $CoSO_4$ = 18·77 pr. ct. cobalt.

The formula of nitrate of Xanthocobalt, $Co_2(NH_3)_{10}(NO_2)_2(NO_3)_4$, requires 18·73 pr. ct.

0·7369 gr. gave 0·4050 gr. $CoSO_4$ = 20·92 pr. ct. cobalt.

The formula of the nitrate of the new series, $Co_2(NH_3)8(NO_2)4(NO_3)_2$, requires 20·99 pr. ct.

For greater certainty I made also a nitrogen determination in this nitrate:

0·5668 gr. gave 168·5 c.c. nitrogen at 13°·5 C and $756{\cdot}1^{mm}$ = 34·79 pr. ct. nitrogen.

The formula cited requires 34·88 pr. ct. The two salts were further readily recognized by their characteristic reactions. In my experiments the proportion of Xanthocobalt salt found was much the greater. The formation of the new nitrate may in this case be represented by the equation

$$2Co(NO_3)_2+8NH_3+4KNO_2+OH_2+O=Co_2(NH_3)_8(NO_2)4(NO_3)_2+2KNO_3+2OKH.$$

and the formation of the nitrate of Xanthocobalt by the equation:

$$2Co(NO_3)_2+10NH_3+2KNO_2+OH_2+O=Co_2(NH_3)_{10}(NO_2)_2(NO_3)_4+2OKH.$$

The green flocky matter which accompanies the formation of the above mentioned nitrates and sulphate is cobaltic hydrate, $Co(OH)_2+2OH_2$, and is of course due to the action of the potassic hydrate upon the solution of cobalt in excess. I varied the above process by adding ammonia first to the solution of cobaltic nitrate, and afterward the solution of potassic nitrite, but the results were the same.

4. *Action of ammonia and potassic nitrite upon a mixture of cobaltic and ammonic sulphates.*—In this case as in the others the solution becomes brown and deposits an orange crystalline mass. If the mass is dissolved in water and a solution of potassic bromide is added, after standing, fine crystals are formed, which after a single recrystallization are pure bromide of Xanthocobalt. In one experiment:

0·5634 gr. gave 0·2496 gr. $CoSO_4 = 16{\cdot}87$ pr. ct. cobalt.
0·7294 gr. gave 0·4496 gr. silver = 45·65 pr. ct. bromine.

The formula, $Co_2(NH_3)_{10}(NO_2)_2Br_4$, requires cobalt 16·86; bromine 45·71. I did not succeed in finding the sulphate of the octamin series among the products in the single experiment which I made with the above mentioned mixture. If present at all its relative quantity must have been small. The formation of sulphate of Xanthocobalt is easily explained by the equation:

$$2.CoSO_4+10NH_3+2KNO_2+OH_2+O=Co_2(NH_3)_{10}(NO_2)2(SO_4)_2+2OKH.$$

but it is not easy to see why the presence of ammonic sulphate should determine the production of sulphate of Xanthocobalt in place of the sulphate of the octamin series.

With these preliminaries I pass to the description of the salts of the new octamin series. These salts as a class greatly resemble those of Xanthocobalt, but are rather more stable. They have a fine sherry-wine color, are usually comparatively insoluble in cold, and are dissolved with difficulty even by boiling water. The solutions when neutral are decomposed by boiling, ammonia being evolved and a black powder precipitated. The addition of a small quantity of acetic acid serves to prevent the decomposition in hot solutions. Mineral acids, even in small quantity, usually produce more or less decomposition on heating. The salts crystallize with remarkable facility, resembling in this respect the salts of Luteocobalt which are, however, much more soluble. As the octamin salts are easily prepared in quantity, they may hereafter be found to possess some value as means of investigation from their remarkable power of crystallization.

Sulphate.—Of all the salts of this series the sulphate is that which is most easily prepared in quantity and free from other products. The general method of preparation has been already pointed out. The mixture of cobaltic hydrate and crude sulphate is to be boiled in very dilute sulphuric acid, filtered, and the solution allowed to stand for a few hours, when the sulphate separates almost completely, in consequence of its insolubility in cold water. The mother liquor contains a large quantity of cobaltic sulphate, and traces of the new salt together with potassic and ammonic sulphates. A second crystallization gives a perfectly pure salt. In large crystals the salt has a dark wine-red color, like the salts of Xanthocobalt. It usually separates from hot concentrated solutions in small, very brilliant, yellow scales which under the microscope appear to belong to the quadratic system. The sulphate is remarkable for its insolubility. Cold water dissolves a very small quantity, the solution taking a golden-yellow color. Even in boiling water the salt is but slightly soluble; but dilute sulphuric acid dissolves it more readily and without decomposition if the boiling be not continued too long. Stronger acid readily decomposes the sulphate by boiling When boiled for some time with dilute chlorhydric acid, the solution gradually becomes violet-red, and on cooling deposits crystals of chloride of Purpureocobalt. Of these crystals,

0·2825 gr. gave 0·1749 gr. $CoSO_4$=23·56 pr. ct. cobalt.

The formula $Co_2(NH_3)_{10}Cl_6$ requires 23·55 pr. ct.

The decomposition is accompanied by effervescence from the escape of gas, apparently nitrogen mixed with a smaller quantity of nitrous acid vapors, and may perhaps be expressed by the equation

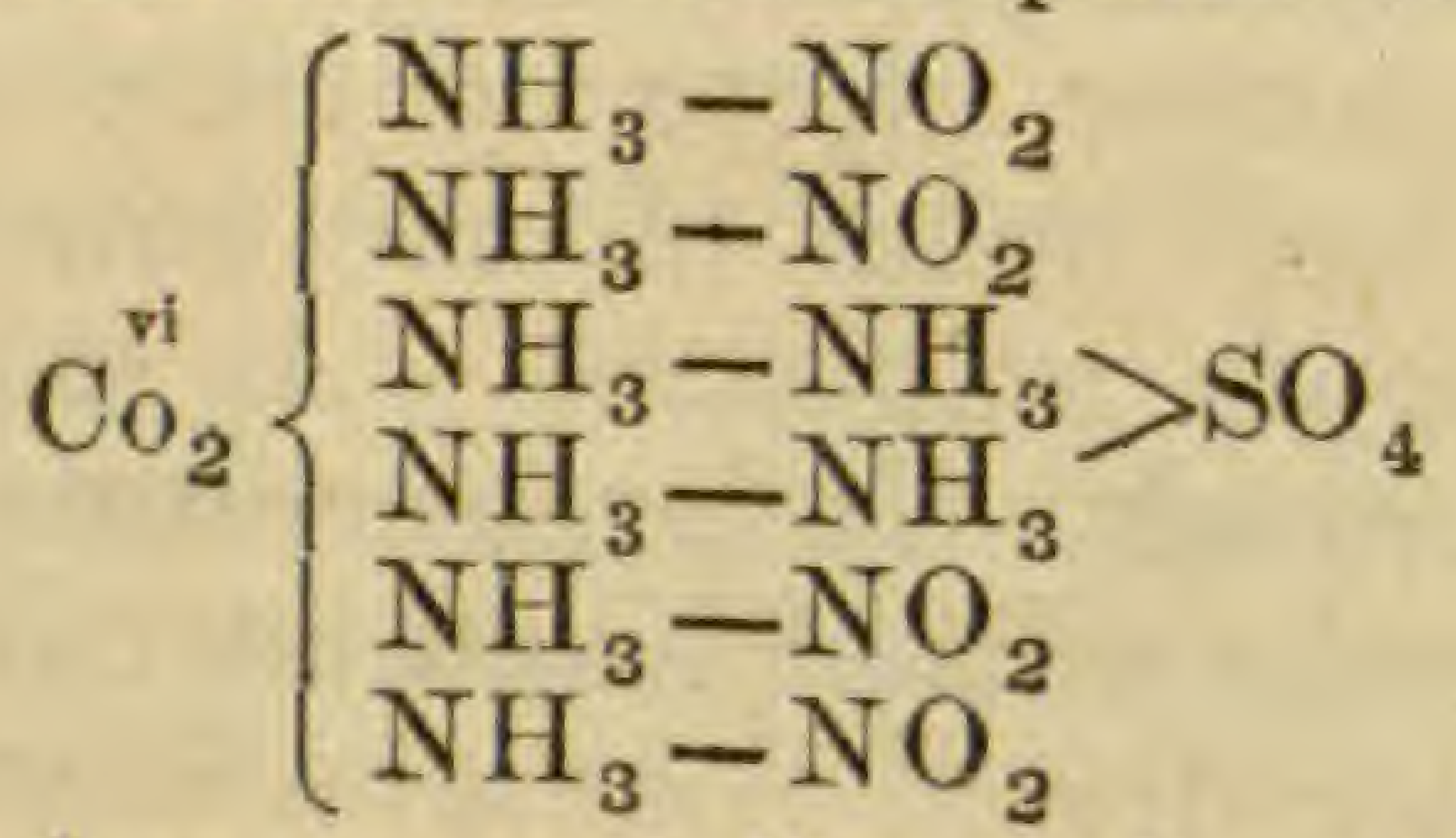
$$2Co_2(NH_3)_8(NO_2)_4SO_4=Co_2(NH_3)_{10}Cl_6+2CoSO_4+12OH_2+2NO_2+12N.$$

In this reaction we pass from a lower to a higher ammonia-base, and Genth and I have shown that we may also pass from Purpureocobalt to Luteocobalt, or from the decamin to the dodecamin series, the higher term being in each case the product of the decomposition of the lower. The formula of the sulphate in the new series is, as stated, $Co_2(NH_3)_8(NO_2)_4SO_4$. The following are the direct results of analysis:

0·6142 gr. gave 0·3596 gr. $CoSO_4$=22·28 pr. ct. cobalt.
0·4207 gr. gave 0·2454 gr. " =22·21 " "
1·5547 gr. gave 0·6785 gr. $BaSO_4$=17·98 " SO_4
0·6960 gr. gave 0·2903 gr. water = 4·63 " hydrogen.
0·4693 gr. gave 123·5 c. c. nitrogen at 9°·5 C. and 754·5^{mm}=31·33 per cent.

			Calculated.	Found.	
Cobalt	2	118	22·09	22·28	22·21
SO_4	1	96	17·97	17.98	
Hydrogen	24	24	4·49	4·63	
Nitrogen	12	168	31·46	31·33	
Oxygen	8	128	23·99	----	
		534	100·00		

On Blomstrand's view of the constitution of the ammonia-metallic bases, the formula of the sulphate may be written:



$$\overset{vi}{Co}_2\left\{\begin{array}{l} NH_3-NO_2 \\ NH_3-NO_2 \\ \left.\begin{array}{l} NH_3-NH_3 \\ NH_3-NH_3 \end{array}\right> SO_4 \\ NH_3-NO_2 \\ NH_3-NO_2 \end{array}\right.$$

I shall discuss this view more fully at the close of this paper.

Chloride.—The chloride of this series cannot be readily obtained by the action of a mixture of ammonia and potassic nitrite upon cobaltic chloride, since, as I shall show hereafter, other products are formed under these circumstances in much the larger quantities, salts of Xanthocobalt predominating. It may, however, be easily prepared in quantity by boiling the crude sulphate with baric chloride and a very small quantity of chlorhydric acid. To avoid loss, the baric sulphate must be repeatedly and carefully washed with boiling water and a trace of free acid. The chloride then crystallizes from the filtrate in beautiful iridescent crystals. The forms of these crystals together with those of other salts of this series I hope hereafter to be able to give in detail. The chloride has the characteristic sherry-wine color of the salts of this series, and the small crystals are very brilliant and exhibit a remarkable iridescence.

The chloride is more soluble than the sulphate, but still belongs to the class of slightly soluble salts, and crystallizes almost completely from hot solutions as these become cold. The salt possesses in a high degree the sharply defined crystalline character of the members of this series, and forms a large number of compounds with metallic chlorides, many of which are of great beauty. The constitution of the chloride is represented by the formula

$$Co_2(NH_3)_8(NO_2)_4Cl_2$$

as the following analyses show:

0·5164 gr. gave 0·3152 gr. $CoSO_4$=23·24 pr. ct. cobalt.
0·6048 gr. gave 0·3683 gr. $CoSO_4$=23·18 " "
0·7188 gr. gave 0·3027 gr. silver =13·84 " chlorine.
0·4846 gr. gave 0·2152 gr. water = 4·92 " hydrogen.
0·6160 gr. gave 172·5 c. c. nitrogen at 16° C. and 768·2^{mm}=32·91 per cent.

			Calculated.	Found.
Cobalt	2	118	23·18	23·18 23·24
Chlorine	2	71	13·94	13·84
Hydrogen	24	24	4·71	4·90
Nitrogen	12	168	33·00	32·91
Oxygen	8	128	25·17	----
		509	100·00	

The corresponding bromide, $Co_2(NH_3)_8(NO_2)_4Br_2$, resembles the chloride so closely that no special description is necessary. In this salt,

0·3944 gr. gave 0·2059 gr. $CoSO_4$=19·87.

The formula requires 19·73 per cent.

Hyperiodide.—When a solution of iodine in potassic iodide is added to one of the nitrate of this series, a magnificent crystalline cinnabar-red compound is precipitated, which may be washed with cold water and afterward with a little alcohol without decomposition. For analysis, the salt was dried in pleno over sulphuric acid. The crystals are small scales of unusual beauty and richness of color. They are slightly soluble in cold water, and are partially decomposed by boiling water with evolution of iodine vapors. Even long boiling, however, does not appear to decompose them completely. When heated with a solution of sodic sulphite the salt instantly becomes yellow and is converted into the normal iodide. No similar compound is formed when a solution of potassic hyperiodide is added to one of nitrate of Xanthocobalt. The formation of the hyperiodide may be represented by the equation:

$$Co_2(NH_3)_8(NO_2)_4(NO_3)_2+2KI_3=Co_2(NH_3)_8(NO_2)_4I_6+2KNO_3$$

In this salt,

0·5748 gr. gave 0·1494 gr. $Co.SO_4$= 9·87 pr. ct. cobalt.
0·4705 gr. gave 0·2550 gr. silver =63·70 " iodine.
0·3942 gr. gave 49 c. c. nitrogen at 14·5° C, and 736·8^{mm}=14·10 per cent nitrogen.

			Calculated.	Found.
Cobalt	2	118	9·83	9·87
Iodine	6	762	63·50	63·70
Nitrogen	12	168	14·00	14·10
Hydrogen	24	24	2·00	----
Oxygen	86	128	10·67	----
		1200	100·00	

If we consider iodine as triatomic in this salt its constitutional formula may be more simply represented by the expression:

$$\overset{vi}{Co_2}\begin{cases} NH_3=I-NO_2 \\ NH_3=I-NO_2 \\ NH_3=NH_3-I \\ NH_3=NH_3-I \\ NH_3=I-NO_2 \\ NH_3=I-NO_2 \end{cases}$$

Nitrate.—I have already stated that the nitrate of this series may be formed by the action of a mixture of ammonia and ammonic nitrate upon a solution of cobaltic chloride and ammonic nitrate. It is much more convenient, however, to prepare it from the crude sulphate by double decomposition with baric nitrate. The sulphate is to be boiled with a small excess of baric nitrate and a little acetic acid and the baric sulphate carefully washed to avoid loss of nitrate. From the filtered solution the new nitrate crystallizes almost completely on cooling in beautiful orange-yellow needles, and sometimes in distinct prismatic forms. It is much more soluble than the sulphate, though cold water takes up but little. Boiling water and dilute acid solutions dissolve it more readily. The reactions of the base may be studied most conveniently with this salt. The formula of the nitrate is

$$Co_2(NH_3)_8(NO_2)_4(NO_3)_2$$

as the following analyses show :

0·2405 gr. gave 0·1333 gr. $CoSO_4$ = 21·10 per cent cobalt.
0·6564 gr. gave 0·2484 gr. water = 4·21 per cent hydrogen.
0·6148 gr. gave 173·5 c.c. nitrogen at 4°·5 C. and 762·2^{mm}=34·83 %.

			Calculated.	Found.
Cobalt	2	118	20·99	21·10
Hydrogen	24	24	4·27	4·21
Nitrogen	14	196	34·88	34·83
Oxygen	14	224	39·86	
		562	100·00	

The nitrate explodes, though not very violently, on being heated. Its solution gives with a potassic ferrocyanide no precipitate at first, but after some hours beautiful garnet-red acicular crystals are formed. It is most easily distinguished from the nitrate of Xanthocobalt by its crystalline form and by the extremely characteristic precipitates which its solution yields with potassic hyperiodide and with potassic chromate.

Chromate.—When a solution of potassic chromate is added to one of the nitrate of the octamin series a most beautiful lemon-yellow salt is formed, which separates almost immediately in very brilliant scales which appear to belong to the quadratic system, and to be isomorphous with the sulphate. The salt is but slightly soluble in water. Its marked crystalline form renders it valuable as distinguishing the salts of this series from those of Xanthocobalt. In this salt,

0·4660 gr. gave 0·2128 gr. $BaCrO_4$ = 20·95 per cent CrO_4.
0·4659 gr. gave 119·5 c.c nitrogen at 9·75° C. and 753·5^{mm}=30·42 %.

The formula, $Co_2(NH_3)_8(NO_4)_4CrO_4$, requires 20·97 per cent CrO_4 and 30·42 per cent of nitrogen.

Dichromate.—This salt is easily formed by adding a solution of potassic dichromate to one of the octamin nitrate. It separates after a few minutes in beautiful orange-yellow needles which may be redissolved and again crystallized without decomposition. In appearance and solubility it can hardly be distinguished from the corresponding salt of Xanthocobalt,

$$Co_2(NH_3)_{10}(NO_2)_2(Cr_2O_7)_2 + 2OH_2.$$

The formula of this salt is

$$Co_2(NH_3)_8(NO_2)_2Cr_2O_7.$$

0·5604 gr. gave 0·4315 gr. $BaCrO_4$ = 32·91 per cent Cr_2O_7.

The formula requires 33·06 per cent. The determination of CrO_4 and Cr_2O_7, in this and similar compounds containing NO_2, can be effected more accurately by means of a baric salt than by mercurous nitrate, since the nitrous compound always reduces a little chromic acid to chromic sesquioxide.

Platino-chloride.—A solution of sodic platino-chloride, $PtCl_6Na_2$, produces in one of the new nitrate after a time fine orange-brown prismatic crystals which, however, cannot very well be recrystallized without decomposition. The crystals were washed with cold water, dried by pressure and then over sulphuric acid. The analysis was made by boiling the salt with zinc and dilute sulphuric acid, filtering off, and weighing the reduced platinum and determining the chlorine in the filtrate by silver. In another portion of the salt the platinum and cobalt were determined together by gentle ignition in a current of hydrogen gas. In this manner

0·3959 gr. gave 0·0921 gr. platinum and 0·3016 gr. silver = 23·26 per cent platinum and 25·04 per cent chlorine.

0·4459 gr. gave 0·1652 gr. platinum and cobalt = 37·04 per cent. Subtracting 23·26 per cent platinum from this we have 13·78 per cent cobalt.

		Calculated.	Found.
Cobalt	2	13·91	13·78
Chlorine	6	25·12	25·04
Platinum	1	23·23	23·26

The formula of this salt is therefore

$$Co_2(NH_3)_8(NO_2)_4Cl_2 + PtCl_4.$$

Auro-chloride.—A solution of auro-chloride of sodium, $AuCl_4Na$, produces immediately in one of the octamin nitrate a beautiful nearly crystalline precipitate, with a fine canary-yellow color and silky luster. Small quantities of this salt may be dissolved in boiling water without decomposition, but it is very difficult to recrystallize it without great loss from the reduction of the gold. When boiled for a short time the salt is almost completely decomposed. It is remarkably insoluble in cold water. For analysis the salt was dried on bibulous paper, and afterward in pleno over sulphuric acid. The analysis was effected by boiling the salt with zinc as in the case of the platinum salt, and determining the chlorine in the filtrate by silver, but the gold precipitated was found to contain much metallic cobalt. Another analysis was made by simply heating with sulphuric acid, precisely as in the process which Genth and myself introduced for the determination of cobalt in these salts and then washing and weighing the gold. This method was found to give excellent results. In this manner,

0·4791 gr. gave 0·3697 gr. silver = 25·36 per cent chlorine.

0·3942 gr. gave 0·2483 gr. $Au + CoSO_4$ = 0·1391 gr. gold, and by difference 0·1092 gr. $CoSO_4$ = 10·54 per cent cobalt and 35·30 per cent gold.

		Calculated.	Found.
Cobalt	2	10·57	10·54
Gold	2	35·30	35·30
Chlorine	8	25·44	25·36

The formula of the salt is therefore

$$Co_2(NH_3)_8(NO_2)_4Cl_2 + 2AuCl_3.$$

Erdmann's Salt.—O. L. Erdmann* in 1866, described a remarkable salt which is formed when a solution of potassic nitrite is added to a solution of cobaltic chloride containing an excess of ammonic chloride. The liquid quickly assumes a dark orange color, becomes strongly acid and evolves red vapors. After a time very beautiful oblique rhombic crystals are deposited which, according to Erdmann, have the formula (old style) $Co_2O_32NH_3, 3NO_3+KO,NO_3$.

In modern notation the formula of Erdmann's salt may be written $Co_2(NH_3)_4(NO_2)_8K_2$.

Erdmann states that the potassium in this salt may be replaced by other metals, and describes the corresponding ammonium and silver salts. These compounds are especially interesting, because they hold an intermediate position between the two series represented respectively by the terms

$$Co_2(NH_3)_{12}Cl_6 \text{ and } Co_2(NO_2)_{12}K_6.$$

I propose therefore to speak of them more in detail hereafter, and to confine myself at present to their relations to the salts of the octamin series.

When a solution of Erdmann's salt, $Co_2(NH_3)_4(NO_2)_8K_2$, is added to one of the octamin nitrate, a beautiful crystalline precipitate is formed, which after washing with cold water may be redissolved in hot water and then separates in fine orange-yellow granular crystals. The equation representing the reaction is here

$$Co_2(NH_3)_8(NO_2)_4(NO_3)_2+Co_2(NH_3)_4(NO_2)_8K_2=2KNO_3+ Co_2(NH_3)_4(NO_2)_8(Co_2(NH_3)_8(NO_2)_4)''.$$

---

* Journal für prakt. Chemie, xcvii, 385.

The new salt gives with reagents the reactions of the salts of the octamin series. The relation between the two complex atoms which form a molecule of the new salt is worthy of notice, the number of atoms of ammonia and nitroxyl in the one corresponding to the number of atoms of nitroxyl, NO_2, and of ammonia in the other; one complex atom being, to use Graham's convenient expression, chlorous and the other zincous. We have furthermore the relation expressed by the equation:

$$Co_2(NH_3)_4(NO_2)_8(Co_2(NH_3)_8(NO_2)_4)=2Co_2(NH_3)_6(NO_2)_6.$$

Now I shall show, farther on, that there exist several other salts, the empirical constitutions of which may be represented also by multiples of the formula

$$Co_2(NH_3)_6(NO_2)_6,$$

so that we have here, for the first time, I believe, in inorganic chemistry, a series of strictly metameric bodies. In the salt of the octamin series:

0·2600 gr. gave 0·1622 gr. Co 304=23·74 per cent cobalt.

The formula requires 23·79 per cent.

The salts which I have described are not the only ones which contain 8 atoms of ammonia with 2 atoms of cobalt. In our memoir Genth and I made mention of a leek-green crystalline body which we obtained in more than one reaction in quantities too small for analysis, and which we termed, provisionally, Praseocobalt. Braun subsequently denied the existence of any such substance, but in an excellent paper on the ammonia-cobalt compounds, F. Rose has not merely described and analyzed the body in question, but has given a method of preparing it in quantity. Rose gives for the formula of this salt $Co_2Cl_3N_4H_{12}$ (old style). I should write this

$$Co_2(NH_3)_8Cl_6,$$

and give it the atomistic formula

$$Co_2\left\{\begin{array}{l} NH_3-Cl \\ NH_3-Cl \\ NH_3-NH_3-Cl \\ NH_3-NH_3-Cl \\ NH_3-Cl \\ NH_3-Cl \end{array}\right.$$

It thus forms the type of a special octamin series, the relations of which to the salts which I have described are easily seen by comparing the formulas which I have given. Rose has not described any other salts of this series. It seems possible that my series may be derived from this by acting upon the chloride with argentic nitrite; we may have

$$Co_2(NH_3)_8Cl_6+4AgNO_2=Co_2(NH_3)_8(NO_2)_4Cl_2+4AgCl,$$

but I have as yet made no experiments in this direction. Finally Künzel* described, many years since, a hyposulphate, to which he gave the formula $Co_2O_3+4NH_3+2S_2O_5$ (old style). This formula becomes in my view, $Co_2(NH_3)_8S_2O_{13}$ and the salt then belongs to the octamin series, but I am unable to assign to it any plausible atomistic expression, and it is possible that its empirical constitution has not yet been correctly given.

In treating of the salts of my new series it appeared to me more in accordance with the theoretical views which I have adopted to abstain from trivial names. All the members of this series may however be regarded as containing the complex atom $Co_2(NH_3)_8(NO_2)_4$, which alone is constant and which from one point of view may be regarded as a diatomic radical or residue, and those who justify the use of trivial names by their convenience may find the name "Croceocobalt" expressive and appropriate.

(To be continued.)

Cambridge, June 16th, 1873.

ART. XVI.—*Mineralogical Notes on Utah, California and Nevada, with a description of Priceite, a new Borate of Lime;* by B. SILLIMAN.

1. *Enargite*, $3\text{Ꞓu}\,S+As^2Sb^3$.—This hitherto rare mineral exists in two or three localities in a district of Southern Utah, known as the Tintic District, about eighty miles south of Salt Lake City. The localities are, (1) the Shoebridge Mine, (2) the Mammoth vein, Eureka Hill, East Tintic, and, (3) the Dragon Mine, East Tintic. All these localities occur in metamorphic crystalline rocks of the granitic family.

The Shoebridge locality furnishes finely crystallized specimens, associated with octahedral pyrite. The vein in which it is found fills a fissure about four feet wide in granitic rocks. This vertical fissure is filled to the depth of about 80 feet from surface with enargite mixed with pyrite. The whole mass is regarded as a silver ore. A sample of the ore made up from such stock as I had in hand yielded to fire assay 269·25 oz. troy of silver, or $347.34 to the ton of 2000 ℔s.; this is equal to 0·841 per cent of silver, which is considerably above the average value of the vein. Below the depth of 80 feet, the character of the vein changes, as I am informed by one of the owners, Mr. Samuel T. Hatch, of Salt Lake City, to a vein of argentiferous galena, carrying some antimony. In examining many hundred

---

* Journal für prakt. Chemie, lxxii, 218.

pounds of the ore taken from above the galena zone, I found only enargite and pyrite with quartz and some heavy spar as a gangue—and not a trace of galena, as the analysis proves.

The enargite from Shoebridge mine cannot be distinguished by the eye from that which was first mentioned by the late Prof. Root, from the "Morning Star Mine" in Alpine County, California (this Journal, II, xlvi, 201).* It occurs both massive of a brilliant luster and fracture, resembling in color gray copper; and also in brilliant orthorhombic crystals striated on the terminal plans parallel to the longer diagonal. The crystals are sometimes 5 or 6^{mm}. long, but more commonly are not over 2^{mm}. in length. The forms are more simple than the crystals figured from Peru. Dr. Gideon E. Moore, who has studied those from the Morning Star Mine, informs me that their form is identical with the Shoebridge mineral, and is expressed by the crystallographic formula $\infty P \,.\, 0P \,.\, \infty\bar{P}\infty \,.\, \infty\breve{P}\infty$.

Its pyrognostic characters conform to those of the Peruvian mineral, but it contains much less antimony then the California variety. Its specific gravity is 4·861 in fragments to 5·111 solid—almost that of pyrite, and somewhat higher than the Peruvian variety. Mr. E. S. Dana kindly furnished me some time ago the following approximate analysis of the Shoebridge mineral made by the chlorine method upon carefully selected crystals. He obtained—

Sulphur	34·35	Iron	1·06
Antimony	·95	Zinc	*trace*
Arsenic	17·20	Residue (undissolved),	*trace*
Copper	46·94		100·50

The silver was not determined. The iron is probably due to the pyrite, with which the species enargite is intimately associated; this occasions also the excess of sulphur, in the analysis, which corresponds, however, sufficiently well with the formula given above.

At the "Mammoth Vein," in Eureka Hill, the enargite occurs in broad laminated masses somewhat resembling black hornblende, and stained green in the joints by the oxidation of a portion of the copper. It is associated with calcite and is quite free from pyrite. The blowpipe shows it to be free, or nearly so, from antimony. This locality has not furnished the enargite otherwise than in columnar and cleavable masses.

The mineral from Dragon Mine resembles the last named variety, but is more massive. Neither of the two latter varieties have been analyzed.

2. *Bismuthinite*, B^2S^3.—This species is found rather abundantly in three associated mineral veins in Granite Min-

---

* Wrongly quoted in Dana (5th ed.), p. 797, as in vol. xlv.

ing District, Beaver County, Utah, about ten miles west of Beaver City. The main vein, which is said to be about six feet in thickness, contains also bismuth ocher or *bismite*, $\dddot{\mathrm{Bi}}$, staining the surface greenish yellow (a sign by which the vein has been traced at intervals, it is said, for about 2000 feet), and *bismutite* (hydrous carbonate of bismuth), $\dddot{\mathrm{Bi}}^4\ddot{\mathrm{C}}^3\dot{\mathrm{H}}^4$, in yellowish-gray masses inclining to siskin-green. These last two species are due, no doubt, to the oxidation of the bismuthinite.

These three species sometimes form masses of considerable size, but more commonly the sulphid occurs alone in a gangue of almadin garnet of a hair-brown color, with black hornblende, heavy spar and quartz. Yellow pyrite exists in small quantity in the gangue, and by its oxidation has furnished masses of iron oxides. No arsenical ores could be detected in the samples which have fallen under my observation, nor does the blowpipe detect either lead, antimony or copper.

Hitherto bismuthinite has been a rare species in N. America, and I do not know that it has before been found in quantity likely to give it a commercial value.* In the Beaver vein, the metal is said to form about five per cent of the mass.

When this locality is properly opened for mining we may hope to obtain an abundance of good mineralogical specimens of these several species. I am indebted to Mr. J. B. Meader of Salt Lake, and to Col. Head of San Francisco, for the specimens from Beaver, which I have examined.

3. *Wulfenite.*—In a former communication (this Journ., III, iii, 195) I pointed out the absence, so far as observed, of phosphates among the mineral species found in the Wahsatch Range, and the existence of molybdic acid as wulfenite in its place. Further observation has confirmed this statement. In a subsequent visit to that region, and more recently, I have received from Major Wilkes, of Salt Lake City, wulfenite from the Empire mine, Lucin District, Box-Elder County, Utah, in the Wahsatch Range, which for beauty is rarely equalled by the same species from any known locality. The crystals are thin tables 20 to 30^{mm}. broad, of a pure yellow color set on a deep brown iron ochre, and making splendid cabinet specimens.

4. *Orpiment and Realgar.*—These two species are found with galenite in a vein known as the "Lucky Boy mine," in Butterfield Cañon, which is in the Oquirrh Range on the west side of Jordan Valley, Utah.

5. *Priceite.*—This borate of lime, which I received from Mr. Thomas Price, in San Francisco, in March, 1872, has been noticed by Mr. Chase, and its mode of occurrence and probable origin described by him in this Journal (III, v, 287), accom-

---

* I have observed it in minute prismatic crystals in the well-known chrysoberyl locality at Haddam, Conn.

panied by two analyses. A recent examination of this mineral —of the soft chalky variety—affords the following results. Its specific gravity is 2·262 to 2·298. It resembles chalk, but is even softer than that mineral. Its powder under a half inch magnifying power is seen to consist exclusively of minute rhombic crystals. It is insoluble in water which removes only a very minute quantity of common salt, not a constituent of the mineral. It dissolves completely in dilute hydrochloric acid, and this solution promptly deposits abundant crystals of boric acid. Its filtrate is completely free of sulphates, and reacts only for lime, with a trace of iron and alumina. In the close tube it evolves abundant neutral water, and at a red heat fuses to a white enamel. The spectroscope discloses from its solution in hydrochloric acid only the double spectrum of boric acid, with the lines of calcium and sodium. It contains no carbonate of lime, which might very naturally be looked for. Five grams of the air-dried mineral afforded me by the volumetric method only 0·7 c.c. of CO_2, equivalent to $\frac{1}{25000}$ of calcium carbonate in the weight taken—hardly a trace.

Its water of constitution is very constant—and it is almost non-hygroscopic. Two determinations of the water in the air-dried mineral gave 18·395 and 18·40 per cent of water, while two of the same dried at 212° gave each 18·29 per cent.

Dried at 212°, three analyses made by hydrofluoric acid—which leaves the boric acid to be determined by the loss—gave as follows:

	1.	2.	3.	Mean.	Oxygen ratio.
Water	18·29	18·29	18·29	18·29	1·8
Lime,	32·38	31·37	31·73	31·83	1
Na Cl. $\not{F}e$ $\not{A}l$	·93	1·00	·97	·96	
Boric acid	48·50	49·34	50·01	49·00	3·7

The oxygen ratio gives approximately $4\dddot{B}$, $3\dot{C}a$, $6\dot{H}$; the lime is a little too high. The probable formula of the mineral is $\dot{C}a^3\dddot{B}^4 6\dot{H}$, which makes the mineral to differ from hydroboracite by containing one-third less water and no magnesia. This formula requires: water 19·43, lime 30·21, boric acid 50·36 =100.

This mineral is certainly different from the cryptomorphite of How, to which it has been provisionally referred by Price and others. It has the microscopic crystallization described by Dr. Robb as belonging to the Nova Scotia species; but the absence of soda and the greater ratio of the protoxide base carries it much nearer to hydroboracite, from which it is separated by containing no magnesia and less water. It is certainly not a mechanical mixture, as its finely divided condition might seem to indicate. The microscope completely sustains the constant results of analysis on this point. As it appears therefore to be a new species, I would propose for it the name *priceite*, in honor of Mr. Thomas Price, the well known metallurgist of San Francisco. Mammillary and radiate masses of aragonite, some of great size, but more frequently as crusts, occur with the priceite, and were at first mistaken by the miners for a variety of this borate of lime.

6. *Ulexite.*—The boronatrocalcite of Ulex proves to be an abundant mineral in Nevada and Arizona. The specimens of this species which I have examined are from near Columbus, Esmaralda County, Nevada, where it occurs in beds of considerable extent, mixed with sulphate of soda and gypsum. It is found in round masses, as large as the fist and larger, which when broken show the fine fibers of silky luster not to be distinguished from the *tiza* of Peru. This species, it is said, occurs abundantly in the Arizona desert, and also near Wadsworth, Nevada, much mingled with dirt.

Near Columbus, Nevada, they have likewise found large quantities of borax diffused in the soil, and Prof. Price informs me (June 6, 1873), "that all the borax produced there is obtained by lixiviating the soil and crystallizing out the borax in the usual way. I have been informed by trustworthy parties that they can manufacture at least forty tons of commercial borax every day; the difficulty is to find a market for so much."

About twenty miles west of San Bernardino, California, is the so-called "Cane Spring District," where ulexite is found over an area, said to be about ten miles in width by fifteen in length. The surface of the ground is covered with efflorescent salts, commonly known as "alkali," beneath which the borax salts (chiefly *ulexite*) are found, at a depth of a few inches, when they exist at all. As these "alkaline" wastes are now attracting attention from the commercial importance attached to the borax salts, we may hope to obtain yet other contributions of interesting species. The saline salts removed in obtaining the borax salts recur again after an interval of time, during which the process of solar evaporation in a rainless region brings up by capillary action from a lower stratum fresh portions of the saline solutions. It is a fact long familiarly known to travelers in these desolate regions, that while the lagoons, where any exist, contain only water too strongly saline to be drank, that wells sunk to a moderate depth in the saline soil afford water which can be used. This water is only a more dilute solution of the same salts, which on reaching the surface by capillarity, form the peculiar "alkali" incrustations of the desert.

7. *Borax.*—On the eastern slope of the Sierra Nevada, not far from Walker's pass, borax is found in what appears to be the bed of an ancient lake, large crystals of tinkal having been found in the hardened mud, like the well known crystals of borax found in the mud of Clear Lake in California. But by

far the largest quantity of the borax exists mixed with other salts, incorporated in a sort of indurated mud from which it is extracted by lixiviation.

I have examined several samples of this material which Prof. Price has kindly sent me. One of them, by his assay, contains about half its weight of borax. It is a light gray clay-like looking body, with a strongly saline and alkaline taste. effervesces with dilute hydrochloric acid, and tinges the flame of alcohol green. They are all alike in reacting alkaline, and for sodium, boracic acid, chlorine and sulphuric acid. The portion insoluble in water is attacked by dilute hydrochloric acid with effervescence, and contains alumina, lime, a little ferric oxide and magnesia. Minute crystals of gypsum exist in some of them, but no gaylussite, glauberite or boracite could be detected. Similar deposits containing borax exist in Panamit and Death's Valley in Lower Nevada, which desolate districts have yet to receive a careful scientific examination, for which, in Professor Price's opinion, they offer an interesting but certainly not very inviting field. There are few parts of the earth's surface where human life and endurance are more severely taxed.

8. *Chrysocolla.*—This species, in specimens of unusual size and beauty, is found in a vein, or heavy deposit, of thirty to forty feet in thickness, in the railroad mining district, Elko county, Nevada. Above one hundred tons of it were sent last year to the Revere Copper Company, where it yielded 28½ per cent of copper.

9. *Compact Anglesite.*—This variety of anglesite occurs in large quantity at the Union mines near Cerro Gordo, Inyo county, California, in an Alpine region about twenty miles east of the Sierra Nevada mountains, and at an elevation of more than 8,000 feet above tide. The mineral vein, or ore deposit, occurs in limestone and makes its appearance on the west slope of the mountain (which rises some thousand feet or more higher than the vein). It was indicated at surface by a few boulders or isolated masses of galena, which on exploration ran into a nearly continuous mass of galena mixed with a reddish-brown sand colored by sesquioxide of iron, but without quartz or epigene species derived from lead. Singularly enough, the carbonates of lead occur *below* the anglesite, mixed with the latter species and with galena. At the depth of 600 feet from surface, the ore course is about fifty feet wide, the entire absence of water at that depth and above being a noticeable fact, in considering the paragenesis of species. Water is brought by mules and Indians from a distance of some miles, to supply the hoisting machinery and other needs of the mine, at a cost of 10c. per gallon, and is economized by a careful condensation.

This anglesite often includes unchanged galena. It is of a gray to grayish-yellow color, sometimes dark, or with seams of yellow covered with druses of small crystals of anglesite, which are quite colorless, brilliant and transparent. The masses are banded like agates. Its density is 6·08, and its pyrognostic characters are those of anglesite. It contains on an average of mining samples about 55 ozs. of silver to the ton of 2,000 lbs., which is materially less silver than is found in the unchanged galena. The "bullion" (silver lead) of this mine as sent to market contains about 120 ounces of silver to the net ton. My informant for these economical facts is Mr. F. F. Thomas, a graduate in Arts and Science at Yale, who is in charge of the smelting works at these mines.*

10. *Platinum and Iridosmine.*—Since the publication (this Jour., v, 384) of my note on the crystalline sands of the Cherokee gold washings in Butte county, California, I have obtained, through the kindness of Mr. G. A. Treadwell, who at my suggestion gave the proper directions, samples of the heavy sands which accompanied the "clean up" of the gold to the last stage of concentration before going into the melting pot. These heavy sands I find to be largely composed of scales of platinum mixed with yet more abundant iridosmine. When the adhering mercury and other foreign matters which disguise the true character of the platinum residues are removed by a slight washing in acid, the beauty of these species is seen, and it is quite easy to select each by the aid of a glass. A few minute zircons and brilliant microscopic crystals of chromite (?) were selected from the sample of about 25 grams which I received. The search for laurite and the anomalous mineral believed by Dr. Genth to be new (this Jour. II, 246), which he described as occurring among sands from California, in 1853, was not successful.

Mr. Glass, the resident manager, informs me that the platinum and its associate minerals are quite abundant at Cherokee, but as the quicksilver does not amalgamate them they have no means of escape from the mechanical force of the stream which washes away much the larger part, thus entailing a loss which there is no means now known to prevent.

Platinum and iridosmine were very early observed in California by Blake and others, among especially the sands of the surface placers near the sea, on the northern coast and in Oregon. But I believe this is the first notice of their being found in the older deep placers now so extensively worked by the hydraulic process.

The "Black Sands" of the Cherokee deep placer washings I find to be composed chiefly of *chromites*. The magnet selects quite sparingly a few crystals and masses of *magnetite*, some of them being also strongly magnetic. An occasional mass of

---

* The compact anglesite from Arizona, described by Prof. Brush in this Journal, (III, v, 421) is not distinguishable from the Cerro Gordo mineral.

brown iron (*limonite*) occurs, giving off water in the tube, becoming magnetic by heat, and reacting only for iron. The search for *ilmenite* resulted in finding only chromite, with its well-marked reactions. It is highly improbable but that ilmenite exists, but I have not yet after some time and much pains succeeded in finding it. The mass of sands searched by an exploring-glass, discloses some other species besides the abounding zircons, among which the most conspicuous is *rutile* in minute prisms of a fine red color, transparent, sometimes doubly terminated, but rarely compounded; 68 of these little crystals of rutile weighed only 58 milligrams; garnets, epidote, and a few minute fragments undetermined are sparcely found. We may therefore enumerate the mineralogy of the Cherokee washings, so far as known, as yielding gold, platinum, iridosmine, diamond, zircon, topaz, quartz in several varieties, chromite, magnetite, limonite, rutile, pyrite, almadine garnet, epidote. A further search on larger samples of the sands will undoubtedly reveal yet other species. The matrix which has furnished most of the species enumerated (the gold and platinum metals probably excepted), is probably syenite, boulders of which are among the frequently recurring factors of the gravel mass.

11. *Diamonds in California.*—About twenty well-formed crystals of diamond have been picked out of the "sluices" in the deep placer workings at Cherokee, Butte County, since the attention of the miners has been called to the existence of this gem in such situations. One of these diamonds which I have examined weighs about 2¼ carats, and is of a faint yellowish color, with curved faces, and the form of fig. 58, in Dana's Mineralogy. Some of these stones were of a pure water, and have been cut and set as gems.

12. *Sands of the Arizona Desert.*—The search for "diamonds," "rubies," and "emeralds" in 1872, led to the sending of several expeditions into Arizona and southern Nevada. I have had, by the kindness of Mr. Geo. A. Treadwell, an opportunity of examining a portion of the findings of one of these parties, which explored a region about eighty-five miles northwest of Fort Defiance in Arizona. The region is described as one of porphyritic and other eruptive rocks. The "rubies" are garnets, some of very fine color and good size, but whether pyrope or common garnet, an analysis only can determine. Some of them, cut in San Francisco, which I have seen, compare well in color and beauty with the Bohemian stones. The "emeralds" are chrysolite, too faint in color to be used as gems. The "diamonds" are quartz, some opaline, others hyaline, and all smoothly polished. In addition, I find the alalite variety of pyroxene, fluorite (white), magnetite, ilmenite, oligoclase and jasper.

ART. XVII.—*Remarks on the Distribution of the Fossils in the Lower Potsdam Rocks at Troy, N. Y., with descriptions of a few new species;* by S. W. FORD.

WHEN, in the summer of 1871, I published a brief notice of my investigations among the ancient rocks overlooking the Hudson River upon the east in the vicinity of Troy,* I hoped to be able to present shortly thereafter a more detailed account of these rocks, and of their intimate stratigraphical arrangement. Several circumstances have, however, prevented the carrying out of my intended labors in this direction with any degree of satisfaction to myself, and I shall therefore leave the further consideration of this subject to a future occasion. In the present paper I shall confine myself mainly to a few observations relating to the distribution of the fossils in these rocks; and to the description of the remainder of the new species which they have afforded, in so far as these are sufficiently well preserved to admit of being characterized.

The only rocks of the Lower Potsdam at Troy that have thus far proved fossiliferous are certain thin limestone masses, associated with the great body of coarse slates of which the formation at this place is principally composed. These masses are four in number, or at least occur in four distinct north and south ledges. They all occur within a tract not to exceed half a mile from west to east and considerably less than a quarter of a mile from north to south. Within this tract there are several other ledges, some of them holding thin deposits of limestone; but in these I have not as yet succeeded in finding any fossils. The following is a section across the Hudson River at Troy, not drawn to scale, but designed simply to show the general arrangement of the rocks in this vicinity.

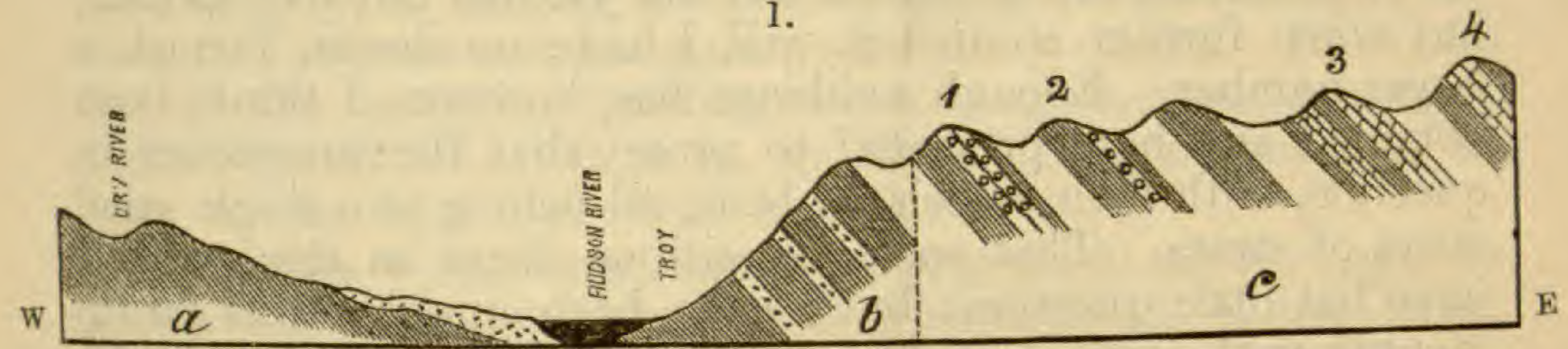
At the point of the section indicated by the vertical dotted line a great dislocation most probably occurs, bringing up the more ancient strata *c* and causing them to overlap or stand above the newer *b*. This would, however, hardly be suspected from the physical structure of the region; since, so far as I have been able to ascertain, the rocks throughout the entire length of the section have the same average (easterly) inclination. I have nowhere observed the precise line of contact between the rocks of *b* and *c*, unless it be in a high ridge about a mile and a half north of this city, where the hard dark-colored slates and thin gray sandstones of the Lower Potsdam appear to overlap conformably the newer shales. At Troy there is a considerable space between them covered with drift.

---

* "Notes on the Primordial Rocks in the vicinity of Troy, N. Y." This Journal for July, 1871.

The limestones of *c*, which I have for convenience sake designated simply as limestones 1, 2, 3 and 4, are those already referred to as being the only portions of the Lower Potsdam at Troy that have proved fossiliferous. The annexed table presents a list of the species obtained from them so far as described; and shows also the manner of their distribution among them.

1.



a. Shales of the Hudson River formation holding *Trinucleus concentricus*, *Leptæna sericea*, and graptolites. The above species occur at Dry River, opposite Troy.
b. Black shales with thin layers of sandstone, holding graptolites, most probably of either the Hudson River or Utica formations.
c. Slates, sandstones, limestones and limestone conglomerates of the Lower Potsdam group.
1–2. Conglomerate limestone interstratified with coarse slates.
3–4. Even-bedded limestone similarly situated.

Table showing the distribution of the fossils in the Lower Potsdam group at Troy, N. Y.

	Limestones,	1	2	3	4
1.	Archæocyathellus Rensselaericus*	--	*	?	--
2.	Obolella desquamata	*	*	*	*
3.	" crassa	--	*	*	--
4.	" cælata	--	*	*	*
5.	" nitida	--	*	*	*
6.	Stenotheca rugosa	*	*	*	*
7.	Scenella retusa	*	*	*	--
8.	Hyolithellus micans	*	*	*	*
9.	Hyolithes Americanus	--	*	*	*
10.	" impar	--	*	*	*
11.	" Emmonsi	--	*	*	*
12.	Leperditia Troyensis	--	--	*	--
13.	Microdiscus speciosus	--	*	*	*
14.	" lobatus†	--	*	*	*
15.	Conocephalites trilineatus	--	*	*	*
16.	Olenellus asaphoides	--	*	*	*
17.	Agnostus nobilis	--	--	--	*
18.	Bivalve of undetermined relations	*	*	*	*

It will be seen from the above table that out of the eighteen species enumerated, thirteen are common to limestones 3 and 4;

---

* This species was described in the March No. of this Journal for the present year, and referred by me provisionally to the genus *Archæocyathus*, Billings. I now consider it entirely distinct from that genus, and have adopted here the generic name at that time proposed for it in the event of its proving to be an independent form. The characters of *Archæocyathellus* are those of this species.

† This species equals the *Agnostus lobatus* of Hall (Pal. N. Y., vol. i, p. 258, pl. lxvii, figs. 5 a–f), and appears to me to belong to *Microdiscus* rather than to *Agnostus*. It occurs in great numbers in the limestones at Troy, but I have never seen a specimen of it showing all the parts in connection.

thirteen to Nos. 2, 3 and 4; fifteen to Nos. 2 and 3; while five are found in all four. No. 1 does not present as good facilities for examination as the others, and has yielded but five species; but when further studied it will, I have no doubt, furnish a larger number. Enough evidence has, however, I think, been obtained and here presented to prove that the limestones in question, with their associated beds, all belong to a single great series of strata. That some repetitions occur in this series I have but little question; but I have been unable, thus far, to identify with certainty the rocks of any of the exposures examined with those of other exposures situated either to the east or the west of them. The thickness of this series remains still undecided. I do not conceive that limestone No. 4 forms the eastern limit of this series: on the contrary, there is much to lead me to suspect that the formation has a rather wide spread beyond; but as the beds to the east of this band that I have examined have, up to this time, proved barren of fossils, I have made the section to terminate with it.

This series I consider for the present to occupy a lower geological horizon than the typical Potsdam sandstone of the New York survey; and to be of nearly if not exactly the same-age with the *Olenellus* or Georgia slates of Vermont, and the *Olenellus* limestones on the north shore of the Straits of Belle Isle, determined by Mr. Billings. It may yet prove to be a trifle more ancient or more recent than the above named strata, but there can, I believe, at any rate be no great difference between them in this respect. The fauna of this series is wholly distinct specifically from that of the Upper Potsdam of Wisconsin and the true Potsdam of New York, as well as from that of the more ancient St. John's or Menevian group of New Brunswick and its equivalent in the Primordial of Newfoundland; although connected generically with each of them and strongly so with both that of the Upper Potsdam and Menevian. It will be observed that in this fauna the genus *Microdiscus* is represented by two species. This genus is new to the fauna of the Lower Potsdam, but it will probably yet be found to range throughout the Primordial, since it is known from both the Longmynd and Menevian groups of Wales, the St. John's group of New Brunswick, the Lower Potsdam as above stated, and may possibly be present in the Upper Potsdam of Wisconsin, in the shape of certain minute pygidia referred by Prof. Hall with doubt to *Agnostus* (16th Reg. Rep. 1863, p. 180). It occurs also, as is well known, in Augusta county, Virginia, where it is associated, according to Dr. Emmons, with graptolites. The genus *Archæocyathellus* is, so far as known, peculiar to the fauna of the Troy limestones.

On the south shore of the St. Lawrence, in Canada, there occurs a great series of strata referred by the Geological Survey of Canada to the Potsdam group, the conglomerates of which have afforded several of the species found in the Lower Potsdam at Troy, as well as several occurring in the Lower Potsdam of Vermont and Labrador, with many others. The exact age of the formation holding these conglomerates is not yet positively settled; but it is, by Mr. Billings, regarded as at least not far from that of the Potsdam.

The fauna of the Troy limestones appears to me to supply in part a long-recognized blank in the Paleontology of our State. The Primordial fauna with us has hitherto been a meager one, being confined, with the exception of *Scolithus*, to the few species found in the Potsdam sandstone at Keeseville, Essex County. In the Troy limestones we now have, however, quite an extensive and strongly-marked fauna, establishing many important relations between these rocks and the Primordial of other regions and other horizons, both at home and abroad. This fauna is probably yet far from complete; and should these rocks be further investigated, I have no doubt that many additions will be made to it in the future. My own opportunities for study in this field have been very far from what I could have desired; and have prevented me from giving to it that connected and systematic investigation of which I believe it eminently deserving.

Descriptions of new species of Fossils from the Lower Potsdam group at Troy, N. Y.

Microdiscus speciosus, sp. nov.

Description.—Head destitute of eyes and sutures, semi-elliptical, with a conspicuous border all around, thickened at the edge, which in the majority of cases carries from 5 to 6 minute tubercles on each side; border expanded in front. Glabella long, conical, prominent, smooth, without neck furrow, extending in an obscurely triangular projection slightly beyond the posterior outline, separated from the cheeks by rather wide and deep dorsal furrows, sometimes, though only in very rare instances, obscurely lobed by from three to four faint furrows on each side. Cheeks convex, prominent, well defined by the dorsal and marginal furrows. Posterior angles narrowly rounded.

2.

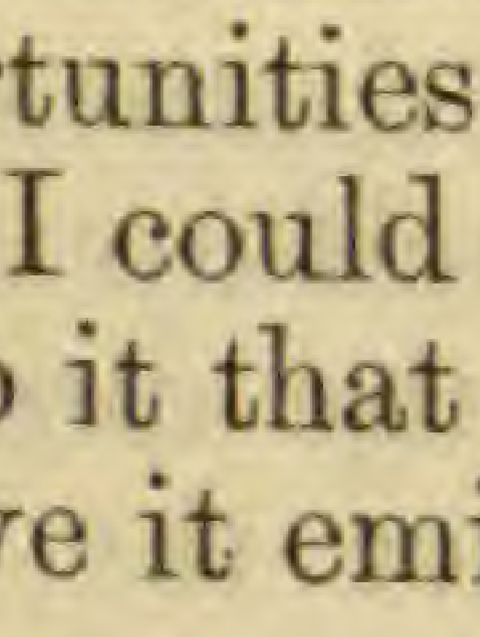


Fig. 2. *Microdiscus speciosus.* *a.* Head; *b.* Pygidium. Natural size. The parts figured belong to two different individuals.

Thorax with four equal segments. Pleuræ pointed, straight except at their extremities, which are bent down and slightly recurved, deeply grooved for nearly their whole length. The rings of the axis have a slight groove across them in the posterior half of each. The fourth or hindmost ring appears to be anchylosed to the pygidium, at least it invariably accompanies it when the latter is found isolated.

Pygidium as long as the head and of nearly the same shape, but slightly narrower, taking the extreme measurements, and more rapidly tapering; gracefully curved in outline. Marginal rim distinct all around, widest anteriorly, distinctly raised or thickened at the edge. Axis conical, sometimes acutely so, long and slender, extending very nearly to the margin, divided by faint cross furrows directed slightly backward into eleven rings or segments. Side-lobes highly convex and without furrows. The axis and side-lobes appear to overhang the marginal rim at the posterior extremity, giving the border the appearance of being only about half as wide behind as it is in front.

The entire surface is finely punctate. In one specimen of the pygidium, out of a large number of perfect specimens examined, there appears to be a twelfth ring in the axis.

Length of a specimen of the usual size with all the parts in place, but too imperfectly preserved to be figured, half an inch. Length of thorax 0·13 of an inch. I have seen but a single specimen showing conclusively the true number of thoracic segments. This species had the habit of rolling itself up into a ball, and is quite often found in this state. In the specimen just noticed, the pygidium is bent slightly under the body. Nearly all of the specimens that I have seen, that were in a perfect condition before extraction, exhibit this tendency to coil themselves up, which appears to account for the thorax breaking away in most cases.

This pretty little trilobite occurs in both even-bedded and conglomerate limestones of the Lower Potsdam at Troy; also at Bic Harbor, Canada, where it has been collected by Mr. T. C. Weston of the Geological Survey of Canada. The Troy specimens were collected by the writer. It is a rather common fossil at Troy, the head and pygidium usually occurring detached from the thorax. The head sometimes attains a length of 0·38 of an inch, but this is quite unusual.

This species closely resembles *Microdiscus punctatus* (Salter), from the Menevian group of Wales;* but it differs from that species in not possessing a neck spine, in the greater number of its caudal rings, and in having the marginal rim of the head tuberculated. The head, compared with that of *Microdiscus Dawsoni* from the St. John's group of New Brunswick (Acadian Geology, Dawson, 1868, p. 654), is proportionally longer, and is wanting in the grooves of the border of that species.

Leperditia Troyensis,† sp. nov.

The following description is based upon a single right valve, the only specimen of this species that I have seen.

---

* Quart. Jour. Geol. Soc., Aug., 1864, p. 237.

† Figures of this and the following species will be given hereafter.

Description.—Minute, obscurely pentagonal in outline, greatly narrowed in front, broad behind, narrowed at either extremity, posterior one somewhat obtusely angular. Dorsal margin straight, ventral margin gently rounded. Surface depressed convex, convexity greatest a little behind the mid-length. Eye-tubercle prominent. Marginal rim well-defined all around except at the hinge. A distinct marginal groove can be traced entirely around the carapace, but it is very faint in the upper portion. It is most distinct along the forward half of the ventral outline. Surface smooth and polished.

Length 0·18 of an inch; breadth 0·12. Occurs in even-bedded limestone of the Lower Potsdam at Troy. Collected by the writer.

The characters of this species agree very closely with those of *Leperditia Solvensis* Jones,* from the Menevian group of Wales: but our species is larger, a little different in shape, and provided with a distinct eye-tubercle. They appear, however, to be very nearly related.

In the limestones at Troy there occur certain small lamellibranchiate-like shells whose affinities I shall leave for the present an open question. They are very abundant, and are represented up to this time by a single species. Externally they present something of the appearance of a small *Modiolopsis.* As no undoubted lamellibranchiates have, however, been hitherto detected in strata certainly more ancient than the Calciferous Sandrock, it is quite possible that, when they come to be better understood, they will be found to belong to some as yet imperfectly known group of crustaceans. While I am unable to decide to what class they belong (although inclining to the belief that they are lamellibranchiates), I consider some notice of them needful here and shall describe them as fully as the material will allow, without for the present giving them a distinct name. The following is the description:

Bivalve of uncertain class, gen. nov. ?

Description.—Shell transversely oblong or suboval in outline, convex, widest posteriorly, narrowed at either extremity, with an oblique posterior ridge, and small depressed umbones situated anteriorly, sometimes presenting an obscurely bi-lobed appearance in front. Dorsal margin nearly straight, ventral margin uniformly rounded. In the interior of the left valve, as shown by a gutta-percha cast of an impression in stone of this valve, there is a wide and deep furrow with a slightly raised line along the middle of it corresponding to the oblique ridge on the outside; and a distinctly impressed line passing

---

* Annals and Magazine of Natural History, 2d series, vol. xvii, Feb., 1856, p. 95.

from the lower anterior into the upper posterior portion of the valve following the curved ventral edge, from which it is separated by a broad flattened border. This line is deeply sunken anteriorly, becomes almost obsolete or discontinuous in passing the oblique internal furrow, beyond which, in the posterior portion of the shell, it is less distinct, though clearly shown. Just in front of and above the anterior limit of this line there is a slight conical protuberance. Further than this nothing can be made out, owing to the imperfection of the material. The shell is thick, with the surface finely striated concentrically.

I have never observed a specimen of this singular little shell with the two valves together, but they are frequently found side by side in the same hand-specimen of stone.

Length rarely more than 0·16 of an inch; usual width about 0·10. Occurs in both even-bedded and conglomerate limestone of the Lower Potsdam at Troy. Collected by the writer.

Besides the foregoing species I have from the Troy limestones several specimens of an *Orthis*, but too imperfect to describe; and also a few specimens of what seems to be an undescribed *Lingulella*, which cannot at present be dealt with for the same reason.

Troy, N. Y., May 14th, 1873.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a new Determination of the Earth's Density.*—Cornu and Baille have redetermined the density of the earth by means of the torsion-balance, first employed for this purpose by Cavendish in 1798. Their researches commenced with a complete study of the torsion-balance, as an instrument for absolute measurements. Profiting by the information thus acquired, they constructed the apparatus with which to obtain the constant of attraction—and hence the earth's density,—in a cellar room of the École Polytechnique. The lever of the torsion-balance consisted of a small aluminum tube 50 centimeters long, carrying at each extremity a copper ball weighing 109 grams. At its center was a small mirror, which reflected to the reading telescope the image of a scale placed 5·6 meters distant. The filament of suspension was an annealed silver wire, 4·15 meters long. It was put in position in September, 1871. At the time of the experiment, the balance made a double oscillation in 6m. 38s. The attracting mass was mercury contained in two hollow cast-iron spheres 12 centimeters in diameter, so connected that all the mercury could be forced into either or be divided between them. As improvements over the apparatuses used by Cavendish, Reich, or Bailly, the authors

note: 1st, the reduction of the size of the apparatus to one fourth, which is an advantage, since—the time of oscillation being the same—the deviation is independent of the weight of the suspended balls and inversely as the homologous dimensions; 2d, the use of mercury instead of lead; 3d, the elimination of electric perturbations by good ground connections; and 4th, the electric registering apparatus, which gives graphically the number of oscillations, the time of each, and the minor attending circumstances. Two series of observations, comprised in twenty groups, and including more than two hundred complete oscillations, were made with this apparatus, one being in the summer months of July and August, the other in the fall and winter months of 1872–73. The summer series gave for the mean density of the earth 5·56; the winter series 5·50. The mean variation was 1·25 per cent for the summer, and 1·5 per cent for the winter series. The difference in the results is due to a slight flexure of the lever; the authors regard, therefore, the first above given as the more accurate. Moreover, the value obtained decreases according to an almost regular law, as the attracted masses increase: varying from 6·02 when the lever was used alone, to 5·60 when the mass upon it was heaviest. This source of error is eliminated when the mass of the lever is inappreciable in relation to that of the balls. Calculating the limiting value by applying an empirical formula representing this law of variation, the mean density of 5·55 is obtained. The authors take 5·56—the mean of the summer determinations given above,—as accurate to within one per cent.—*Compt. Rend.*, lxxvi, 954, April, 1873. G. F. B.

2. *On Spectral Lines of Low Temperature.*—The Marquis of SALISBURY has observed that there appears in the tube of a thermometer whose bulb rests on an insulated metallic plate connected with one of the secondary poles of a powerful induction coil, the other pole being unconnected, a greenish light in the vacuum above the mercury, produced, as it would seem, by induction. The point of special interest, however, is the fact that no perceptible heat attends this light, uninterrupted action even for five minutes producing a rise in the mercurial column of only three-fourths of a degree; and even this, the author thinks, may not be due to heat. This light then, appears at a temperature below 60° F. It is strong enough for spectroscopic examination, and affords a spectrum differing in different thermometers. Instruments of the best makers, like Casella and Elliott, gave only three lines which were identified as mercury lines. A feeble fourth mercury line appeared once. In thermometers of makers of less repute, four additional lines appear, which, by comparison, were ascertained to be carbon lines. They are due, evidently, to a want of cleanliness in preparing the instrument, the surface of glass seeming to attract readily thin films of grease. In a very dirty thermometer, one or two additional lines appeared in the green. These results are interesting since they show that carbon vapor becomes luminous under electric influence at a lower temperature

than hydrogen. If, for example, a Geissler tube containing a hydrocarbon be arranged as described above, and the free pole be applied to the upper end, the full discharge passes, and the hydrogen F and the carbon lines *ff* appear. But on withdrawing the free wire, F disappears while the carbon lines remain, nearly as bright as before. As, therefore, the carbon lines are visible when the hydrogen lines have not yet appeared; so the carbon lines have begun to expand while the hydrogen lines still remain sharp, and may reach the condition of a continuous spectrum much sooner. The author suggests that by admixture of other elements with the mercury of a thermometer, the lowest temperature of their luminosity may be determined.—*Phil. Mag.*, IV, xlv, 241, April, 1873. G. F. B.

3. *On the Solvent power of liquid Carbon Dioxide.*—By means of an ingenious apparatus, consisting essentially of a hydrostatic press, by which mercury may be forced—if necessary, under a pressure of 900 atmospheres—into a cylindrical reservoir of glass terminating in a narrower thick tube, CAILLETET has succeeded in liquefying carbon dioxide gas under conditions which enable him to test its properties. Liquid carbon dioxide is colorless, mobile, and a non-conductor of electricity. A powerful induction-spark appears white and dazzling in the liquid, but does not decompose it. Attempts to determine its coefficient of compressibility gave no uniform results. Sodium chloride, sodium sulphate, calcium chloride, calcium carbonate, sulphur, phosphorus, stearin, and paraffin, are insoluble in carbon dioxide. Iodine is sparingly soluble, with the color given by carbon disulphide. Potassium carbonate becomes dicarbonate (?) insoluble in an excess of the liquid. Water dissolves it only slightly, petroleum 5 or 6 times its bulk. It is only slightly dissolved by carbon disulphide, but is miscible with ether in all proportions. It dissolves liquid, but not solid fats, and is not reduced by sodium.—*Compt. Rend.*, lxxv, 1271, Dec., 1872. *Bull. Soc. Ch.*, II, xix, 20, Jan., 1873. G. F. B.

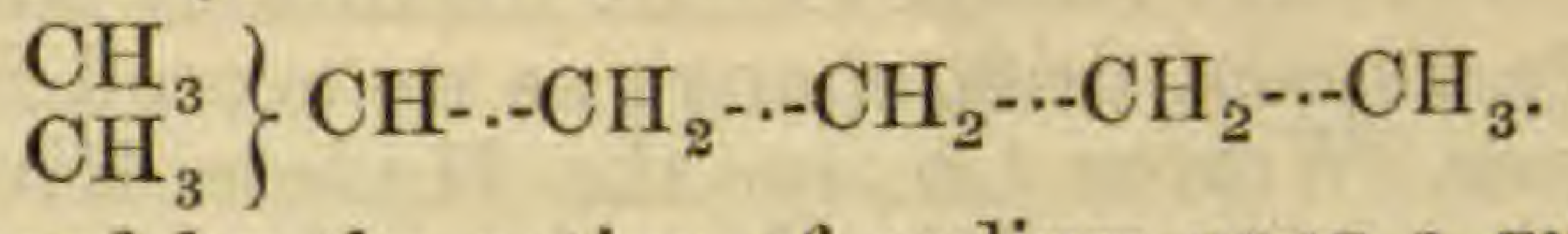
4. *On the Density of the Vapor of Phosphoric Chloride.*—Two theories of equivalence are in use; one of these assumes it to be variable, the other invariable. Phosphoric chloride has been appealed to by both parties in proof of the accuracy of their positions; the one claiming that in PCl_5 the phosphorus was a pentad, while in PCl_3 it was a triad; the other that phosphorus was always a triad as in PCl_3, and contending that PCl_5 was a *molecular* combination of PCl_3 with Cl_2, as was proved by the density of its vapor. WURTZ, as the champion of the former view, having ascribed its anomalous vapor-density to dissociation, has redetermined this density, taking care to reduce the dissociation to a minimum. He first used the methods of Wanklyn and Playfair, and volatilized the chlorides in a balloon containing air, immersed in a bath of paraffin, at temperatures from 129° to 145°, and under a pressure of vapor of 148 to 391 mm. The results gave a density for the vapor of 6·118 to 6·7; mean 6·5. The calculated density for two volumes is 7·217. In his second series of experi-

ments, Wurtz sought to avoid the dissociation by diffusing the vapor of the phosphoric chloride in a space filled with one of the products of this dissociation, phosphorus chloride. In this way, a series of twelve experiments was made, at temperatures from 160° to 175°. The results are as follows, the number of the experiment being given in the first line, the density obtained in the second, and in the third the tension of the vapor in millimeters of mercury:

I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
7·25	7·38	7·74	7·06	7·03	8·30	6·88	7·16	7·44	6·80	7·00	6·68
194	338	168	271	343	174	411	394	214	413	318	423

The mean of these results is 7·226; a number according well with the calculated density, 7·217. Hence when dissociation is prevented, phosphorus chloride is normal in vapor density, the compound PCl_5 is an atomic combination, in which each chlorine atom has an equal value, and the equivalence of phosphorus is variable.—*Compt. Rend.*, lxxvi, 601, March, 1873. *Bull. Soc. Ch.*, II, xix, 451, May, 1873. G. F. B.

5. *On Ethyl-amyl.*—This hydrocarbon was discovered by Wurtz in 1855 and has since been investigated by Schorlemmer, who obtained from it the chloride, acetate, alcohol, and corresponding acid. This latter chemist having proved that each of the normal paraffins, on treatment with chlorine, gives both a primary and a secondary chloride, it appeared of interest to test this question in the case of paraffins not normal in constitution. GRIMSHAW, under his direction, has investigated ethyl-amyl, which, since it is obtained from amyl alcohol, has the constitution



$$\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right\}CH\text{--}CH_2\text{--}CH_2\text{--}CH_2\text{--}CH_3.$$

It was prepared by the action of sodium upon a mixture of ethyl and amyl bromides, the former being in excess. From 150 grams of each, 100 grams of product were obtained, 80 grams of which were ethyl-amyl and 20 grams diamyl. After purification, the former boiled constantly at 90° and had a specific gravity of 18·4° of 0·6833. On chlorination, a product boiling from 140° to 150° was obtained; this was converted into the acetate, which boiled from 160° to 175°; and yielded, on treatment with potassium hydrate, a mixture of two alcohols, one boiling at 146°–148°, the other at 163°–165°. These were oxidized together, and afforded (1) isoœnanthylic acid, boiling at 210°–213°; and (2) methyl-amyl-ketone, boiling at 143°–145°. Hence the primary alcohol above mentioned is isoheptyl alcohol, and the secondary alcohol is methyl-amyl-carbinol. From these results it appears that ethyl-amyl or dimethyl-butyl-methane, is acted upon by chlorine in the same way as the normal paraffins.—*J. Chem. Soc.*, II, xi, 309, April, 1873. G. F. B.

6. *On a New Synthesis of Aromatic Acids.*—Since the alkali-alcohols, when acted upon by carbon dioxide, yield fatty acids, the phenols thus treated may be expected to give homologues of salicylic acid. So the acetylene series of hydrocarbons, yielding,

as they do, metallic derivatives easily, should, by this treatment, also afford a series of acids. PATERNÒ, therefore, passed a current of dry carbon dioxide gas through acetenyl-benzol, containing fragments of sodium. By suitable methods the product was purified and found to be phenyl-propiolic acid, $C_6H_5.C{\equiv}C.COOH$. He is still investigating this subject.—*Gaz. Chim. Ital.*, ii, 553, Feb., 1873. G. F. B.

II. GEOLOGY AND NATURAL HISTORY.

1. *On Glacial Movements in Northern New York;* by R. P. STEVENS. (Editorial correspondence, dated New York, June 17, 1873.)—I have just come back from a trip into the mountains west of Westport, Lake Champlain, returning via Whitehall through the northwest corner of Saratoga Co. On my trip, I kept constantly in mind the subject of glacial movements, and made many observations confirmatory of the view, that the courses in the valleys corresponded to the direction of these valleys.

1. Along the valley of Lake Champlain, in the lower lying rocks, the general direction of the striæ corresponded to the longer axis of the valley or north and south, though there was a variation of 20°.

2. On the higher hills and mountains the striæ are more from the northwest to southeast. This is very apparent at Split Rock Mt., just north of Westport, also in the mountains west toward Elizabethtown, and at Mt. Moriah. It is a striking feature of the landscape to see the struck side of mountains and the streaming through the gaps of drift, change as we ascend from the lake.

3. At Luzerne, Warren Co., on the Hudson River, the drift moved down the stream or southward, conforming to the trend of the valley, and forms long and high sandy ridges with or without large boulders. In the town of Corinth, it occurs piled into large hills and filling up an ancient valley.

4. But, in Hadley, Saratoga Co., just opposite the village of Luzerne, the Sacanadaga River flows from the west, the valley opening into the Hudson at almost right angles. The drift flowed down this valley or eastward, even in some bends having a north of east direction.

Ascending Mt. Anthony, which lies in the angle of the two rivers, we find evidence of drift flowing over from the northwest. This is more marked on ascending from the Sacanadaga into the mountains of Day Township. When up to the height of these mountains, we could plainly see that the drift moved over the valley and over the Kayderoseras Mts. south of it. Their heads have been shaved off by ice action, which moved over them from the northwest.

It was to me very interesting to find such confirmation of the view set forth by Prof. Dana. I thought I could see just where the change of course took place as we ascended the hills, and I hardly doubt, that if I had been on foot and had my aneroid with me, I could have marked the exact elevation above the valleys, and observations made at widely separated localities would have confirmed each other.

In the valley of Champlain, I found seven distinct terraces from the water level up to 750 feet. I found *Tellina Groenlandica* in No. 1 and No. 4, the latter two hundred and fifty feet by estimate above the lake.

2. *Deep-sea chalky deposits but little magnesian.*—The analyses which have been made of the chalky mud that has been brought up from the bottom of the Atlantic, have found but little magnesia. An analysis by J. Hunter obtained (Jour. Chem. Soc., II, viii, 144) 4·00 per cent of carbonate of magnesia to 61·34 of carbonate of lime; and another of J. Mahony (Chem. News, xxi, 91) 1·76 per cent to 58·80 of carbonate of lime. Besides these constituents, Hunter's analysis found 23·36 silica with 5·31 of alumina, 5·91 of sesquioxide of iron, besides the above = 99·92; and Mahony's, 26·60 silica, 3·80 sesquioxide and phosphate of iron, with 4·20 of soluble salts, 2·30 of organic substance, 2·50 water and 0·08 FeO.

An analysis by C. W. Gümbel (Jahrb. Min., 1870, 753) of a specimen stated to have been obtained in 29° 37′ N. lat. and 18° 20′ W. long., at a depth of 2,350 fathoms, and made after separating 10 p. c. of foraminifers and large, organisms, and 1·3 of mineral grains, found 1·26 per cent of lime and magnesia supposed to be in part combined with phosphoric acid, 1·44 carbonate of magnesia, with 59·65 carbonate of lime, 20·90 silica, 3·05 organic substance, and 2·34 water and loss.

3. *Nummulites and Orbitolites in the Mesozoic, Belemnites in the Eocene, and Ammonites in the Carboniferous.*—GÜMBEL has announced the occurrence of a species of Nummulite, which he names *N. Jurassica*, in the Jurassic beds of Franconia; also two species of Orbitolites, *O. præcursor* Gümb. and *O. circumvallata* Gümb., in the Lias of the vicinity of Roveredo (Jahrb. f. Min., 1872, 241), although till recently this genus was unknown from rocks below the Cretaceous. We now know also of Eocene belemnites—*B. rugifer* Schlœnb.—from the Eocene of Ronca; and lately Mr. Waagen has discovered, in the Carboniferous formation of India, supposed to be of the Carboniferous age, true Ammonites.—*Bibl. Univ.*, May 15, 1873.

4. *Bed of the Rhine at the falls of Schaffhausen changed in the Glacial era.*—Mr. WURTEMBERGER observes that the falls of the Rhine at Schaffhausen did not exist in the Glacial era. The river at the falls is cut out of the Upper Jurassic limestone, and its right bank is covered with well characterized drift. Along a course cutting off the present bend in the stream, there is no trace of the limestone, and only deposits of pebbles, indicating the site of an old N.N.E. and S.S.W. valley of erosion or river bed, nearly in the direct course of the stream. The glacial deposits evidently filled this ancient valley, and thus forced the river from its course, giving it a bed around south and west to a point where, by a fall

of about eighty feet, it regains again its old channel.—*Jahrb. Min.*, 1871, 582.

5. *Phosphatic character of the shells of Obolus.*—Analyses by A. Kupffer show that the shells of Lower Silurian *Obolus* have nearly the composition of a fluor-apatite. He obtained from a specimen from Jamburg in Ehstlands,

$\overset{\cdot\cdot\cdot\cdot\cdot}{\bar{\mathrm{P}}}$	$\ddot{\mathrm{C}}$	Fl	$\overset{\cdot\cdot\cdot}{\bar{\mathrm{F}}}\mathrm{e}$	$\dot{\mathrm{M}}\mathrm{g}$	$\dot{\mathrm{C}}\mathrm{a}$	ign.	quartz.
36·57	2·42	3·31	4·90	0·62	50·47	2·57	0·53=101·39

from which, deducting the oxygen in excess, on account of the fluorine, 1·59, leaves 99·80.

A concretion of Trilobite shells contained, according to the same chemist, PO_5 19·45, CaO 45·06, CO_2 16·45, Fl 2·88, with a little FeO, MgO, and 6·80 of volatile matters mainly bituminous, corresponding to 42·46 phosphate of lime, 31·81 carbonate, 5·91 fluorid of calcium, with some carbonate of iron, and other impurities.

6. *Statistics of Mines and Mining in the States and Territories west of the Rocky Mountains* (for 1871); by ROSSITER W. RAYMOND, U. S. Commissioner of Mining Statistics. Washington: Government Printing Office, 1872. 566 pp. 8vo.—This volume, so long expected, has been delayed by no fault of the author, whose promptness in the dispatch of his work is well known. It embodies the statistics of 1871, and is known as the Report of 1872, but its publication has been delayed until July, 1873, although copies were distributed to members of Congress in March, 1873. This delay in the issue of a document so important to a large number of persons engaged in industrial and scientific pursuits in a great degree, baffles the object of the Commissioner—which the Commissioner on his part so well and promptly discharges. The contents are divided in three parts, into twenty-one chapters with an introduction and appendix. Part I, Condition of Mining Industry. Part II, Metallurgical Processes. Part III, Miscellaneous. The States and Territories considered are California, Nevada, Oregon, Idaho, Montana, Utah, Arizona, New Mexico, Colorado, and Wyoming. The details of facts respecting each of these regions are full of interest, and are compiled with care from the most authentic sources. The chapter on the treatment of auriferous ores in Colorado is translated, with annotations by the Commissioner from a series of articles by Mr. Albert Reichenecker of Central City, Colorado, printed originally in the German *Berg- und Hütten-Zeitung*, and is illustrated by original drawings of the mill machinery and a full discussion of the results of crushing and amalgamation. The results of Mr. J. D. Hague's investigation on the same subject (*Mining Industry*, vol. iii, King's 40th Parallel Survey) are also given, both as to the mechanical treatment of ores and the results of smelting. A chapter is given on the "Speed of Stamps in Colorado," and another on "The Washoe Pan Amalgamation," abridged from Mr. J. D. Hague's memoir in the volume just named, and, for the chemical part, from the researches of Mr. Arnold Hague in the same volume. The Plattner Chlorination process for the treatment of Auriferous Sulphurets

contain the latest results by Dabken, of Grass Valley, who is the best authority for the American development of this method—and Mr. F. B. Miller's gold refining by chlorine gas, as practiced in Australia, is also given in detail. The smelting of silver ores (chapter xv) completes the list of metallurgical processes. The bullion products of the U. S. have been carefully compiled by Mr. Raymond, and we append from the Mining Journal the amounts produced for the years from 1869 to 1872 inclusive.

	1869.	1870.	1871.	1872.
Arizona	1,000,000	800,000	800,000	625,000
California	22,500,000	25,000,000	20,000,000	19,049,098
Colorado	*4,000,000	3,675,000	4,663,000	4,661,465
Idaho	7,000,000	6,000,000	5,000,000	2,695,870
Montana	9,000,000	9,100,000	8,050,000	6,068,339
Nevada	14,000,000	16,000,000	22,500,000	25,548,801
New Mexico	500,000	500,000	500,000	500,000
Oregon and Washington	3,000,000	3,000,000	2,500,000	2,000,000
Wyoming	------	100,000	100,000	100,000
Utah	------	1,300,000	2,300,000	2,445,284
Other sources	†500,000	525,000	250,000	250,000
Total,	61,500,000	66,000,000	66,663,000	63,943,857

The decline of over two and a half millions in 1872 is attributed to the decline in the workings of shallow placers in California and the Territories; while the permanent works (quartz mines and hydraulic mines) have made increased returns, especially the silver mines of Nevada, which have increased 11½ millions since 1869. The product of 1872 was about equally divided between gold and silver mines, if the bullion of the Comstock lode is reckoned in the latter class. Mr. Raymond says: "The transition from precarious surface mining to organized permanent and extensive work is going steadily forward. Every year witnesses a substantial gain; and though the aggregate production may fluctuate, there is no real retrogression, but a constant advance, in this most important industry."

7. *Royal Mineralogical Museum in Dresden.*—A note by Dr. Geinitz in the Dresden Journal of June 7th, states that the Dresden Museum has been recently enriched by the gift of a specimen of *pterosaur*, recently obtained at Eichstädt, Bavaria, which has the *impression of the wings distinct;* and that in this respect and others it is so much like the specimen that was found at the same place in 1872 and purchased by the Museum of Yale College, that the two might be taken for twins. The spread of the wings is about three feet. The species is closely allied, according to Meyer, to the *Rhamphorhynchus Gemmingi.*

8. *Descriptive and Analytical Botany, by* Le Maout *and* Decaisne; *translated by* Mrs. Hooker, *with additions, appendix, &c., by* J. D. Hooker. pp. 1066, small 4to. 1873. London: Longmans, Green & Co.—The full title of this important work is subjoined,‡ for the advantage of the many who in this country are

---

* Including Wyoming. † Including Utah.

‡ A General System of Botany, descriptive and analytical, in two parts. Part I, Outlines of Organography, Anatomy, and Physiology; Part II, Descriptions

interested in botany, and who may desire or who ought to procure it. We could not in fewer words explain its nature and scope, the history of its production, and of its reproduction in the present form. It is the *desideratum*, the general work which we are unceasingly asked to indicate by teachers, botanical travelers, scientifically professional men, medical or other, and the amateur botanist, no less than by more serious cultivators of the science, who feel the want of something more than a local manual or flora and a common text-book. Since Lindley's Vegetable Kingdom ran out of print, there has been nothing in the English language to recommend, and perhaps nothing but the French original of this in any other. Lindley's volume was a noble one, in spite of serious faults, and it had the advantage—as yet unapproached—of giving an almost complete account of or references to the medical and economical uses of plants, as well as a list of all the known genera. In the present work, however, we find a judicious selection. Among its many merits, the crowning one, for the devoted botanical student, is in the most copious, excellent, and chiefly new illustrations (in wood-cuts) of the second and far most important part of the work. These give it a value which cannot be over-estimated. Those which are not original are taken from excellent sources, such as the Geneva Am. Bor. Illustrata. The whole are here reproduced from electrotypes taken from the French cuts, so that there is only the difference between the original and the English editions which one ordinarily perceives between the French and the English printing of such illustrations. The first is of much less consequence to us, and might have been abbreviated or revised in some particulars; but the copious illustrations are a great help.

The original work was duly noticed in this Journal. The English reproduction of it has reached us barely in time for the present announcement, which we are unwilling to postpone. Nothing which a critical examination is likely to discover can seriously qualify our judgment (founded on considerable use of the original in French, and a cursory examination of Mrs. Hooker's translation), that this ample volume well supplies a great want in this country; and that the heartiest thanks of all English speaking cultivators of the science are due to the wife of our eminent English botanist, for the spirit with which she has undertaken, and for the successful execution of, her most laborious share in its production. As to Dr. Hooker's part of the work, there is no need to commend it. The wonder is how and when he found time for it.

and Illustrations of the Orders. By EMM. LE MAOUT, M.D., Member of the Philomathique Society of Paris, and J. DECAISNE, Member of the Instistute of France, Professor of Cultivation, Jardin des Plantes, Paris. With 5500 figures by L. Steinheil and A. Riocreux. Translated from the original by Mrs. HOOKER. The Orders arranged after the method followed in the Universities and Schools of Great Britain, its Colonies, America, and India; with Additions, and Appendix on the Natural Method, and a Synopsis of the Orders, by J. D. HOOKER, C.B., F.R.S., L.S. and G.S., M.D., D.C.L., Oxon., LL.D., Cantab., Director of the Royal Botanical Gardens, Kew; Correspondent of the Instistute of France. London: Longmans, Green & Co. 1873.

We can only here add that, in its English form, the small folio is brought down to the small quarto, or rather to something between quarto and octavo (i. e., the volume is 10×7×2 inches), which will generally be thought an improvement. It is brought out under the cordial coöperation of the original authors, and is published, by the Longmans, for 52½ shillings. A. G.

9. *Fly-catching in Sarracenia.*—In the English edition of Le Maout and Decaisne's System of Botany, noticed above, I find the following note by the editor. There is nothing answering to it in the original French.

"*Sarracenia rubra* has been vaunted in Canada as a specific against small-pox, but has not proved to be such. The pitcher-shaped leaves are effective insect-traps; a sugary excretion exudes at the mouth of the pitcher and attracts the insects, which descend lower in the tube, where they meet with a belt of reflexed hairs, which facilitate their descent into a watery fluid that fills the bottom of the cavity, and at the same time prevents their egress." (p. 214.)

Sarracenia rubra (which does not grow within several hundred miles of Canada) is a slip; *S. purpurea* being meant. But the present object is to call attention to the statement that *Sarracenia* produces a sugary excretion which attracts flies to their ruin, this being the first time, so far as I know, that any such statement has appeared in print. The fact of the excretion in *Sarracenia flava* is certain. My attention was called to it several months ago by Mr. Hill of North Carolina, who had observed it, who rightly described the excretion as appearing on the inner face of the over-arching hood, just above its base, and who insisted—I know not upon what evidence—that it intoxicates or stupifies the insects that sip it, whereupon they tumble into the well beneath. To test this statement, some strong plants were secured by Mr. Canby and myself, during a visit to Wilmington, N. C., in April last. We observed then and since, that the water which fills the bottom of the narrow tube, and in which flies are drowned, is a secretion; it distils in drops from the inner surface of the young pitcher, before the orifice opens; yet, in this species and in *S. purpurea* (unlike *S. psittacina* and *S. variolaris*) there is little to hinder rain from falling in; and from this source I imagine most of the water comes which is found in old leaves. But it was only recently, and after a summer temperature was established, that any traces of the "sugary excretion" over the orifice could be detected. This made its appearance at first in the form of minute pearly globules, distinctly visible only under a lens; at length it forms flattened drops, and even patches, distinctly sweetish to the taste and viscid to the touch. I have not found any of this excretion at the orifice of the pitchers of *S. purpurea*, nor in *S. variolaris*, but I have not had good materials for observation in the latter case.

That the insects which abundantly fall or find their way into *Sarracenia* pitchers do not generally escape, but die and decompose there, is obvious. That more commonly they do not perish by drowning in *S. flava* is equally clear. While all the lower and gradually attenuated part of the tube is filled with dead flies in our plants growing in the house, there is only a little moisture at the very bottom. One would hardly think that the fine and sharp deflexed bristles, which line the lower half of the tube only in *S. flava*, would greatly impede the return of a fly, they lie so closely against the wall of the tube. But I find that a house-fly, either large or small, when thrown into this lower part of the tube, is quite unable to get out, and there it perishes. Probably the advantage derived by the plant is equally secured whether their prey decomposes in the moist air of the cavity or in the water in which they are often immersed.

A main object of the present publication of this note is to ask observers to note whether any viscid secretion appears anywhere on the smooth portion, below the orifice of the pitcher, of *S. purpurea.* I am confident there is none upon the hood, which is wholly beset with unusually stiff deflexed bristles. I have had no full-grown specimens of this season to examine; and from analogy I should expect the sugary secretion, if any, to appear only in warm weather. A. G.

10. *Dionæa.*—The brief account of the action of this queen of fly-traps in Le Maout and Decaisne's Treatise, now becomes so much more conspicuous in its English dress, that it may be worth while to note, 1. that one does *not* find "on their upper surface two or three glands which distil a liquid attractive to insects." The scattered bristles on the surface of the trap, through which the sensitiveness is manifested, secrete no liquid. 2. Nor is it true that "when the insect is dead and all movement has ceased, the plates expand again and await a fresh victim." The trap does not open until, after several days, it has digested the soluble parts of its prey. This part of the work was probably prepared by Le Maout; and to several other statements in it may be extended the disclaimer appended to some of them by the English editor, viz: that they are opposed to all the established phenomena of plant-life, as known to English observers. A. G.

11. *Primitiæ Monographiæ Rosarum*, auct. F. CRÉPIN: fasc. 2, 1872.—M. Crépin, one of the curators of the Royal Belgian Museum of Natural History at Brussels, and an able botanist, devotes a large part of this pamphlet of 130 pages to a revision of the Roses of the Herbarium of Wildenow. It is a separate issue from the Bulletin of the Royal Botanical Society of Belgium, May 11, 1872. It contains some matters of interest to us.

Under *Rosa Kamschatica* is an important discussion of the species and its whole history, identifying it with *R. rugosa* Thunb., to which also belongs *R. ferox* Lind., and the recent *R. Regeliana* of the *Illustration Horticole.* It is the Hedgehog Rose of the old English gardens.

Rosa blanda is also critically discussed, and on the whole *R. fraxinifolia* of Gmelin is thought to be a cultivated form of it.

Rosa Carolina L. The first and the sixth sheets represent this species; the rest, at least in part, belong to *R. lucida.*

Rosa parviflora Ehrh. All the specimens appear to be of this species, and the first sheet came from Muhlenberg.

Rosa lucida Ehrh., came also in part from Muhlenberg. Crépin concludes that it is a very polymorphous type, and the union of *R. parviflora* with it is apparently justified. But he is to consider the question in a special article on the American Roses.

Rosa nitida Willd. The first folio in the herbarium under this cover belongs to *R. Sinica* (*lævigata* Michx.), as had been already stated; the second, along with one specimen of the species in question (as cleared up by a specimen from the Botanic Garden, preserved in Link's herbarium), contains two which are thought to belong to *R. parviflora.* The question, whether *R. nitida* can be a form of *R. lucida*, is reserved.

Rosa gemella Willd. The first folio contains *R. Carolina*, a slender specimen. The second, probably the type of the species, Crépin supposes to be the "*R. blanda*, auct., non Jacq. R. Solandri," i. e., *R. blanda* Ait., to which the present writer referred it. It may be worth noting that it was not "Torrey qui avait examiner l'herbier de Willdenow," but his associate.

We solicit for M. Crépin copious specimens of all our wild Roses, in all their forms, and from every part of the country. To any who will thus contribute good materials for the monograph which he is engaged upon, Dr. Crépin will return critically named specimens of European Roses. A. G.

III. ASTRONOMY.

1. *A Catalogue of Auroras observed from* 1776 *to* 1784, *in Labrador.* (Communicated by CLEVELAND ABBE.)—There has lately come into my possession a manuscript volume of meteorological observations made at Nain, Labrador, in 1776–1784, and at Okkak in 1778–1782. Portions of these observations have been long ago made use of by meteorologists, but the complete series has never, that I am aware of, been reduced; indeed its very existence has been known to but few. At present, in view of the interest taken in the questions relating to the secular periodicity of the aurora, I propose to give merely the dates on which such are noted in the journal of observations, omitting entirely the sometimes quite minute remarks of the observer, as to the characteristics of the individual appearances. The auroras are generally described under the heads of "Nord Licht," "Nord Schein," "Bogen Licht." In the latter case the directions and positions of the arcs are generally given.

The records were made by the following observers:

At Nain, by Samuel Liebisch, 1776 Oct. 1 to 1780 Aug. 31; by David Krügelstein, 1780 Sept. 1 to 1784 July 31, and a note on the aurora of 1784 Aug. 14.

At Okkak, by Jens Hafen, from 1778 Oct. 1 to 1782 Aug. 3.

It will therefore be seen that the record here given for Okkak is a continuation of that published by De la Trobe for the same place, for the years 1777 August to 1780 July, whilst on the other hand De la Trobe's records for Nain from 1777 August to 1780 August are probably identical with the corresponding portions of the observations by Liebisch, in the work now in my hands.

The list of dates of auroras is as follows: I have by a star designated those dates that are given in Lovering's Catalogues, on which auroras were recorded elsewhere.

Auroras observed at Nain, Labrador.

1779. Feb. 12;* Nov. 11.
1780. Sept. 1, 2,* 4,* 5, 6, 25, 26; Oct. 7, 21, 24,* 25, 29; Nov. 1, 15, 17, 25,* 28;* Dec. 1, 2, 17, 19.* 30.*
1781. Jan. 21;* Feb. 1, 22; March 3, 6, 11, 19,* 23,* 26, 29;* April 18; Aug. 17,* 24, 25,* 26,* 30, 31; Sept. 11, 12, 17, 20, 21, 26;* Oct. 15,* 18,* 19, 28; Nov. 9, 10, 11, 13,* 14,* 15,* 16,* 22 (7 a. m.), 25; Dec. 5, 6, 12* (6 and 7 a. m.), 15, 16,* 20.
1782. Jan. 2,* 16, 17; Feb. 2; Aug. 1, 13, 14, 22,* 30;* Sept. 7, 9,* 12,* 13;* Oct. 3,* 26;* Nov. 7, 18, 19 (7 a. m.), 19* (8 p. m.), 20 (7 a. m.), 20* (8 p. m.), 23, 25, 26,* 28.
1783. Feb. 4, 6, 24; March 7; April 23, 24;* Aug. 3, 14, 15, 19,* 22, 25; Sept. 3, 18, 23, 24, 26;* Oct. 1, 4, 12, 17, 23,* 25, 26,* 27,* 28, 29,* 31;* Nov. 2, 14,* 15,* 25, 27; Dec. 16, 18.*
1784. Jan. 9, 10,* 15, 19, 26, 28, 29; Feb. 9, 10, 19, 20, 21, 23;* March 3, 19,* 24; May 5,* 8 (?); Aug. 14.

Auroras observed at Okkak, Labrador.

1778. Nov. 23.
1779. March 24;* Sept. 4,* 5, 14,* 16, 17,* 18,* 19,* 20; Oct. 21; Nov. 3,* 7,* 11, 18.*
1780. Feb. 9.
1781. Oct. 28.

The comparison of these two records sufficiently shows that neither can lay claim to great completeness; the observer, Krügelstein, seems to have been specially on the watch for auroras, but it should be remembered that the period, 1780–1786, was one of the periods of great frequency of this phenomenon.

Of the 145 dates above given for Nain, 93 are not found in the extensive compilations of Lovering, and of the 17 dates for Okkak 8 are wanting in Lovering; of these latter, however, two are found in the record for Nain, leaving 99 new dates of auroras as the result of the present communication.

Washington, July 11, 1873.

2. *Meteors of Nov. 27th*, 1872, *at Teneriffe, Canary Islands;* by O. Frederica Dabney. (From a letter dated American Consulate, Teneriffe, Canary Islands, May 11, 1873, to the Editor of Harper's Monthly, and communicated by him to this Journal.)—Reading lately in your Scientific record for March about the disappearance of Biela's comet and the meteoric showers of November 27, supposed to be fragments of it, it occurred to me that the following might be worth putting on record.

Rejoicing in an atmosphere celebrated for its clearness, our meteoric displays in November are always brilliant, and last year on the very night mentioned, 27th, no less than 500 were counted in the space of about half an hour. On the night of the 29th, about half-past eleven, the family having retired and all lights being out, the rooms were suddenly brilliantly illuminated by an intense bluish-white light, which lasted for several seconds, brighter than moonlight, turning gradually red and then vanishing. As much as four minutes afterward, a report as if a large piece of artillery had been fired in the immediate neighborhood shook the house, and reverberated for some seconds in the surrounding mountains.

The cause of these phenomena seems to have been, from descriptions of those who observed it plainly, a large luminous body of conical shape, going with great velocity point foremost and drawing after it a long fiery train. It was observed from all parts of the island; observers on the north side reporting it as rising out of the sea and vanishing behind the peak; those on the south saw it vanish apparently below the southern horizon some minutes before the report.

The observers having been for the most part peasants and people of little education, it was difficult to obtain the truth from the marvelous reports made. The above, however, seems reliable, and the first part of the description is from personal observation.

3. *Observation of Tempel's Comet of Short Period;* by M. Stephan, Director of the Observatory at Marseilles. (From the Monthly Notices Astron. Soc., May 9.)—

May 1 at $13^h\ 17^m\ 24^s$ mean time at Marseilles; New Observatory.

R.A. $16^h\ 37^m\ 51^s{\cdot}59$ N.P.D. $103^\circ\ 11'\ 52''{\cdot}3$.

The correction for parallax is not applied.

Mean position of Comparison Star, Weisse's 738 H, XVI, for 1873·0.

R.A. $16^h\ 39^m\ 39^s{\cdot}59$ N.P.D. $103^\circ\ 6'\ 19''{\cdot}2$ Lal. 1. Bessel 2.

The comet was still very faint, though somewhat less so than on April 3.

4. *On Recent Estimates of Solar Temperature;* by James Dewar, Esq. (Proc. R. Soc. Edinb, vii, 697.) (Abstract.)—After referring to the recent discussion on the temperature of the sun, in which Secchi, Zollner, Vicare, Deville, and Ericsson have taken part, the author proceeds to group all the known methods of arriving at a knowledge of high temperatures under eight different processes. The following table gives the names of the physicists who have especially employed each process, together with the principle on which it is founded:

(1.) Guyton and Daniell, Prinsep, &c.—Expansion of Solids and Gases.

(2.) Draper.—Refrangibility of Light.

(3.) Clement and Desormes, Deville.—Specific Heat.

(4.) Becquerel, Seamens.—Thermo-Electricity and Electric Conductivity.

(5.) Bunsen, Zollner.—Explosive Power of Gases.

(6.) Newton, Waterston, Ericsson, Secchi.—Radiation.

(7.) Thomson, Helmholtz.—Mechanical Equivalent of Heat.

(8.) Deville, Debray.—Dissociation.

After treating of the great disparity of opinion regarding the temperature of the sun, the author proceeds to detail how it is possible, from the known luminous intensity of the sun, to derive a new estimate of solar temperature. This calculation is based on a definite law relating temperature and luminosity in the case of solids, viz., the total luminous intensity is a parabolic function of the temperature, above that temperature where all kinds of luminous rays occur. So that if T is a certain initial temperature, and I its luminous intensity, a a certain increment of temperature, then we have the following relation:—

$$T + n(a) = n^2 I.$$

The temperature T is so high as to include all kinds of luminous rays, viz., 990° C., and the increment a is 46° C. This formula expresses well the results of Draper, and I have used his numbers as a first approximation. It results from the above equation, that at a temperature of 2400° C., the total luminous intensity will be 900 times that which it was at 1037° C. Now the temperature of the oxyhydrogen flame does not exceed 2400° C., and we know from Fiseau and Foucalt's experiments that sunlight has 150 times the luminous intensity of the lime light; so that we only require to calculate at what temperature this intensity is reached in order to get the solar temperature. This temperature is 16,000° C., in round numbers. Enormously high temperatures are not required, therefore, to produce great luminous intensities, and the temperature of the sun need not, at least, exceed the above number. Sir William Thomson, in his celebrated article "On the Age of the Sun's Heat," says, "It is almost certain that the sun's mean temperature is even now as high as 14,000° C.," and this is the estimate with which the luminous intensity calculation agrees well.

5. *Meteor seen in Newfoundland.*—A letter from Henry H. Cleft to Prof. Henry, Secretary of the Smithsonian Institution, dated Harbor Grace, May 23d, 1873, states that on the 15th of May, at 8^h 5^m P. M., the writer saw a very large and bright meteor in the W.S.W., at an altitude of about 40°, moving rapidly to the westward, and leaving a long trail of yellow light after it. It burst at about $8\frac{1}{2}^h$ P. M. in the N.W. by W., 10° above the horizon; and the matter from it formed a coppery-red cloud below it of the shape of a comet's tail, which remained half an hour.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Flow of Water in Rivers and Canals;* by D. FARRAND HENRY, Chief Engineer Detroit Water Works, and late Assistant in the United States Lake Survey.—The greater portion of this pamphlet was originally published in the Journal of the Franklin Institute. It is mainly a discussion of the relative merits of the Telegraphic Current Meter, invented by the author, and used by him in his experiments for the determination of the outflow of the western lakes, and the double float used by Humphreys and Abbot in their experimental investigation of the hydraulics

of the Mississippi River. The general results obtained by the two methods of observation are also compared, and the points of disagreement considered. An Appendix contains a reply to the criticisms, published in the annual report of the Chief Engineer, U. S. A., to the Secretary of War for 1870, on the author's methods of current measurement, as set forth in his "Progress Reports, submitted to the Superintendent of the Lake Survey;" and a Mathematical Investigation on the use of floats in Guaging Rivers and Streams, by the distinguished mathematician, Prof. S. W. Robinson, of the Illinois Industrial Institute.

The author maintains that the measurement of sub-surface velocities by the method of double floats is liable to the following "principal causes of error," which do not affect measurements made with the telegraphic meter.

(1.) *The error of cross section;* which arises from the fact that "in order to ascertain the true mean area, it would be necessary to know the exact depth of the river past the whole base line; but generally it is considered sufficient to sound out two or three lines across the river, and take their mean depth, which, when the bottom is not perfectly regular, may differ considerably from the true mean depth."

(2.) *The pulsation of the current;* or, the existence, under all circumstances, of "an intermittent velocity, increasing and diminishing in accordance with some yet undiscovered law;" which may materially alter the result obtained by the double float, while all its irregularities will be accurately recorded by the telegraphic meter.

(3.) *The uncertainty of location* of the points at which the float crosses the upper and lower transverse section lines of the stream.

(4.) *Floating bodies move faster than the water in which they are immersed.* "This error is very small compared with the others."

(5.) *The upper float drags the lower.* "This error is also small and depends upon the relative size of the floats, and the velocity of the current."

(6.) *The effect of the current on the connecting cord;* which is to cause the cord to form a curve concave up stream, by reason of which the lower float is raised somewhat, and brought into a faster current. As a consequence the velocity determined by the float is in excess of the true velocity for the estimated depth, in which no allowance was made for the deviation of the connecting cord from the vertical line—the error increasing with the depth. In a series of comparisons of measurements made with the double float and telegraphic meter in the St. Clair River, the author finds, at the depth of 45 ft., the velocity given by the float to be 0·55 ft. in excess of that obtained with the telegraphic meter.

Our author joins issue with Humphreys and Abbot in respect to most of the general results obtained by them, as given in their Report on the Hydraulics of the Mississippi River.

(1.) *Maximum velocity.* The Mississippi hydraulicians place this, on a calm day, at $\frac{3}{10}$ the depth, and in general at depths varying with the force and direction of the wind, as represented by the following empirical formula,

$$d=(0{\cdot}317+0{\cdot}06f)r,$$

in which d is the depth at which the maximum current velocity obtains, f the force of the wind on a scale in which 10 represents the maximum force, and r the hydraulic mean depth.

The author reaches, from his discussion, the conclusion, that "in large rivers, we may consider the surface velocity in a calm time to be nearly the same as the maximum; while in narrow canals, especially when their sides are vertical, it may be considerably less."

(2.) *Form of velocity curve*, at various depths. Humphreys and Abbot adopted a parabola, with the axis horizontal, and at the depth assigned by the formula just given for the depth answering to the maximum velocity, as the best graphical representation of their Mississippi observations. Henry, on the other hand, fixes upon an ellipse, with its minor axis at the surface of the stream, as a closer approximation to the true velocity curve, on a calm day. He finds the parabola to be especially inaccurate when applied to the results of his own observations in the St. Clair River.

(3.) *Mean velocity.* One of the most important results obtained by the hydraulicians of the Mississippi was the establishment of a simple empirical formula connecting the mean with the mid-depth velocity, by means of which the mean velocity in the cross section of a stream could henceforth be deduced from mid-depth velocities observed at several points of the cross section. Henry maintains that the mean velocity obtains at $\frac{6}{10}$ the depth, and recommends as a still easier method of measuring the discharge of a stream, "to obtain the velocities at several points at $\frac{6}{10}$ the depth, and multiply the mean by the area of the cross section."

We must reserve, for the present, any decided expression of opinion relative to the several points at issue between our author and the distinguished hydraulicians of the Mississippi River. We are, however, ready to admit that he has supported his positions with signal ability, and weakened our confidence in important conclusions which we had supposed to be well established. There can be no question, also, that by the invention of his telegraphic meter, and the extended series of experimental determinations made with it, he has contributed materially toward the advancement of the science of hydraulics. His telegraphic meter is certainly far superior to Woltmann's meter, and every other form of stationary meter hitherto devised. The grave objection urged by Gen. Abbot, that the coefficient in the formula for deducing the velocity of the current from the number of revolutions of the meter, must of necessity be incapable of sufficiently accurate determination, seems to have been effectually answered by Henry, by showing that his coefficient has withstood the most

careful tests, applied to both surface velocities and velocities at depths of 40 ft. to 60 ft.
W. A. N.

2. *Death by Lightning;* by Rev. HORACE C. HOVEY, M.A. (Communicated.)—A thunder-storm passed over Kansas City, Mo., on the afternoon of Sunday, June 15th, 1873, the results of which, so far as a single stroke of lightning is concerned, the writer has taken pains to verify by personal examination and the testimony of eye-witnesses.

When the storm arose a number of persons were walking on the broad platform of the amphitheater, in the fair-grounds adjacent to the city. The promenaders, either in ignorance, or negligence, of the laws governing the passage of electrical currents, sought refuge from the rain underneath the leafy branches of some oak trees which shade the locality. Under the tallest of these oaks, fifteen feet from the point where its trunk passes through the platform, and within three or four feet of the overhanging boughs, stood Miss Nora Ritenour and a young gentleman who had accompanied her to the grounds. An electrical discharge sought them out, on its way from the clouds to the earth. She was killed, and he was crippled; while the shock was felt for a hundred yards from the fatal point of impact, jarring buildings, and benumbing and prostrating human beings, so as to prevent spectators for a few moments from coming to the aid of the chief sufferers. When they did so, they found, to their horror, that the body of the young lady was actually undergoing combustion, making it necessary to extinguish the flames by pailsful of water. On inspecting the remains it was found that the first point of contact was the chin, where a red mark was left, as if by a violent blow. The rest of the head showed no external injury except that the hair was burned to a crisp. From the chin the electrical fluid sought the body, breaking the neck, and burning the breast and abdomen through and through. Its exit was by the right foot, leaving only a well marked groove along the limb; but tearing the shoe into shreds. Death must have been instantaneous, and was probably void of sensible pain, if one might judge from the placid features, and the natural and agreeable expression of the eyes.

It seems as if the stroke must first have traversed the adjacent oak; but the most careful examination discovered no disturbance of its branches, or injury done to its sturdy trunk. On leaving the body of Miss Ritenour, the entire discharge passed through the plank on which she stood, piercing it like a musket ball, the upper side of the perforation being smoothly depressed, while underneath it was jagged and enlarged. From the plank the bolt leaped two feet to a beam, along which its path was divided; being marked by a fissure leading in opposite directions to the two posts by which the beam was supported. These posts were of white pine, thoroughly seasoned, and about one foot in diameter. One was merely split from top to bottom, while the other was utterly splintered. To this latter piece of timber, boards had been nailed; and to each nail head, in passing, the electrical fluid paid most discriminating attention, spliting the boards as if with the edge of an axe. The ground at the foot of these posts was not visibly disturbed. No traces of fire were to be seen on the dry, inflammable pine wood, although the living object, on which this memorable thunder-bolt concentrated its fury, was so fearfully burned.

3. *A new and ingenious American Move in the Game of Priority.* [We take this article from the Annals and Magazine of Natural History for July, and would add our full endorsement of its views. No copy of the circular letter referred to has reached us. EDS.]—The following circular letter, partly printed, partly written, which has just come to our knowledge, will, we think, somewhat amuse our readers:

"BUFFALO SOCIETY OF NATURAL SCIENCES, June 6, 1873.

"*To the Secretary of the* ——— *Society:* Dear Sir,—You are hereby notified that a paper entitled "Contributions to a Knowledge of North-American Moths," by A. R. Grote, has been read this evening before this Society, declaring that three new genera [*Litognatha*, *Meghypena*, *Phœcasiophora*] and nineteen hitherto undescribed species *Acronycta* 4, *Agrotis* 1, *Cloantha* 2, *Litognatha* 2, *Meghypena* 2, *Botis* 1, *Eurycreon* 1, *Phœcasiophora* 1, *Penthina* 3, *Graptolitha* 1, *Œta* 1] occur in the North American insect fauna (*whereof these Presents, to which the Seal of this Society is affixed, are evidence*), and that this Society considers the reading of the above paper as securing all rights to its author that he might acquire by publication.

"Mr. Grote's paper has been accepted by the Publication Committee of this Society for publication in its bulletin.

"Yours respectfully, LEON F. HARVEY,
Corresponding Secretary B. S. N. S."

In characterizing this proceeding on the part of one of the youngest publishing societies in the world we are forced to cull a phrase from the slang dictionary; it is simply the "cheekiest" thing we ever remember to have seen. The use of legal phraseology in the words which we have put in italics has quite a peculiar charm, and will doubtless produce its due effect in causing entomologists in all quarters of the world to avoid trespassing on those unknown premises which have been formally handed over by "these Presents" to Mr. Grote by the Buffalo Society of Natural Sciences. It seems hardly credible that experienced naturalists, such as Mr. Grote at any rate is, should have even dreamed of adopting so absurd a course as this. Another favorite American dodge of printing descriptions of new species, with a date attached to them, for private circulation and not for sale, is bad enough, but it must yield the palm to the Buffalo invention.

4. *Transactions of the Academy of Sciences of St. Louis.*—No. 1 of Vol. III, containing 192 and xcviii pages, has just appeared. The articles of the number are—on the genus Yucca, by *G. Engelmann;* on a new genus of Tineidæ with remarks on the fertilization of Yucca, *Riley;* new N. American Hymenoptera,

B. D. Walsh; Atmospheric electricity, *Wislizenus;* Catalogue of earthquakes in 1871, *Hayes;* on the occurrence of iron ores in Missouri, *Gage.*

3. *A Dictionary of Science, comprising Astronomy, Chemistry, Dynamics, Electricity, Heat, Hydrodynamics, Hydrostatics, Light, Magnetism, Mechanics, Meteorology, Pneumatics, Sound and Statics,* preceded by an essay on the history of the Physical Sciences. Edited by G. F. Rodwell, F.R.A.S., F.C.S. 694 pp. 8vo, with numerous illustrations. (American edition. Philadelphia: J. B. Lippincott & Co.)—A good and convenient dictionary of the Physical Sciences, though unequal in the value of its articles.

4. *Physical Geography,* by Arnold Guyot, author of Earth and Man. 124 pp., 4to, with numerous illustrations (Scribner, Armstrong & Co.).—Professor Guyot, one of the best of living physical geographers, has here prepared for academies and higher schools an admirable work on his favorite science. With a profound and comprehensive view of his subject, and of the relations of its several departments, he brings out in a simple way the general truths connected with it, without overloading his chapters with details. The excellent illustrations speak out boldly the facts or principles in view, and cover all branches of the science. There are also a number of large colored maps presenting the distribution of magnetic phenomena, volcanoes and earthquakes, temperature, winds, oceanic currents, course of tidal wave, rains, vegetation, etc. The volume should become a text-book in all our higher schools. We hope that Prof. Guyot may be enabled soon to finish the completer manual for our colleges and the scientific public at large, which he alludes to in his preface.

5. *American Association for the Advancement of Science.*—The twenty-second meeting of the Association will be held at Portland, Maine, and will commence on Wednesday, the 20th of August. Prof. Lovering of Cambridge is President for the year, and A. H. Worthen of Springfield, Illinois, Vice President.

6. *Royal Society.*—Prof. Asa Gray has been elected Foreign Fellow of the Royal Society.

7. *Academy of Sciences of Paris, Session of July 7th.*—The order of the day was the election of three correspondents of the section of Zoology. At the first ballot, in which 44 members took part, the vote stood 38 for Steenstrup and 6 for Darwin; at the second, in which 46 voted, 35 for Dana, 10 for Darwin, with one blank; at the third, 48 voting, 35 for Carpenter, 12 for Darwin and 1 for Huxley. Whereupon Steenstrup, Dana and Carpenter were declared elected correspondents to the Academy.—*L'Institut,* July 9, 1873.

OBITUARY.

John Wells Foster died of rheumatism of the heart, at his residence in Hyde Park, near Chicago, on the 20th of June last, aged 58 years. Col. Foster's name became prominent in science by his connection with the "Geological Survey of the Copper lands of Lake Superior Land District," in 1850 and 1851, associated with Prof. J. D. Whitney. Two Reports and an atlas embody the results of these explorations, the second volume being devoted to the iron region, together with the general geology. This is a work of high value in the development of American geology, both theoretical and practical.

Col. Foster was born at Petersham, Massachusetts, March 4, 1815, and graduated at Wesleyan University, Middletown. He served for a while in the Legislature of his native state. About 1854 he removed to Chicago where he has since resided. His later contributions have been chiefly his work on "The Mississippi Valley: its Physical Geography, etc."—various ethnological memoirs in the Transactions of the Chicago Academy, the American Association for the Advancement of Science, American Naturalist, etc.; researches on the "block coal" and iron ores of Indiana. The last and most important work of Col. Foster appeared at the very moment of his death, entitled "Pre-historic Races of the United States of America," a notice of which will appear in another number.

HENRY JAMES CLARKE, Professor in the Amherst Agricultural College, died at Amherst, Mass., on the 1st of July. His labors as a zoologist, especially in those departments requiring difficult microscopic research, had placed him among the two or three first in the country, and given him a world-wide reputation. He was for a while assistant to Professor Agassiz in preparing his Contributions to the Natural History of the United States, and part of the embryological researches on the turtle are his work. Foremost among his several discoveries with the microscope is that of the true nature of the animal of sponges, till then misunderstood, the last paper on which subject by him appeared in this Journal for December, 1871. He was also the author of a work entitled Mind in Nature, based on structure and development in the animal kingdom, and containing many of his labored results, with illustrations from his own faithful drawings. He was always working, and full of enthusiasm in science, and also a most genial and excellent man.

THOMAS BELDEN BUTLER, physician, jurist, and meteorologist, born in Wethersfield, Conn., Aug. 22, 1806, died in Norwalk, Conn., June 8th, 1873, in his 67th year. Judge Butler entered upon his legal studies after practicing medicine for some years following his graduation in the Yale Medical School, and enjoyed high repute as a jurist. He was a student in many collateral branches of knowledge, especially in agriculture, mechanics, and meteorology. He was the author of "The Philosophy of the Weather" (1856), and of "A concise analytical and logical development of the Atmospheric System: Hartford, 1870." He was chosen Judge of the Superior Court of Connecticut in 1855, and in 1861 of the Supreme Court, of which he was made Chief Justice in 1870.

DE VERNEUIL, the eminent geologist of France, to whose labors the progress of geological science in America, as well as in Europe and Asia, is profoundly indebted, died at Paris on the 29th of May, at the age of sixty-eight years.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XVIII.—*On some results of the Earth's Contraction from cooling;* by JAMES D. DANA. Part V, *Formation of the Continental plateaus and Oceanic depressions.*

V. FORMATION OF THE CONTINENTAL PLATEAUS AND OCEANIC DEPRESSIONS.

IN my papers of 1846 and 1847, I attributed the formation of the great plateaus, called continents, and of the oceanic depressions, to unequal contraction, observing that the oceanic crust, by being the later in consolidation, became more depressed through the continued contraction than the already firm or less-contracting continental crust. The steps in the process I propose now to consider, as a means of further elucidating the subject.

1. *Unequal contraction a fact.*

The *fact* of unequal contraction is manifest from the inequality of level that exists over the sphere dividing it into oceanic depressions and continental plateaus; and unequal contraction, the material of the crust being essentially the same over the two kinds of regions, implies an unequal rate of cooling. Moreover, it is a necessary conclusion that the great areas first consolidating should have been first free from that chemical activity, and those ebullition-like movements due to escaping vapors, which are inseparable from the fluid condition of rocks under merely atmospheric pressure.

2. *Location of the continental areas.*

The areas first to become quiet, and first to cool and consolidate, would have been the shallowest areas, that is, those beneath which the solid nucleus of the globe reached nearest to the surface; for this approach to the surface would have been favored by the chemical quiet; and the less depth would have insured more rapid cooling.

The solid state of the interior mass, under the Hopkins' theory, is due to the pressure of the outer portion, this pressure being capable of producing an increase of density, and, at some depth, that density which belongs to the solid rock; so that downward, either from the plane at this depth, or from some level or levels below it, actual solidity would have existed. It may be that when exterior solidification, that is, the solidification of the crust, was about to begin, the outer limit of the interior solid mass over the solidifying areas was quite up to the spherical plane in which the rock of the interior had the density of solidity. It is at least certain that its limit was as near the surface as was possible under the temperature then existing.

3. *Nature of the cooling crust, and of the liquid layer of which it was formed.*

The change of specific gravity or density which the rock-material underwent in passing from the liquid to the solid state is part of the data required for conclusions on the subject in view; and with reference to it we may first consider the nature of the rock-material.

The larger part of the igneous rocks of the globe are ejections, according to the evidence which has been presented, either from regions *within* the true crust of the earth—that is, the part situated below the supercrust and which was a direct result of the cooling—or from the plastic layer or seas underneath. In either case they are testimony, and have long been so regarded, with respect to the outer liquid layer of the melted sphere. The next best testimony we have is that from the earlier of the surface formations—the Archæan (Azoic). Another source of conclusions, appealed to effectually by Daubrée,* is the constitution of meteorites and parallel facts in the earth's igneous and metamorphic rocks. Still another, used by Hunt, is reasoning from physical and chemical laws to the probable results under the supposed conditions of a cooling globe. We thus arrive at the following conclusions.

(*a.*) The *more prominent minerals* were the following. (1) Some iron-bearing species (bearing also magnesia and lime) of the amphibole family, as *augite, hornblende;* (2) the iron-and-magnesia mineral *chrysolite* (or olivine), to which Daubrée, on the evidence just referred to, gives great prominence; (3) species of

---

* Expériences synthétiques relatives aux Météorites. Rapprochements auxquels elles conduisent, tant pour la formation de ces corps planétaires que pour celle du globe terrestre; par M. Daubrée. Comptes Rendus, lxii, 1866.

feldspar, either the lime feldspar called *anorthite*, the lime-and-soda kind called *labradorite*, the soda-and-lime kind *oligoclase* (and andesine), the soda-feldspar (containing usually some potash) *albite*, the potash-feldspar (containing usually some soda) *orthoclase;* of which feldspars the first two are lowest in silica, 45–55 p. c., the third intermediate in amount of silica, or 60 to 64 p. c., the last two the highest, 65 to 70 p. c.; (4) *magnetite* (or magnetic iron ore Fe_3O_4, but often titaniferous); and (5) perhaps *quartz* or free silica, and *mica*. Serpentine and chlorite are omitted from the list on the ground that they are always metamorphic. The question with regard to quartz is discussed below.

(*b.*) The *principal rocks* in their relation to the subject before us fall naturally, as Elie de Beaumont first formally announced,* into two series—although there are intermediate kinds through which the two graduate into one another:—*one*, low in silica, or *basic*, containing less than 56 p. c. of silica; *the other*, high in silica or *acidic*, containing 56 p. c. or more.

The *basic* rocks include dolerite and the related igneous rocks: made up of augite and labradorite, with sometimes anorthite or oligoclase, often chrysolite, and generally magnetite in disseminated grains, and varying in specific gravity mostly between 2·8 and 3·2.

The *acidic* comprise (1) most trachyte and related feldspathic rocks, consisting of one or more of the feldspars, oligoclase, albite, or orthoclase, with usually a little hornblende and magnetite, and sometimes mica, and not unfrequently free quartz—sp. gr.=2·5–2·75; (2) syenite, consisting of orthoclase and hornblende with quartz—sp. gr.=2·9–3·1; hyposyenite, consisting of orthoclase and hornblende without quartz—sp. gr.=2·9–3·2;† diorite, consisting chiefly of oligoclase or albite with hornblende—sp. gr.=2·80–3·1; granite, consisting of orthoclase (sometimes along with albite or oligoclase), quartz and mica—sp. gr.=2·6–2·75.

(*c.*) These igneous rocks are also conveniently arranged with reference to their origin into an *iron-bearing* and a comparatively *iron-free* series.

* Bull. Soc. Geol. de France, II, iv, 1253, 1847. De la Beche has the idea in chapter xviii, on igneous rocks, of his Geological Researches (1834). Bunsen uses it in his memoir on the volcanic rocks of Iceland (Pogg., lxxxiii, 201, 1851), and also Durocher later, in his memoir on Comparative Petrology.

† The name *syenite* belongs by right of priority to the quartz-bearing rock, as it was described from the locality Syene in Egypt, where that kind occurs; and I, therefore, call the kind free from quartz *hyposyenite*. Syenite is a rock of the hornblendic series in all its geological relations, it graduating often into hyposyenite in Archæan regions; and it is bad to make it, as done by some German lithologists, a hornblendic variety of granite. It deserves to stand as a distinct species, and it naturally leads off the hornblendic or syenitic series of crystalline rocks, as granite does the non-hornblendic or granitic series.

The *former* include the rocks containing as essential constituents one or more of the iron-bearing minerals, augite, hornblende and chrysolite, and often also magnetite; and are divided into two groups, the *doleritic*, containing pyroxene, and the *syenitic* containing hornblende in place of pyroxene.

The *latter* comprise those mostly (seldom wholly) free from these iron-bearing minerals, as the *trachytic* and *granitic* kinds.

(*d.*) The *presence of quartz* among the chief constituent minerals of the true crust is not certain. Of the above-mentioned rocks, the basic iron-bearing (or doleritic) kinds are far the most abundant among acknowledged igneous rocks; and this fact seems to indicate that *quartz or free silica was not abundant in the original liquid rock of the globe.* Its *absence*, which Mr. Hunt urges, is seemingly opposed by the fact that it is present in so many trachytes, as well as in syenite and granite, and the related rocks. But Hunt is right in holding that in general granite and syenite (the quartz-bearing syenite) are undoubtedly metamorphic rocks where not vein-formations, as I know from the study of many examples of them in New England; and the veins are results of infiltration through heated moisture from the rocks adjoining some part of the opened fissures they fill. These rocks, although common, present therefore no positive testimony on the side of the presence of quartz. Mr. Hunt urges, in support of his opinion, the experiment of Rose, in which fused quartz on cooling had the low density and other characters of the form of silica called opal, and not those of quartz. But the evidence is inconclusive, since a laboratory experiment cannot inform us what would be the condition of silica on cooling from fusion, provided the process of solidification took some millions of years. But Rose's experiment does seem to settle the question as regards all quartz-veins, since if of igneous origin, their little width would have insured comparatively rapid cooling; and it thus sustains the evidence in favor of the view that such veins, like most mineral veins, were filled through the aid of heated moisture. Professor Hunt's argument from the probable condition of the material of the liquid sphere, when about to solidify at surface,—or the fact that the lime and magnesia now in our limestones and waters, and the soda in our waters, must have been mainly in the condition of silicates, and that therefore the free silica would have thus been in combination,—is of great weight; and, considering the vast amount of limestone in the earth's formations, it favors the view, derived from the prevailing doleritic character of igneous rocks, that silica would have been mostly, if not wholly, in combination, and that the chief feldspars present were the lime-and-soda species, labradorite and oligoclase. Granite and syenite—common rocks of Archæan terranes—

are just the rocks that are likely to have been formed over the earth's surface after the action on the crust of the foul atmospheric vapors that settled upon it as it began to solidify. If there were mainly doleritic material and other labradorite mixtures in that crust, the result of the conflict would have been a removal of part of the bases and the liberation of silica, making free quartz and quartz-bearing rocks.

Again, the general fact that the doleritic rocks, and even most trachytic, contain disseminated grains of *uncombined* oxide of iron in the form of magnetite (Fe_3O_4) adds to the strength of the argument against the general diffusion of quartz, that is, free or uncombined silica, if not proving its absence.

(*e.*) The *presence of a large proportion of iron* is a marked feature of most igneous rocks. This ferriferous quality is not characteristic solely of the doleritic and syenitic kinds; even the most purely feldspathic trachytes usually contain some disseminated magnetite and hornblende; and from this extreme there is a shading off in trachytic rocks toward dolerites, syenites, or hyposyenites. It should be here understood that augite and hornblende are essentially identical in chemical constitution, though differing in crystallization. Hornblende has often a slight excess of silica (making the oxygen ratio of the bases and silica frequently $1:2\frac{1}{4}$ as in the feldspar oligoclase, instead of $1:2$, as in augite, and this may be one reason for its occurrence by preference in the trachytes, in which oligoclase and orthoclase predominate, and that of augite in the dolerites, in which labradorite is the predominant feldspar. In labradorite this ratio is $1:1\frac{1}{2}$, and in andesine $1:2$. Mixtures of labradorite and oligoclase, which constitute the base of some doleritic rocks (melaphyres, in which the silica constitutes over 55 per cent), would have $1:2$ for this oxygen ratio when the proportion of labradorite to oligoclase was 1 to 2.

The basic iron-bearing feature of the first solidified crust is attested to also by the nature of the lowest rocks of the supercrust, that is, by the Archæan formations overlying the true crust and directly or indirectly made from it. We find among the Archæan terranes the feldspar labradorite far more abundant than in any later metamorphic rocks; the rock hypersthenite common, which is much like dolerite in elemental constitution; others, ossipyte and a chrysolitic hypersthenite, which are closely related to peridotite or chrysolitic dolerite; other rocks that are almost solely chrysolite; another, diabase, which has the composition of a chloritic dolerite; other kinds, referred to hypersthenite and diabase, which approach melaphyre. And besides, there are diorite, consisting of hornblende and albite or oligoclase, and hyposyenite, consisting of hornblende and orthoclase.

These iron-bearing kinds of Archæan metamorphic rocks much exceed in amount the granitic kinds that are free from iron. Moreover, in these Archæan formations, the granitic as well as the iron-bearing, there are immense beds of iron-ore, as seen in New York, Canada, Northern Michigan, Missouri, Sweden and Norway, the thickness of single beds frequently exceeding a hundred feet; and thus, although the surface over which Archæan rocks are exposed is relatively small, its iron is in vast amount. In fact, unlike human history, the earth's iron age was its earliest. Now since these great iron-ore beds are of sedimentary or marsh accumulation (for they occur interstratified with quartzite, chlorite schist, syenitic schist, and other metamorphic rocks), the iron was gathered from the preexisting crust rocks. They therefore prove that iron was a very common ingredient in the original fused material of the surface of the liquid globe.

(*f.*) We hence have reason for the inference that the original fused material contained largely the ingredients of the iron-bearing rocks, dolerite, peridotite, diorite, hyposyenite, besides trachyte and the related kinds; and *perhaps* in small proportions those of the quartziferous trachytes, if not of granite and syenite.

It is not certain, from present knowledge, whether the slow cooling would not have made hornblende through the crust-mass, in place of the akin species augite. Yet the considerations mentioned on the preceding page suggest that augite may have characterized the basic portions of the crust, and hornblende the smaller acidic portions; and if so the prevailing rock is strictly doleritic.

(*g.*) In view of the large proportion of iron, the *mean specific gravity of the true crust* can hardly be less than 2·9, and probably it is as high as 3·0.

(*h.*) The *method of distribution* of the basic (doleritic) and the less abundant acidic (or trachytic) kinds in the earth's outer viscid layer before solidification—whether in separate layers, the latter over the former, as Durocher urges, or whether in separate local streams or regions made by the boiling movements and the great oceanic-like currents in the liquid mass, through the principle of liquation on a large scale—need not be here considered. I merely add that observed facts seem to be best explained on the latter view, since the existence of the two layers is not proved by the study of the Archæan terranes. If it had existed at the beginning of solidification, and the trachytic layer was thick enough not to have been obliterated by cooling before the era of the more recent trachytic ejections over the great Pacific slope, the constituents of the iron-bearing or doleritic rocks should exist but sparingly in the Archæan, instead of being the prevailing kinds.

4. *Change of density and volume in solidification.*

All the rocks above mentioned have a higher density in the solid state than when in fusion. According to Delesse,* granite decreases in density in passing from the stone to the glass condition,† 9 to 11 per cent; syenite, syenitic granite 8 to 9; diorite, 6 to 8; dolerite and melaphyre, 5 to 7; basalt and trachyte 3 to 5 per cent. The difference in volume is thus large between a rock in the solid and glass state. As to the difference between the glass and liquid states we have no precise observations, and only know that it is very small.‡

From the above facts, sustaining the near absence of quartz-bearing rocks from the crust, and, therefore, of granite or syenite, and the other considerations presented, we may take 8 per cent as the probable average change of density for the earth's crust between the stony and the liquid states; which is equivalent to a change of volume from 100 to 92 per cent in passing from the liquid to the stone condition.

5. *Process of solidification and continent-making.*

The crust over the areas of solidification, after attaining a thickness that would enable it to overcome by its gravity the cohesion in the liquid rock beneath, would have sunk in masses, and then have been remelted by the heat beneath, and this remelting would have cooled somewhat the liquid layer. So, this process of crusting, and sinking with an overflow from either side, remelting, and cooling, would have gone forward until the masses could sink without much remelting, to bring up at the level where the density of the liquid layer was that of the solid rock, if this liquid layer had not become so stiffly viscid by the cooling as to offer too great resistance to their reaching quite to this level. The sinking rock-masses may have had their density somewhat increased by the pressure to which they were subjected on descending; but whatever density they acquired, this density would determine the limit to which—setting aside resistance from viscidity—they would sink. It may be that portions went down until they came in contact with the nucleal solid mass. As the crust sank the liquid material adjoining would have continued to flow over the solidifying area and add to the solidifying material.

---

* Bull. Soc. Geol. de France, II, iv, 1380, 1847. Delesse's results agree nearly with those of St. Claire Deville. Bischof in 1841 found the volume of basalt in the vitreous and crystalline states as 1 to 0·9298; for the same, in the fluid and crystalline states, as 1 to 0·8960; and for granite, the corresponding ratios, 1 to 0·8420, and 1·07481.

† It is to be here noted that the glass and stone conditions are distinct molecular states of the same substance, the former produced under rapid cooling, the latter under slow; and that common glass will become stone if solidified under a prolonged cooling process.

‡ I am informed that at the Lenox Glass Furnace in Berkshire, Mass., no contraction is noticed in the cooling of the glass.

Finally, a layer of crust-rock, miles in thickness, would have been made over the great continental areas. Throughout the other portions of the sphere, the surface, whether all liquid or in incipient solidification, would have the level of that of the continental areas. For the sake of the illustration, suppose them to have been all liquid, and the continental crust twelve miles thick, and the oceanic areas to go through the same process of solidification as had been completed over the continental areas: when, finally, the material of the oceanic regions had solidified down to the same plane with that of the continental, that is to the *twelve*-mile limit, the oceanic crust thus formed would have become depressed in the consolidation (on the above ratio of 8 per cent less volume for the liquid than solid) 5,000 feet; or, if the layer consolidated were thirty-six miles thick, 15,000 feet; that is, supposing the continental part to undergo no contraction during the time. As such contraction would have been in progress from the continued cooling, the above 5,000 feet is not the actual depth the basin would under the supposed circumstances have acquired; and yet, since the change of volume in the cooling of solid rock is small, it is not very wide from the fact.

The case here supposed is partly hypothetical because the condition over the oceanic areas when the solidified crust of the continental areas was completed may have been that of incipient solidification, so that some of the contraction had already taken place. But apart from this it represents correctly, as appears to me, the steps in the process, and illustrates how it is that great depressed areas would have been an inevitable result, and why they should have had comparatively abrupt sides or a basin-like character. The present mean depth of the oceanic areas below the mean level of the continental plateaus is probably about 16,000 feet. The thickness of the layer of liquid rock required to make a depression of 16,000 feet by its consolidation would be about 38¼ miles. But as contraction has gone on through time over both continental and oceanic areas, this is the mean excess of depression for the oceanic area. What part of this excess existed when the oceanic depression was first made there are no facts for satisfactorily deciding. If the coral-island subsidence was due in any considerable part to radial contraction beneath the Central Pacific crust itself, it is probable that the excess has increased even in Cænozoic time.

I find no explanation, in the present state of science, wherefore most of the dry land of the globe should have been located about the north pole, and of the water about the south. Physicists say that it indicates greater attraction, and therefore a greater density, in the solid material beneath the southern ocean. But why the mineral ingredients should have been so gathered about the south pole as to give the crust there greater density is the unanswered query. It may be that magnetite is much more abundantly diffused through the Antarctic crust than the Arctic. This is only one of many possibilities, and it is at present without a satisfactory fact to stand upon, beyond the general truth that iron was universally present.

6. *Resulting crystalline texture of the crust.*

The doleritic and trachytic rocks of the true crust, and whatever else exists in its constitution, cannot be present with just the *texture* we find in the rocks of existing dikes and volcanic mountains. For, as above-stated, the crust has cooled with inconceivable slowness, far more extreme than that which has attended the formation of any of the coarsest granites and syenites. And, since the coarseness of crystallizations is generally in proportion to slowness of cooling, the texture of the whole should have been after the character of the coarse Archæan syenite or hyposyenite and vein granite, or else in much larger crystallizations. One or another of the cleavable feldspars is, in all probability, everywhere present; and since the cooling, and therefore the crystallization, has been in progress through many millions of years, and still goes on—the probability is that the feldspar crystallizations and cleavage-planes of the first-formed crust-layer were lengthened downward for very long distances, if not indefinitely. If so, the existence of a cleavage structure in the crust as courses of easiest fracture, such as I have appealed to elsewhere in explaining the origin of the courses in the earth's great feature-lines,* is not an unreasonable supposition.

7. *The Continents always the continental areas.*

The above-stated effects of contraction lead to the necessary conclusion that the oceanic and continental areas were defined when the earth's crust first began to form, if not also still earlier, during the progress of its nucleal solidification. It is hardly possible to conceive of any conditions of the contracting forces that should have allowed of the continents and oceans in after time changing places, or of oceans as deep nearly as existing oceans being made where are now the continental areas;—although it is a necessary incident to the system of things that the continental plateaus should have varied greatly in their outlines and outer limits, and perhaps thousands of feet in the depth of some portions of the overlying seas; and also that the oceans should have varied in the extent of their lands. The many characteristics of the continental borders: for example, the contrast between the landward and seaward slopes of the mountains, and even of the plications constituting them, the

---

* This Journal, II, iii, 381, 1847.

positions of volcanoes and of regions of igneous eruptions and metamorphism, indeed all the features declare which side of each border chain is the oceanic, and which the continental, and protest against speculations that would reverse the order. The early defining, even in Archæan time, of the final features of North America, and the conformity to one system visibly marked out in every event through the whole history—in the positions of its outlines and the formations of its rocks, in the character of its oscillations and the courses of the mountains from time to time raised, sustain the statement that the American continent is a regular growth. The same facts also make it evident that the oceanic areas between which the continent lies have been chief among the regions of the earth's crust that have used the pent-up force in the contracting sphere to carry forward the continental developments.

If this was true of the North American continent, the same in principle was law for all continents.

CONCLUSION.

I here close this reconsideration of the views brought out in my papers of 1847. Of the principles then presented, and briefly recapitulated in the opening pages of this memoir, vol. v, pp. 423–426, I have found reason to modify some points connected with section 4 on mountain-making, and part of section 8, or that on metamorphism: the former, in consequence of some new considerations of my own, and of two ideas, of fundamental value, which I owe to LeConte;* the other in view of Mallet's recent contribution to Vulcanology. I purposely avoided in my early papers any expression of opinion as to the nature of the earth's interior (having had Hopkins's argument of 1839–1842 in view) and hence there is nothing on this point in the statements then made that requires change.†

The views on mountain-making now sustained suppose the existence, through a large part of geological time, of a thin crust, and of liquid rock beneath that crust so as to make its oscillation possible, and refers the chief oscillations, whether of elevation or of subsidence, to lateral pressure from the contraction of that crust; and this accords with my former view, and with that earlier presented by the clear-sighted French geologist, Prévost.

I hold also, as before. that the prevailing position of mountains on the *borders* of the continents, with the like location of

---

* Introduced in Part I, v, 431, and Part II, vi, 12, 13.

† The later paper of Prof. Hopkins, read before the British Association, did not appear in this country until after my articles of 1847 were in print; and I have since then been deferring my adoption of the views now accepted from it, until the idea of the earth's interior solidity should have additional affirmation from the physical and mathematical side. This it has recently had through the writings of Sir William Thomson and others.

volcanoes and of the greater earthquakes, is due to the fact that the oceanic areas were much the largest, and were the areas of greatest subsidence under the continued general contraction of the globe.

Beyond these points there are additions and modifications. In addition to admitting the nucleal solidity of the globe, and the present partial union of the crust to the nucleus, these include the recognition of the following principles:

(1.) That in mountain-making on the continental borders, the oceanic crust had the avantage through its lower position of *leverage*, or, more strictly speaking, of obliquely upward thrust, against the borders of the continents.

(2.) That, among mountain elevations, there are those which, like the Alleghanies, are the result of one process of making, or *monogenetic*, and those that are a final result of two or more processes at different epochs, or are *polygenetic*.

(3.) That there are two kinds of monogenetic ranges—those that are geanticlinals, or *anticlinoria*, like the region of the Cincinnati uplift; and those that were the result of a slowly progressing geosynclinal, with consequently a very thick accumulation in the trough of sedimentary beds, ending in an epoch of displacements and solidification, and often of metamorphism of the sedimentary beds, as in the case of the Alleghanies and other *synclinoria*.

(4.) That great mountain chains are combinations of synclinoria and of anticlinorian elevations.

(5.) The principle advocated by LeConte (restricted as indicated) that plication, shoving along fractures, and crushing are the true sources of the elevation that takes place *during the making* of the second of the two kinds just mentioned of monogenetic mountain ranges or synclinoria.

(6.) That, on the oceanic side of the progressing geosynclinal referred to, there has been generally, as the first effect of the thrust against the continental border, a progressing geanticlinal which usually disappeared in the later history of the region, —gravity, and the yielding and plication in the region of the geosynclinal favoring this disappearance.

(7.) That the locus of the region of subsidence on a continental border was in general alongside of a region of thickly stiffened unyielding continental crust, and that pressure against the stable area beyond was one source of the catastrophe of mountain-making.

(8.) That each epoch of plication and mountain-making ended in annexing the region upturned, thickened and solidified, to the stiffer part of the continental crust, and that consequently the geosynclinal that was afterward in progress occupied a parallel region more or less outside of the former, either landward or seaward, and commonly the latter.

(9.) The principle adopted from LeConte, that the bottom of a geosynclinal becomes weakened, as subsidence and surface sedimentary accumulations go forward, through the access of heat from below or the rise of the isogeotherms (the change of level in a given isothermal plane having been seven miles in the Appalachian region), and that this in an important degree has made possible the catastrophe in which synclinoria have resulted.

(10.) That, while igneous eruptions and metamorphism have each attended the formation of synclinoria, still in cases where the plication was greatest the igneous eruptions have been least in amount or absent.; and that the most extensive igneous eruptions have taken place on continental borders after the crust had become too much stiffened to bend freely before the lateral pressure.

(11.) That in the upturning and plication attending mountain-making, the heat from the transformation of the motion was sufficient (in connection with other heat from a rise of the isogeotherms due to previous surface accumulations) to cause metamorphism; and also the pasty fusion which obliterates all stratification and gives origin to granite, and which may fill cavities or fissures, and so make veins that have all the aspect of true igneous ejections; and, as a more extreme effect, it may produce, as Mallet says, the degree of fusion which belongs to plastic trachyte, and give rise to trachytic and other ejections through fissures or volcanic vents. But—

(12.) That the chief source of igneous rock is the plastic layer situated beneath the true crust, or the local fire-seas derived from that layer.

The discussion has enlarged beyond its limits in my previous publications, and many additional facts and conclusions have been brought forward. The various conclusions go forth to be tested by the further developments of science.

ART. XIX.—*On a Secondary Spectrum of very large size, with a Construction for Secondary Spectra;* by Prof. O. N. ROOD.

WHEN two prisms of different substances are arranged so as to compensate each other for color, it is ordinarily found, on passing a ray of white light through the combination, that a residual spectrum of very small dimensions and peculiar appearance still remains. It is well known that this *secondary spectrum* is due to the circumstance, that the spacing of the colors in the two original spectra is not accurately correspondent, and that its dimensions vary with the amount of the disproportionality of the original constituents. Sir David Brewster seems to have made the most extended set of experiments on this subject, and has given a list of substances, arranged in the order in which their spectra differ in this respect.*

His mode of experimenting was quite simple, consisting merely in giving the two prisms such refracting angles as produced the best approximation to achromatism, and then in viewing through the combination the bar of a window with the naked eye. Under these circumstances he found the window-bar fringed on one side with a very narrow line of green color, the line of color on the opposite side being purple. The secondary spectrum can also sometimes be observed as a defect in telescopic or microscopic lenses; here also we have the green and purple fringes, but as in the other case, the phenomenon is quite inconspicuous, and is easily overlooked by those to whom it is for the first time presented.

I have recently found it possible, by a proceeding of a different kind, to produce secondary spectra whose size is quite gigantic as compared with those just mentioned, and which display the fixed lines with a distinctness that allows the study of their peculiar construction by ordinary spectroscopic methods. The essential condition for the production of a large secondary spectrum is a large difference in the *spacing* of the colors of the two primary constituents, and the largest secondary spectrum observed by Brewster was that furnished by a prism of sulphuric acid in combination with one of oil of cassia, these substances standing at the opposite extremes of his table. A vastly greater difference is, however, obtained, if we employ as one of the constituents the spectrum furnished by oil of cassia, bisulphide of carbon, or even flint glass, the other being the *normal spectrum* obtained by the use of a diffraction grating. Here we approach very nearly, if we do not actually realize, the maximum difference of spacing that is attainable in the present state of optical science, and hence give to the secondary spectrum its maximum dimensions.

Apparatus, &c.—A spectroscope provided with collimating and observing telescopes was employed; it was provided with a flat circular brass plate seven inches in diameter, which supported the prism and the grating; the vertical axis around which the observing telescope revolved was capable of being adjusted under any desired portion of this plate. The observing telescope was provided with a micrometer eye-piece of the kind described by me in the July number of this Journal;

---

* Sir David Brewster's Treatise on New Philosophical Instruments, p. 354: see also his work on Optics.

with its aid the distances between the lines in the original, or in the secondary spectra, were measured. The collimating telescope was arranged so that its optical axis could be directed across any desired portion of the supporting brass plate. All these parts were capable of being independently leveled.

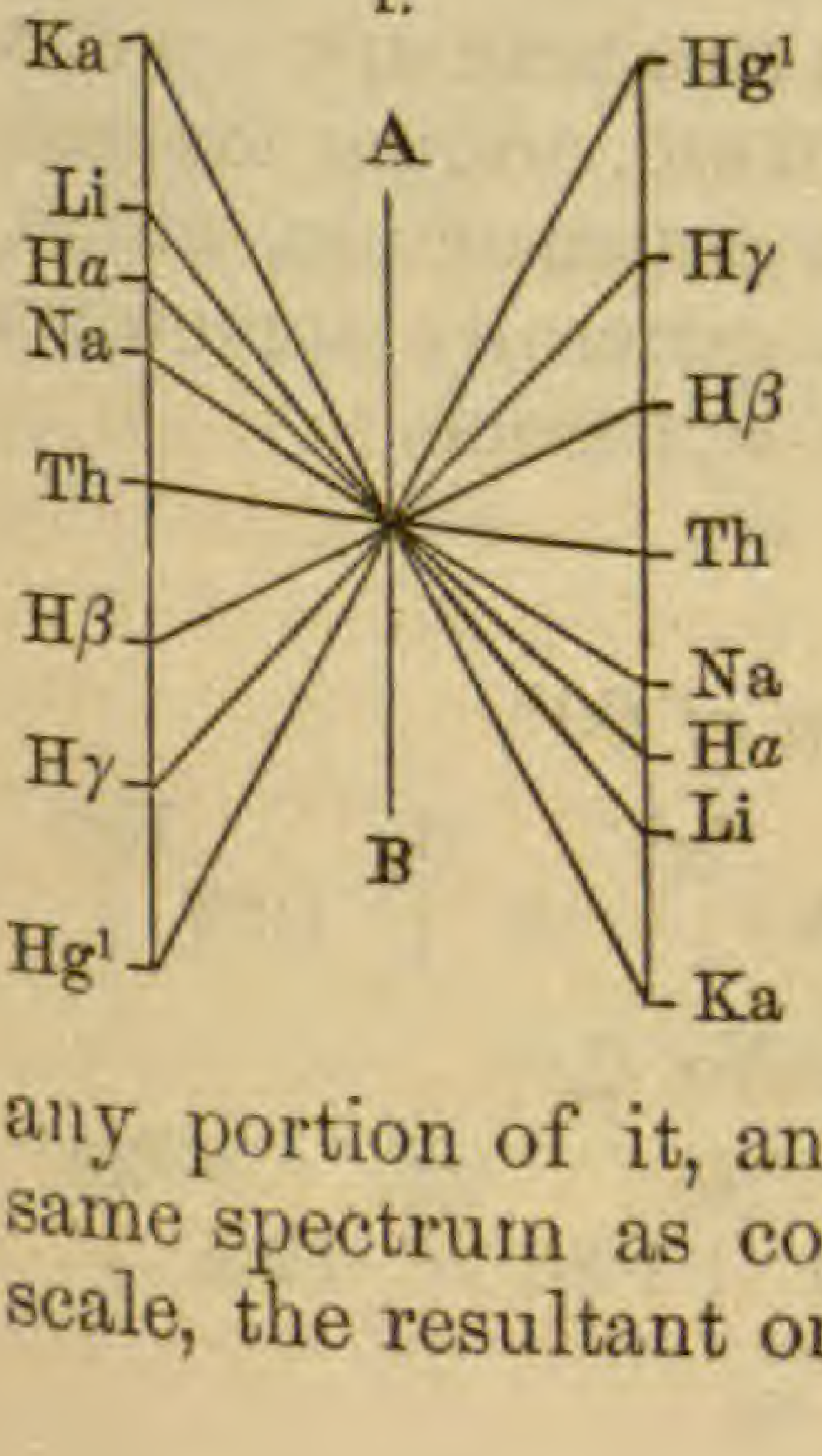
In the experiments described in this paper only two prisms were used, their angles being approximately 60°; one was made of ordinary flint glass, the other was filled with bisulphide of carbon. Mr. Rutherfurd kindly supplied me with two of his superb diffraction gratings; both were ruled on glass, the finer, No. 1, having 6480 lines to the inch, while the other, No. 2, in the same space contained 4320. The *equality* of the intervals between the lines was equal, if not superior, to that in the gratings of Nobert which have come under my observation; the spectra were brilliant.

The lines of the solar spectrum are not adapted for the study of the arrangement of the colors of the secondary spectrum, owing to its peculiar structure, consisting as it does of a spectrum bent back or folded on itself and in some portions very much contracted; the identification of solar lines becomes, hence, all but impossible in the majority of cases. Accordingly I selected a number of chemical lines of easy identification, which in point of fact proved to answer quite well. They were as follows: the potassium line at the extreme red end of the spectrum (Ka), the red lithium line (Li), the red hydrogen line (Hα), the sodium line (Na), the thalium line (Th), the blue hydrogen line (Hβ), and in some cases the violet hydrogen line (Hγ). For the most refrangible portion of the spectrum I employed two mercury lines, viz: the final line, which is somewhat less refrangible than the solar line H, and which is marked by Huggins with the number 5158; also the line next but one to it, 4775, Huggins. This last line is a little less refrangible than the violet hydrogen line (Hγ), and is far more brilliant. These lines I have indicated in the spectra given below by the symbols Hg^1 and Hg^3. The most refrangible of the caesium and rubidium lines were also sometimes employed to divide up, for purposes of measurement, the rather extensive tracts in the blue and violet portions. The potassium line was best obtained by a flame of common illuminating gas somewhat under-fed with oxygen, so as to avoid danger of fusing the platinum wire; the salt selected was the nitrate. The hydrogen lines were from a spectral tube containing the rarefied gas, the thalium line from a mixture of the sulphate of thalium with carbonate of soda, which ensured the necessary presence of the line due to the latter. The mercury lines were generated by the aid of platinum and mercury electrodes, in connexion with an induction coil and Leyden jar. All these lines were plainly visible in both the primary spectra; in the secondary spectra, also, sometimes all were present, though usually the potassium line was too faint to admit of accurate measurement, and sometimes this was the case with the violet hydrogen line.

Mode of experimenting.—Light from the slit was rendered parallel by the collimator and fell upon *the prism*, which was placed in the position of minimum deviation for the Na line; emerging from this, it fell upon the grating, which was also arranged at its position of minimum of deviation for the same line. The vertical axis of the observing telescope was placed directly under the grating, prism and grating being arranged in the sense of balancing each other's action. With the aid of the chemical lines above enumerated and the micrometer eye-piece, a map of the secondary spectrum was then noted down, and afterward by two distinct processes, maps of the two primary spectra were obtained, the prism and the grating, as before, being in the position of minimum deviation for the Na line.

Construction for secondary spectra.—Before giving the results of these experiments, I will describe a simple construction which is quite useful in the study of secondary spectra, as it furnishes correctly, not only the order and direction in which the lines are disposed, but also their actual distances apart. If we adopt the convention of representing achromatism, not by the parallelism of lines representing the rays, but by their *intersection*, we obtain immediately the annexed construction, for the resultant action of two opposed but equal and similar spectra. Let the vertical parallel lines represent the spacing of the original spectra; joining the corresponding points by straight lines, the resultant spectrum is found on the line AB, midway between the two primary spectra, and is in this particular case a point, all the rays having been united and perfect achromatism attained, fig. 1. If, on the other hand, we reduce one of the original spectra to a point, and as before complete the construction, a real resultant spectrum will be found on the line AB, correct in its spacing and of half the size of the actual physical resultant spectrum (which in this case is the remaining original spectrum), and so on for all other cases; or in general, if S = the length of the physical resultant or secondary spectrum, or the length of any portion of it, and S' = the corresponding length of the same spectrum as constructed, then S = 2S'; or if drawn to scale, the resultant or secondary spectrum in the construction

1.



will always be half the size of the actual physical spectrum which it represents. It is evident that the construction is independent of the relative position of the lines representing the two primary spectra, demanding only that they should be represented by straight parallel lines.

It is not actually necessary to go through the labor of executing the projections on paper, as a far more accurate result can otherwise be obtained. Upon inspecting the construction, fig. 1, or one with dissimilar primary spectra, it at once becomes evident that the distance of any two lines apart in the secondary spectrum (on the line AB), will be equal to one-half the difference between the corresponding distances in the primary constituents, or

$$l''=\frac{l'-l}{2},$$

and hence in the actual or physical secondary spectrum we shall have

$$l''=l'-l,$$

where l'' is the distance between any two lines in the secondary spectrum, l' and l the corresponding distances in the two primary spectra. Hence to construct a correct map of the secondary spectrum in any case, it is only necessary to make maps of the primary spectra with the spectroscope and any convenient set of lines, when the above formula at once furnishes the desired result, and gives also the point of *inflexion*, if attention is paid to the algebraic signs of the intervals between the lines, which is most simply effected by taking the extreme red as a starting point, and making the distances measured to the right of it positive, those to the left negative.

Experiments.—Three principal cases arise: 1st, where the opposing spectra are of equal or nearly equal lengths; 2d, where the spectrum from the grating preponderates; 3d, where the prismatic spectrum is the longer of the two. I give below for these cases the measurement made on the two primary spectra and on the actual physical secondary spectrum, adding for each of these cases the results obtained from the construction, which, for a reason hereafter to be mentioned, are generally somewhat more correct than those obtained with the telescope.

1st Case.

Spectrum from flint glass prism of 60°.

Ka		Li		Hα		Na		Th		Hβ		Hg^3		Hγ		Hg^1
	4·5		·9		4·8		5·6		6·7		9·9		·3		10·6	

Spectrum of 1*st order*, *grating No.* 2.

Hg^1		Hγ		Hg^3		Hβ		Th		Na		Hα		Li		Ka
	4·75		·2		6·45		6·45		7·1		8·75		1·85		12·5	

Actual secondary spectrum due to the above in combination.

Th		Hβ		Na		Hg^3		Hγ		Hα		Li		Hg^1
	·4		1·3		2·1		·3		1·5		1·05		2·75	

Secondary spectrum from construction.

Th		Hβ		Na		Hg^3		Hγ		Hα		Li		Hg^1		Ka
	·25		1·25		2·2		·1		1·65		·95		3·25		4·75	

The magnifying power of the observing telescope was about 12 diameters.

2d Case.

Spectrum from bisulphide of carbon prism of 60°.

Ka		Li		Hα		Na		Th		Hβ		Hg^3		Hg^1
	4·6		·8		5·4		6·3		8·		13·3		15·4	

Spectrum from grating No. 1, 2*d order.*

Hg^1		Hg^3		Hβ		Th		Na		Hα		Li		Ka
	6·5		9·3		8·7		9·5		11·8		2·7		17·1	

Actual secondary spectrum due to the above.

Hβ		Th		Na		Hg^3		Hα		Li
	·6		3·5		0		6·7		1·7	

Secondary spectrum from construction.

Hβ		Th		Na		Hg^3		Hα		Li		Hg^1		Ka
	·7		3·2		·1		6·3		1·9		·7		11·8	

The magnifying power of the observing telescope was about five and a half diameters.

3d Case.

Spectrum from bisulphide of carbon prism, 60°.

Ka		Li		Hα		Na		Th		Hβ		Hg^3		Hg^1
	10·1		2·		11·35		13·45		17·6		28·35		33·85	

Spectrum from grating No. 1, 1*st order.*

Hg^1		Hg^3		Hβ		Th		Na		Hα		Li		Ka
	7·6		9·78		9·5		10·7		13·25		2·85		19·	

Actual secondary spectrum from the above.

Na		Hα		Th		Li		Hβ		Hg^3
	1·9		·8		·13		7·87		18·2	

(*The same repeated.*)

Na		Hα		Li		Th		Hβ
	1·7		1·		·2		7·6	

Secondary spectrum from construction.

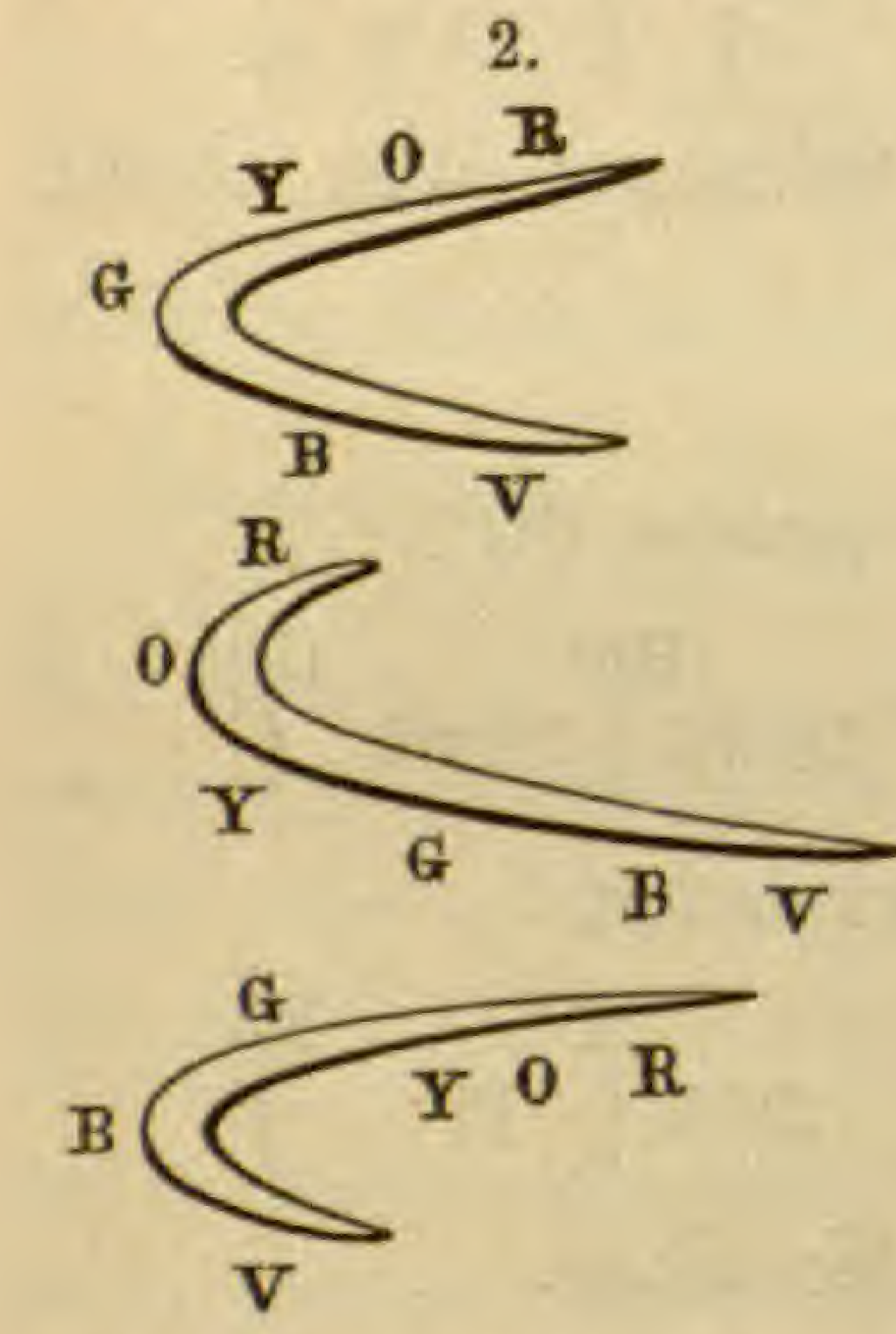
Na		Hα		Li		Th		Hβ		Ka		Hg^3		Hg^1
	1·9		·85		0		8·1		·8		17·77		26·25	

The magnifying power of the observing telescope was about 12 diameters.

The difference between the two *actual* secondary spectra in this last set of experiments is due to slight errors in adjusting for the position of minimum of deviation at the time of combination, as a small error in this respect produces, as I ascertained by direct experiment, a much larger one in the secondary spectrum. Also the differences between the set of actual secondary spectra, and those given by the formula, are mainly to be attributed to this same cause. The accuracy of the measurement in the second set of observations is somewhat inferior to that in the other two, owing not only to the low magnifying power, but to the employment of a rather awkward method for obtaining the positions of some of the lines. The maps of the spectra in last set are, on the other hand, free from this reproach.

In this place I will mention a beautiful and instructive experiment, which reveals at a glance the nature of the secondary spectrum which happens to be under examination, and permits its study in a qualitative way. Instead of using as the source of light a slit, let a pin-hole be employed, and the refracting edge of the prism being vertical, the diffraction grating is to be revolved in its own plane, somewhat, so that its lines shall no longer be vertical. This proceeding reduces the secondary spectrum to a line, and upon viewing it with the naked eye or with the observing telescope, it will be found to be curved, and upon slightly rotating the grating or prism around their vertical axes, will run through all the changes that under the circumstances are possible, as is roughly indicated in fig. 2. From this figure it will be seen, that we must regard as a true secondary spectrum a resultant spectrum in which any two, even closely adjacent lines, are united; even although the actual union of different *tints* has not been effected, and the general appearance still resembles that of one of the primary constituents.

2.



Application of the construction to the secondary spectrum produced by two prisms.—Although it has been shown that the construction above given applies to the case of a prism placed next the collimating telescope when balanced by a diffraction grating placed next to the observing telescope, it by no means immediately follows that, by reversing their respective positions, results would be obtained which could be accurately predicted by the construction, or by the formula founded on it. One of the disturbing causes here introduced is the thickness of the prism, which in the other mode of arranging the apparatus is indifferent. To determine the amount of the difference due to an exchange of the position of the prism and grating, I made a few experiments which may now be detailed.

The diffraction grating No. 1 was placed next the collimator, and balanced with the bisulphide of carbon prism of 60°; both were arranged for the minimum of deviation of the sodium line, and the secondary spectrum A was obtained. The whole apparatus was then re-arranged, and the same experiment repeated, with the result given in B.

	Na		$H\alpha$		Th		Li		$H\beta$		Hg^3
A		1·9		·8		·1		7·6		17·2	

	Na		$H\alpha$		Th		Li		$H\beta$		Hg^3
B		2·		·65		·33		7·48		17·1	

On comparing these secondary spectra with those obtained in the 3d case, it will be seen that the differences are not larger than the necessary errors of observation, except in the distance between $H\beta$ and Hg^3, where the difference is about twice as great as it otherwise ought to be. A second perfectly similar experiment was now made with flint glass prism and grating No. 2, with the result given in C.

	Th		$H\beta$		Na		Hg^3		$H\alpha$		Li		Hg^1
C		·3		1·3		2·25		1·75		1·1		2·85	

On comparing this secondary spectrum with that obtained in case 1st, it will be seen that it is even more closely correspondent than A and B. Other experiments were also made where the positions of the prism and grating were repeatedly interchanged, and the maps of the secondary spectra *immediately* compared, and from this work it results, that for *practical* purposes such exchange may be made without the introduction of serious errors, and that hence the above construction, practically, applies to the secondary spectrum furnished by *two prisms* of different materials.

It is thus seen that the construction furnishes a simple means of determining the size and arrangement of the secondary spectrum furnished by two prisms of selected angles, placed in any desired positions relative to the incident ray and to each other, the accuracy of the result depending mainly on the exactness with which the measurements on the primary constituents are effected, and it may possibly prove useful, in dealing practically with the secondary spectra in optical instruments. It is hardly necessary to remark, that the use of an eye-piece provided with cross-hairs and a micrometer screw would easily give results considerably more exact than those detailed in this article.

I may add that the construction is evidently applicable to the case where the two primary constituents do not oppose, but add, to each other's effect, and that with it, two secondary, can be treated like two primary spectra. In this last case the two secondary spectra, if equal and similar in all respects, and opposed, of course destroy each other; but what is more to the point, the construction shows that even where the secondary spectra are additive, their sum, or the total extent of the tertiary spectrum, will be smaller when the secondary spectra are dissimilar in arrangement, than when this is in both identical, though here the matter of the choice of tints for union comes into play and must be considered.

Quite large secondary spectra with lines were also obtained by achromatizing one 60° prism of bisulphide of carbon with a train of seven water prisms, and by the pin-hole method some experiments were made on the secondary spectra obtained by achromatizing two or more prisms of a given substance, placed in the position of minimum of deviation, by a single prism of the same material much inclined; these matters were, however, not pushed far enough to give results of much interest in this connection.

Columbia College, July 11th, 1873.

ART. XX.—*Notes on the Corundum of North Carolina, Georgia, and Montana, with a description of the Gem variety of the Corundum from these localities;* by J. LAWRENCE SMITH, Louisville, Ky.

THE corundum formations in North Carolina and Georgia are the second in importance in the United States that have been brought to my notice; and the one in North Carolina is by far the most interesting in this country, and perhaps of any yet known, in the extent of the formation, the distribution of the corundum, and the purity of the mineral.

This mineral was first discovered in North Carolina in 1846—about the time I was engaged in developing the geology of emery in Asia Minor and the Grecian Archipelago; and upon communicating to American geologists my discoveries in relation to the associate minerals of the emery in Asia Minor, and directing them to search for the same in connection with the corundum found in different parts of America, the same associates were discovered in connection with the North Carolina corundum as well as that from other localities.

At this time there had been discovered but one detached block, but no other specimen could be found in that locality. There the matter rested until 1865, when C. D. Smith (to whom I am indebted for valuable information contained in this paper), assistant of Prof. Emmons, geologist of North Carolina, had brought to him by one of the inhabitants of the country west of the Blue Ridge Mountains a specimen of rock which was recognized as being corundum, and on visiting the spot this geologist discovered the corundum *in situ*, and a number of specimens were collected. Since that time public interest has increased in relation to this substance, and it has been discovered in such quantities as to make it an object of interest to the arts as a substitute for emery, and very rapidly other localities were brought to light along a distance of forty miles.

The colors of the corundum as found along this zone of outcrops are blue, gray, pink, ruby, and white. Sometimes it has broad cleavage faces, and then again it occurs in hexagonal prisms. One hexagonal prism weighed over three hundred pounds. There is a difference in the cleavage and the associate minerals at different localities.

In the development in North Carolina the corundum occurs in chrysolite or serpentine rocks, and outside of serpentine it has not been found. These chrysolite rocks belong to a regular system of dikes, which have been traversed for the distance of about one hundred and ninety miles. This system of dikes lies on the northwest side of the Blue Ridge, and has a strike parallel to the main mass of the ridge, and has an average distance from the summit of the ridge of about ten miles. It continues this strike to the head of the Little Tennessee River, say from Mitchell to Macon County, one hundred and thirty miles. Here the ridge curves around the head of the Tennessee and falls back about ten miles to the northwest. In conformity with this elbow in the ridge, the disturbing force shifts to the northwest and re-appears at Buck's Creek, having the same relative position to the Blue Ridge.

The serpentine appears at intervals along this whole line of one hundred and ninety miles. There is a corresponding system of dikes traversing the southern slope of the Blue Ridge, but not so regular and compact as the system on this northwest side, nor are the outcrops so frequent. The main mass of the ridge bears no evidence of having been disturbed at all, at least none has been found. From Mitchell County to Macon the serpentine is usually inclosed in a hard crystalline gneiss, which bears rose-colored garnets, cyanite, and pyrite. After its shifting to the right it occurs in hornblendic beds and gneiss. At Buck Creek and thence southwestward the hornblende beds assume very large proportions. and instead of common feldspar have in them albite, making an albitic syenite. At Buck Creek (which is named Cullakenih) the chrysolite covers an area of about three hundred and fifty acres. One or two observers have fallen into the error of confounding the two dike systems, whereas they have no connection whatever. According to them the northern system cuts through the Blue Ridge at rightangles, and then turns back on the opposite side of the ridge. Now there are no such phenomena connected with these outcrops. They evidently belong to separate systems. The outcrops along the northern system occur at intervals ranging from one to fifteen miles. The belt or zone along which these outcrops occur never exceeds four miles in width on the northern side of the ridge. On the opposite side the system is not so well defined, and the outcrops are rarer.

Upon these serpentine beds there exists chalcedony, chromite on some of them, chlorite, talc, steatite, anthophyllite, tourmaline, emerylite, epidote on some of them, zoisite, and albite, with occasionally asbestus and picrolite, as also actinolite and tremolite. The corundum at some places seems to occur mostly in ripidolite in fissures of the serpentine. At Cullakenih the corundum with its immediate associates is in chlorite, except the red variety, which is in zoisite, containing a minute quantity of chrome.

Throughout all the range of rocks for the great extent referred to, corundum forms a geognostic mark of this chrysolite-rock, just as it does of the calcareous rock bearing corundum described by me in Asia Minor. They belong to the same geological epoch, and overlie the gneiss.

The closest investigation shows that the chrysolite in North Carolina takes the place of calc-rock in Asia Minor; that these are invariably the gangue rock in the two different quarters of the globe; but, as remarked above, the contiguous rock shows them both to be of the same geological period, overlying directly the primary rocks; and both of them are also identical geologically with the Chester emery formation of Massachusetts.

While all the localities of corundum and emery I have examined exhibit certain marked and prominent characteristics common to them all, and evince unmistakable evidence of geological identity, yet each locality has its peculiar characteristics. In all cases, however, the masses of corundum give evidence of having been formed by a process of segregation, as described in my memoir on the Asia Minor emery.

In Asia Minor the Gumuch-dagh emery has but little black tourmaline associated with it, and instead chloritoid in crystals or lamellæ; also its diaspore is rare, but when found is prismatic, affording the finest perfect crystals yet seen, from which M. Dufrenoy made his last study of the crystallography of this mineral; and the emery is associated with calcareous rock overlying gneiss. The Kulah emery from the same part of the world is equally in calcareous rock, and has very little chloritoid or chloritic mineral associated with it.

The Naxos and Nicaria emery of the Grecian Archipelago is also in connection with calcareous rock, but has no chloritoid associated with it, but in its place black tourmaline is abundant.

While in the above localities the rock bearing the corundum is calcareous, that in Chester, Mass., has hornblendic gneiss immediately on one side of the vein, and is accompanied with a large amount of magnetic oxide of iron. Tourmaline also abounds in this corundum, and like the Asiatic variety it contains rutile, ilmenite, etc.

In the localities forming the subject of this memoir the following minerals are deserving special notice.

Corundum.—This mineral occurs in finer and more beautiful variety than in any yet known locality. The masses in many instances are very large, weighing six to eight hundred pounds, having fine large cleavages, and are remarkably free from foreign ingredients. The crystals are also fine, and in some instances of great size and beauty. Two of them discovered by Col. Jenks, and now in the possession of Prof. Shepard, have been described by him.* They are respectively three hundred and twelve and eleven and three-fourths pounds in weight. The largest is red at the surface, but within of a bluish-gray. The general figure is pyramidal, showing, however, more than a single six-sided pyramid, whose summit is terminated by rather an uneven and somewhat undefined hexagonal plane. The smaller crystal is a regular hexagonal prism, well terminated at one of its extremities, the other being drusy and incomplete. The general color of this crystal is a grayish-blue, though there are spots, particularly near the angles, where it is of a pale sapphire tint. Its greatest breadth is six inches, and its length over five. Some of the lateral planes are coated in patches with a white pearly margarite.

The smaller crystals are often transparent at their extremities. It is, however, in color that the corundum of this locality excels. It is gray, green, rose, ruby-red, emerald-green, sapphire-blue, and all intermediate shades to colorless. Many pieces of the blue and red have been cut and polished, presenting very good characters as gems, without being of the finest quality.

---

* This Journal, III, iv, 109, 175, (1872), in an elaborate memoir "on the Corundum region of North Carolina and Georgia."

Diaspore.—While this mineral is found so abundantly with the corundum of Chester, Mass., I have not been able to find it with the North Carolina corundum. Several specimens of supposed diaspore have been submitted to me, but on close examination it was found to be colorless cyanite.

Chlorite.—This mineral abounds in this locality, and, as has been stated, is the gangue-rock of the corundum; it not only surrounds the corundum, but permeates it. There are several varieties, varying in color from a yellowish-green to a dark-green, and differing a little in composition. Two specimens from the same locality were composed as follows:

	Large plates.	Friable.
Silica	27·00	29·15
Alumina	21·60	10·50
Oxide of iron	16·63	23·50
Magnesia	22·00	25·44
Water	12·30	10·04

Margarite (*Emerylite*).—This curious mica—curious so far as that since my first pointing it out as a characteristic of the emery formation in Asia Minor and the Grecian Archipelago it has been found wherever corundum is, and in the case of Chester emery was the means of leading to its discovery,—at the N. C. localities is abundant mixed with the associated minerals. Chemical analysis was made of a specimen with the following result:

Silica	32·41
Alumina	51·31
Lime	10·98
Soda	2·43
Water	2·13

Zoisite.—This mineral occurs in two forms—a black variety and a light-green variety. These minerals have been called by some Arfverdsonite, but neither of them have the composition of that mineral. Their compositions were as follows:

	Light green.	Lake Geneva.	Black variety.
Silica	45·70	43·59	45·90
Alumina	24·01	27·72	13·34
Peroxide of iron	4·56	2·61	11·46
Lime	13·44	21·00	12·20
Magnesia	8·03	2·40	12·53
Soda	2·91	3·08	3·39
Water	·60	----	·66
Oxide of chrome	·52	----	----

The green variety has a very pale chrome-green color; for comparison the analysis of a similar specimen from Lake Geneva is annexed.

Andesite.—This mineral occurs mostly in a granular form. Its composition is—

Silica	64·12
Alumina	24·20
Soda	9·28
Lime	2·80
Oxide of iron	·14

The other minerals associated with this emery formation are magnetic oxide of iron, chrome iron, rutile, asbestus, talc, actinolite, black tourmaline, chalcedony, anthophyllite, spinel, albite and picrolite.

On the existence of the Ruby and Sapphire in North Carolina and Montana Territory.

The corundum locality that I have described in North Carolina furnishes masses of corundum from which small pieces can be detached, of good blue or of ruby color, perfectly transparent, and nearly free from flaws. When cut and polished they are gems of no mean value. I have not seen the most perfect of them that have been cut, but I have some polished specimens of fine color but with many flaws.

The question naturally arises, what may be the prospects of obtaining the gem from that locality in sufficient quantity to warrant exploration? Up to the present time its occurrence is so different from those in known localities in the East Indies that we are rather inclined to the opinion that it will only be occasionally that pieces of corundum will be found of sufficient purity and beauty to be of much value as gems; for it is well known that very small defects, if they do not destroy altogether the value of the gem, depreciate its value to a very great extent.

About a year ago a quantity of rolled pebbles were sent to me from the territory of Montana, which upon examination I found to consist principally of corundum; they were like the rolled pebbles from the ruby localities in the East Indies, each one being a little crystal in itself, more or less abraded on the angles, and being of a compact, uniform structure. They were flattened hexagonal prisms with worn edges. They were either colorless or green, varying in shade from a light to a dark-green; some were bluish-green, but none red; there were some red pebbles, but on examination they proved to be spinel.

These pebbles are found on the Missouri River near its source, about one hundred and sixty miles above Benton; they are obtained from bars on the river, of which there are some four or five within a few miles of each other. In the mining region of this territory on these bars considerable gold is found, it having been brought down the river and lodged there, and the bars are now being worked for the gold. The corundum is found scattered through the gravel (which is about five feet deep), and upon the bed-rock. Occasionally they are found in the gravel and upon the bed-rock in the gulches from forty to sixty feet below the surface, but it is very rare in such localities. It is most abundant upon the Eldorado bar situated on the Missouri River about sixteen miles from Helena; one man could collect on this bar from one to two pounds per day.

I have had some of the stones cut, and among them one very perfect stone of three and a half carats, and of good green color, almost equal to the best oriental emerald.

My opinion is that this locality is a far more reliable source for the gem variety of corundum than any other in the United States I have yet examined.

ART. XXI.—*The Geology of the Bosphorus.*

[THE following notes are the result of a careful investigation of the rocks of the Bosphorus, made in company with Mr. W. T. Forbes, Instructor in Mathematics in Robert College.—GEORGE WASHBURN.]

THE straits of the Bosphorus conduct the waters of the Black Sea into the Sea of Marmora. The general direction of the stream is from N.E. to S.W. Its length is about eighteen miles and its average width about one mile. Its depth is about the same as the height of its banks, which rise abruptly from its shores from two hundred to six hundred feet. These banks are broken by narrow valleys and steep gorges at right angles to the course of the Bosphorus. This broken, hilly country extends inland for many miles on both sides of the straits.

The general character of the rocks is the same on both sides, but changes suddenly near Kavak, about six miles from the Black Sea, and again in the midst of old Stamboul at the mouth of the Marmora. The bleak and barren rocks above Kavak are such as might be seen if a passage were cloven through Mt. Vesuvius, and this volcanic region extends, with irregular boundaries, about six miles east and about fourteen miles west of the Bosphorus. Below Kavak, as far as the Sea of Marmora, there are stratified rocks of the Paleozoic age, which extend inland about sixteen miles on the European shore, and about twenty-five miles on the Asiatic. They are bounded on the former by Tertiary strata, and on the latter by Cretaceous.

The Paleozoic rocks.—These rocks were formerly called Silurian. M. Roemer afterward claimed that they were Upper Devonian. Tchihatcheff in his work on Asia Minor, Dr. Abdullah Bey in various articles in German scientific journals, and Mr.

Swan in an article published by Murchison, express the opinion that they belong to the Lower Devonian. This is now the generally received opinion. It is based upon the fossils found by these gentlemen, chiefly at Caudlija, Arnaout Knie and Cartal, on the Sea of Marmora; but even in these localities many fossils have been found which are rather characteristic of the Upper Silurian period, and the rich deposits which have been discovered by Mr. Forbes and myself at Hissar and Baltaliman appear to belong chiefly to this earlier formation, although they contain fossils usually considered as Devonian.

It seems probable, upon the whole, that in this vicinity there was no clearly marked separation between the Upper Silurian and the Lower Devonian periods; our fossils belong distinctly neither to one nor to the other, but rather to a transition period between the two. Dr. Abdullah Bey, in a notice of our investigations, lately published, acknowledges that the deposits discovered by us at Baltaliman are probably Silurian. He says: "Looking at the peculiarities of the local fauna of Baltaliman, we think that this must be considered in a different light. Its enormous richness in trilobites, which approach the forms characteristic of the Silurian formation, permits us to believe that we find ourselves here at the limit where the Upper Silurian formation is in immediate contact with the Lower Devonian of the rest of the Bosphorus."

He bases his opinion, that the rest of the Bosphorus is Devonian, upon the fact that de Verneuil, the distinguished geologist of Paris, examined a large number of his specimens and pronounced most of them Devonian; but even Verneuil acknowledges that some of them were characteristic of the Silurian period—that "there seems to be no clear line of demarcation between the Upper Silurian and the Lower Devonian." "The fossils and rocks of the Bosphorus have a remarkable resemblance to the Silurian deposits of Bohemia." Tchihatcheff notices that he has a specimen from Caudlijah upon which are found a Devonian brachiopod (*Chonetes sarcinulata*) and a Silurian trilobite (*Phacops longicaudatus*). We have ourselves a single specimen three inches square found at Baltaliman, which exhibits a perfect pygidium of *Phacops longicaudatus*, a *Pleurodyctium problematicum* and a *Spirifer subspeciosus*. These admissions of Abdullah Bey, de Verneuil and Tchihatcheff, and these facts, certainly confirm the views expressed above as to the age of the rocks of the Bosphorus. Another fact of at least negative value is that no trace of fish and no sufficient evidence of the existence of plants has ever been found in these rocks, both of which might be expected in the Devonian period.

The principal rocks found in this formation are sandstones, shales, and limestones, with more or less quartz either in veins or in isolated blocks. The *sandstones* are of every variety, sometimes passing into true conglomerates, sometimes of a fine close grain, and with colors about equally varied, gray, yellow, and red predominating. The *shales* also vary in quality and color, some of them very nearly approaching slates, while others are marlites resembling some of those of the Tertiary period. All the soil which covers our hills, and is washed down to fill the valleys is formed by the disintegration of these shales, which is going on wherever they are reached by the air and rain. The *limestone* is generally of a dark blue tint veined with calcite and sometimes with quartz, often enclosing nodules of iron and often sparkling with iron pyrites. The stone varies much in texture and quality, and although generally blue, is found at various points of a black color and often of a reddish or yellow tint. In some cases the grain is very fine without any appearance of crystalization; in others the stone is so changed as almost to resemble marble; sometimes it is very hard and sometimes soft and crumbling. The better qualities, though expensive to cut, are much used for building purposes.

The *fossils* of the Bosphorus formations are found chiefly in the shales and in some kinds of the blue limestone, but very seldom in the sandstone. The stone which contains them is rarely used either for building or for lime, and consequently they are seldom found in the great quarries. The deposits on the Asiatic shore are more extended than on the European.

On the Asiatic shore fossils are abundant in the Giants Mountain, where they generally have a bright red color owing to the presence of oxide of iron. From Beicos, near the foot of the mountain, down to Caudilli they are found everywhere along the shores and on the hills, but especially at Caudlijah and Geukson. The hill between Caudlijah and Kurfess, which is crowned by a beautiful grove of stone-pines and covered by an old Turkish cemetery, is made up of fossiliferous rock, and has furnished most of the specimens of Tchihatcheff and Abdullah Bey At Geukson the best specimens came from a point about two miles back from the Bosphorus, where the Sultan has cut through a new road to his farm.

Between Caudilli and Scutari we have found nothing except on heights near Bulgurlu and on the road to Alem-dagh.

On the European shore fossils are found on the extreme northern boundary of the Paleozoic rocks near Yeni-Mahallé—also at Therapia and Kalender—but all of them in a worn state. At Yeni Kusi, Stenia, Emirghian, and in the main valley of Baltaliman we have found nothing near the shore and only here and there one on the hills, although these villages are opposite the rich deposits of Caudlijah.

But on the hills behind Hissar and in the valley beyond them, which opens into the great valley of Baltaliman, we have made our most interesting discoveries. We have wandered over these hills and valleys again and again without finding anything and with very little hope, but a more careful and determined search, to which we were led by accidentally finding a *Loxonema* in a detached rock, brought to light a quarry in the garden of the Sultan's brother-in-law, which contained rich deposits.

About two hundred feet higher than this garden and nearer the Bosphorus we found another Turkish garden, where the underlying rock was broken up last year to the depth of four feet, and this proved to be a garden of *trilobites*. While the work was going on we visited this place as often as the ugliness of the keeper could be mollified by a reasonable backsheesh, but the work was soon done, the vineyard planted, the melons growing and the *trilobites* buried.

The Turkish cemetery in front of Robert College contains rocks which furnish many fossils, but they are poorly preserved. At Arnaoutkuei there are old quarries, which furnished former explorers with most of their specimens and which are still full of fossils. No other deposits of any importance are known to exist on this side of the Bosphorus, though others may yet be found. At Kartal and Pendik, on the Sea of Marmora, the fossils are abundant and do not differ essentially from those on the Bosphorus.

Within certain limits, however, each of the principal localities on the Bosphorus is characterized by a fauna peculiar to itself. The vineyard spoken of at Hissar, for example, abounds in *Trilobites* with only now and then an *Orthis*, or a *Cyathophyllum*. The valley of Baltaliman, 200 feet below, is especially remarkable for the great abundance and variety of its *Orthids*, and the variety and beauty of its *Crinoids*, and *Trilobites* are common, but of different genera from those found upon the hill above. From the latter we have specimens of *Conocephalus*, *Bavarilla*, *Asaphus*, *Cheirurus*, *Phacops*, and perhaps others. From Baltaliman, we have a great variety of the *Cryphæus*, *Phacops*, *Conocephalus*, *Homalonotus*, including three of the *Phacops longicaudatus* and one of the *Homalonotus delphinocephalus* of great size. In the Geukson Valley on the opposite side of the Bosphorus, we have found specimens of the Homalonotus of great size—several of the *Homalonotus Gervillei*, of which we have found no trace anywhere else. This last is figured in the plates of Tchihatcheff's Asia Minor. He remarks in reference to it, that his plate is taken from a specimen found in Normandy, and that it is doubtful whether the small fragment found by Abdullah Bey really belongs to this remarkable species. The three specimens found by us at Geukson are fully equal to the one given in his plate.

Almost all the fossils of this part of the Geukson Valley are very large and peculiar to the locality. The *Spirifer* exists everywhere, especially the *Spirifer subspeciosus.* The same may be said of the several varieties of *Pleurodyctium* especially the *problematicum* and *Constantinopolitanum;* also of several species of *Cyathophyllum.* Many varieties of *Orthoceras* and *Trochoceras* are found at Arnaoutkuei and Caudlijah; a few at Baltaliman and Geukson. We have found in all ten or twelve species, the names of most of which we do not know, but among them is the *Trochoceras Barrandei* of de Vernueil, which is probably a misnomer; it is probably a *Lituites.* The species of *Orthis* are found in all the localities, but most abundantly at Baltaliman; from this single quarry we have at least thirty species, including a number of new ones, to two of which Dr. Abdullah Bey has given the names of Mr. Forbes and myself. The genus *Leptæna* is especially characteristic of Caudlijah, where at least twelve or fifteen species exist in abundance; at Baltaliman it is hardly found at all. The *Pterinea elegans* also is common at Caudlijah and Geukson, but is not found at Baltaliman. *Rhynconella*, *Strophomena* and *Chonetes* and species of other genera abound in various localities. Crinoids and corals of many kinds, and some of them of great beauty, occur at all the points mentioned. Should we have the good fortune to receive a visit from some thoroughly competent paleontologist, we shall submit the Robert College collection to his consideration and publish a full catalogue of our specimens. At present there are many which we cannot determine.

The Eruptive Rocks of the Bosphorus.—These rocks may be divided into two groups, those which are massed at the northern extremity of the Bosphorus, and those which are found in dikes at different points in the midst of the stratified rocks. These two groups are of different ages and of different origin, and must therefore be considered separately.

It is our impression that we have at the northern extremity of the Bosphorus the remains of a true volcano. The general appearance and structure of the rocks is the same as of those about Vesuvius or Etna. We find trachyte, diorite, basalt, vast collections of conglomerate of every kind of coarseness, often composed of masses of black doleritic porphyry with other forms of rock which are very difficult to determine. These are often regularly stratified, but in other localities in immense masses, broken only by irregular fractures.

As there is no visible crater from which all these rocks could have been thrown out, nor indeed anything which looks like a crater of eruption, we must suppose that this crater is now hidden beneath the waters of the Black Sea, possibly at some little distance from the shore. It is certain that these volcanic rocks extend out under the sea, to some distance, and there is nothing in the nature of the case to make it improbable that there was once a vast volcano there, which vomited out all the eruptive rocks on both sides of the Bosphorus as far down as Kavak, and afterward in some later convulsion of nature sank below the surface of the sea. We have found nothing in the rocks to determine at what period this volcano existed, but we think it may be asserted that it was not contemporaneous with the eruptions of the lower Bosphorus.

The only historical evidence upon the subject is the tradition of the Cyanean rocks or the Symplegades. There are certain rocks near Fanaraki which now bear this name, but without a shadow of right. These rocks are mentioned by Strabo, who alludes to the ancient story that they were floating islands. He says that in his day two islands existed at the mouth of the Bosphorus, about twenty stadia apart, one near the European and one near the Asiatic shore. The rocks now called Cyanean are on the European coast, with no corresponding ones on the Asiatic, and they have evidently been connected with the main land within a short period of time. Their geological composition is exactly similar to the nearest point of the coast which is only *fifty feet* distant, and is connected with the island by a continuous ledge of rock, with deep water on either side, but with not more than two to three feet of water above the ledge. The sea breaks here with tremendous force and has evidently worn this passage through the rocks. If Strabo ever saw the islands of which he speaks, which is doubtful, they have since disappeared, either worn away by the sea or sunk beneath its waters. Homer, in the Odyssey, says of these rocks: "These then are lofty rocks, and near them the vast wave of Amphitrite resounds; the blessed Gods call them the Wanderers: here neither birds pass by nor the timid doves which carry Ambrosia to father Jove; but the smooth rock takes away some one of them, and the father sends another to make up the number. From this has not yet any ship of men escaped, which ever has come to it; but the wave of the sea and the *storms of destructive fire* take away planks of ships and bodies of men together. The Argo alone," etc. From this passage, I think it may be inferred that the Cyanean rocks were active volcanoes, and that at least the tradition of such volcanic islands was current in the time of Homer. What is said of the birds confirms the idea, for it can hardly be imagined that birds could be caught by the islands coming together though they might be by volcanic eruption.

It is possible then that the volcanic remains at the mouth of the Bosphorus belong to the present geological period, that the centers of eruption were already surrounded by the sea in the time of Strabo, and that they have since sunk below the surface. This seems to me, on the whole, the most plausible theory in regard to the Symplegades. They were volcanic craters that made the passage into the Black Sea extremely dangerous, and sometimes, perhaps, filled up the channel by their eruptions, thus giving rise before historic times to this well known fable.

The second group of eruptive rocks upon the Bosphorus has no apparent connection with the first. There is no evidence of any volcanic action below Yeni Mahallè. We find hundreds of dikes in the stratified rocks filled with material which is evidently eruptive, but which differs from the great volcanic domain of the upper Bosphorus in composition almost as much as in form. It is true that a few of these dikes are filled with trap, almost black, but ordinarily we find some variety of porphyry, especially dioritic porphyry. The most interesting illustration which we have of an eruption of this last is found in the valley of Bebec. In this deep gorge we can study, perhaps better than anywhere else, all the phenomena of these local eruptions, which have turned, folded and twisted the stratified rocks of the Bosphorus in such an extraordinary manner, as to make it utterly impossible to discover any regularity in the dip or strike of the strata. At Bebek there is a dike of beautiful dioritic porphyry more than 200 feet wide, which can be traced for at least half a mile, although there are generally stratified rocks above it, which have been modified in texture, twisted and rolled back by this eruption. Smaller dikes appear at other points at Bebek, so that it is not improbable that the whole hill back of the village owes its elevation to this eruption. Arnaoutkuei, Hissar, Koulali and Geukson, indeed all the prominent points on the Bosphorus, furnish equally manifest, though not always equally interesting, examples of these eruptions. In many cases the eruptive rock has decomposed much more rapidly than the stratified rocks about it, and in different localities it may be seen in every stage of decomposition, until in some cases it is distinguishable from sand or clay only by the few crystals of feldspar or amphibole which it contains. At Geukson the great extent of this eruptive rock, which is exposed by a new road, makes it almost certain that it underlies the whole hill, and we have here the curious phenomenon of well-preserved fossils in perpendicular strata lying directly against the porphyry.

It is an interesting fact in this connection that the Paleozoic domain which has been so completely broken up by volcanic action, has enjoyed since historic times a long immunity from earthquakes. Many earthquakes have been recorded in Constantinople, some very severe, but they have spent their force on the region of the Tertiary formation and on the adjacent southern slope of Stambool, never, so far as we can learn, doing any serious damage on the Bosphorus. The walls and towers of the castles at Hissar remain unshaken, while the old walls of the city have been split and cracked in every direction.

The Mines of the Bosphorus.—These are of iron and copper. There is an iron mine, formerly worked, not far from the village of Beicos on the Asiatic coast, and a copper mine at Sariya on the European shore, now worked by an Englishman, who sends the ore to England to be smelted there. This most interesting mine is situated just at the point where the volcanic rocks of the upper Bosphorus end and the Paleozoic rocks commence. On one side of the valley you have absolute barrenness and desolation, on the other the luxuriant and picturesque scenery which has made the Bosphorus so famous. The locality of the mines is marked by groups of hills—white, red, and yellow—which are perhaps mostly the refuse of old mining operations, and are composed of disintegrating quartz, conglomerates, and variously-colored clays and earths. The metalliferous rocks are sometimes quartz, sometimes limestone or shales, and sometimes of a peculiar gray argillaceous stone, the character of which is difficult to determine. Those rocks all furnish pyrites of iron, copper and arsenic, and are decidedly richer than the average of English copper mines. Their extent is unknown. Thus far they have been worked only in a primitive way by running galleries into the sides of the hills, following the veins of metalliferous rock. There seems to be little doubt that these deposits are connected with the volcanic rocks, as we find traces of copper on the Asiatic shore, not opposite Sariya, but higher up in the eruptive rocks, or where these meet the Paleozoic. We find *iron* pyrite sand nodules everywhere, but there is no trace of copper below Sariya until we come to the Prince's Islands in the Sea of Marmora.

The origin of the Bosphorus.—It is evident, from the facts already stated, that what now constitutes the Paleozoic zone of the Bosphorus, a territory of about 700 square miles, rose above the seas at the commencement of the Devonian period as a single island. For ages it continued to be so. It was not until the close of the Tertiary period that it was united to the continent of Europe, although it was probably during the Cretaceous epoch that it became a part of Asia. Until its union with Europe, the Mediterranean, the Black Sea, and the Caspian were all one body of water. The Caspian was separated from the Black Sea, and its surface is now variously estimated at from 80 to 300 feet below the level of the latter. The formation of the Thracian peninsula cut off the Black Sea from the Mediterranean, and it had to seek some outlet. Before this time the succession of local eruptions mentioned above had broken up the strata of the old Paleozoic island so as to form deep valleys in all directions. As the waters of the Black Sea rose, they found their way into one after another of these valleys until they reached the Marmora, which was then probably a lake. The rise in the Marmora cut through the channel of the Dardanelles. There is no evidence whatever of the Bosphorus having been opened by a single eruption or earthquake, or of any raising and breaking of the rocks on a continuous line. The only thing which makes the problem a difficult one is the existence of the great volcanic domain at the northern extremity of the straits. The channel of the Bosphorus passes through this a distance of more than four miles. How was this part of the channel formed? If we knew the age to which this domain belongs, we might answer this question. As it is, it must remain a matter of speculation.

ART. XXII.—*Explorations of* 1872: *U. S. Geological Survey of the Territories, under Dr. F. V. Hayden; Snake River Division.**

THE party gathered at Ogden, Utah, during May and June; and its scientists explored a considerable stretch of territory in the neighboring portions of the Wahsatch Mts., while animals and supplies for the season's work were slowly got together.

Upheaval and folding have here proceeded on a vast scale, the main front ridge of the Wahsatch range consisting of an immense anticlinal, somewhat complicated on its front (western) face by subordinate folds, which would be apt to confuse one who passed hastily over them. Except where portions of these folds remain, the front of the ridge is here mainly composed of gneissoid rocks, showing strong westerly dips; while the crest and eastern slopes are composed of quartzites and limestones, also with strong dips but easterly ones. The general section of these upper strata is as follows:

1. Gray and drab limestones, largely siliceous	3000 ft.	Carboniferous.
2. Ferruginous quartzites	2000 to 2500 "	Devonian?
3. Blue and gray magnesian limestones, part pebbly	1900 to 2000 "	Upper? and Lower Silurian.
4. Gray calcareous shales	1000 to 1200 "	
5. White and ferruginous quartzite, base pebbly	1500 "	Potsdam.

From discoveries made farther north, it became evident that at least the lower part of the limestones of No. 3, together with

---

* This notice has been prepared for this place by Prof. Frank H. Bradley, Geologist of the Expedition in the Snake River Division.

probably the whole of No. 4, must belong to the Quebec Group. The upper part of No. 3 may possibly represent the Upper Silurian, since the characteristic Niagara coral, *Halysites catenulatus*, was obtained by Dr. Hayden, in 1871, in Box Elder Cañon, about 25 miles north of Ogden, from a bed of limestone which appears to belong to this member of the section. The quartzites of No. 2 give no indication as to their age, but are referred to the Devonian merely on account of their relative position. The Carboniferous limestones of No. 1 are in some places quite fossiliferous, though mostly not so. On a hasty trip to the mining districts of Little Cottonwood Cañon, about eighteen miles southeast of Salt Lake City, the lower part of this series of limestones was found to include some layers containing Subcarboniferous fossils allied to or identical with forms common at Spergen Hill, Indiana.

Leaving Ogden on June 24th, the party followed the roads running north along the base of the Wahsatch Mts., crossing Bear River just below the point at which it breaks through the range, and reaching the divide between the Great Basin and the Columbia drainage, at a point on the Montana stage-road, about eight miles above Malade City. As we pass northward, the range loses much of its elevation; and, about Malade, the upper strata disappear, while the mass of the mountain is composed of variously-colored limestones, with intercalated shales and sandstones, most of which contain very numerous Trilobites, Brachiopods and other fossils characteristic of the Quebec Group. Mr. Meek is of the opinion that the fossils, so far as studied, will not justify a reference of the beds to an horizon higher than what has elsewhere been called Calciferous, though he admits the impossibility of distinguishing certain pygidia, which are rather common in one of the lower layers, from those of *Bathyurus Saffordi.* About 2,000 feet of strata are here exposed: and it is probable that more detailed study than it was possible to give, at the time of our visit, would show a distribution of species in the successive layers which would correspond with progress in time during their deposition. As Malade City is only a few hours ride by stage from Corinne, it is to be hoped that collectors, who may be passing over the Central Pacific R. R., will visit the locality and work out the details of the section.

The terraces surrounding the Salt Lake Basin, of which thirteen were counted near the mouth of Ogden Cañon, where the river currents had been checked by the lake when at its higher levels, though only three are prominent along most of the border of the basin, run above Malade City; and the uppermost one apparently coincides so nearly with the summit of the divide as to leave one in doubt whether or not there was formerly a dribbling outflow from the Great Basin to the Columbia. There certainly was not any very *abundant* outflow at this point: but, from all reports, large outlets did exist, from the head of Malade River across to Bannock Creek, and from Bear River, by the way of Red Rock Pass, to Marsh Creek, a tributary of the lower part of Port Neuf River. Still another outlet existed, though it probably had but small volume, from the bend of Bear River Valley, near Soda Springs, across to the head of the Port Neuf. These should be examined in detail. In descending Marsh Creek, two terraces are very prominent; and a third is dimly outlined at about a thousand feet above the stream.

On reaching the Port Neuf, we first encounter the volcanic rocks which have filled the great plains of the Snake River Basin. The valley of the Port Neuf is floored with basalt, which escaped from one or more old craters near the bend of Bear River, and flowed between sixty and seventy miles, at least, if it did not indeed extend itself far beyond that, over the plains of the Snake. In the upper cañon of the Port Neuf, the stream flows on or in the lava beds, being constantly broken, at short intervals, by small falls over dams of calcareous tufa deposited from numerous springs along its course: but, in the lower cañon, it has fewer breaks, and runs mostly in channels excavated in the Quebec Group limestones and Potsdam quartzites of the adjoining hills, while the basalt stands as a high table in the center of the valley, broken only at the edges, where the stream has partly undermined it by removing the gravel of the old stream bottoms over which the lava originally flowed.

As we reach the plains, we find them underlaid by from three to five layers of basalt separated by beds of sand and gravel, showing as many repetitions of the volcanic eruptions, occurring after long intervals, during which intervals the mountain streams brought down and distributed widely over the plains immense amounts of well-rounded pebbles and sand, consisting mainly of quartzites, limestones and metamorphic rocks, but including also some of the lavas themselves. Upheaval has gone on here until a very recent period; since upturned porphyries and basalts, interlaminated with Pliocene sandstones and limestones, occur at many points along the foot-hills bordering the plains; but such disturbance seems to have now nearly or entirely ceased.

Reaching Fort Hall on July 3d, wagons were "turned in," a pack train was outfitted, fresh supplies were secured, and the party started again, on the 12th, across the broad lava plains to the northward, leaving for a time the Paleozoic rocks which form the mountain ranges and which are overlaid (unconformably?), about Fort Hall, by Jurassic limestones and sandstones and by the Pliocene rocks aforesaid. Vast accumulations of drifting sand cover portions of this eastern edge of the great plains, driven by the southwest winds which sweep up the valley for a large portion of the year.

Crossing Snake River, at Taylor's or Eagle Rock Bridge, the stage-road was followed to Market Lake, where the party bid adieu to civilization and struck out into the mountains. At the junction of Henry's Fork with the main Snake, two crater cones were found, standing upon the river bottoms within walls of basalt which bound the immediate valley of the present stream, and so evidently of comparatively modern date. The cones consist almost entirely of tufaceous sandstone, apparently formed under water, and inclosing many pebbles which evidently came from one of the beds of river gravel under the basalt, through which the eruption took place.

The Sand Hill Mts. were visited, and gave some evidence of having been once a volcanic crater, though the bounding walls are now so much broken down as to make their original continuity somewhat doubtful

In approaching the Teton Mts., the basalts, which are, in some parts, cut up by cañons 700 feet or more in depth, were left behind; and more ancient porphyries formed the foot-hills of the range. The axis of the range was found to consist of granites, gneisses and schists, overlaid unconformably by from fifty to seventy-five feet of compact ferruginous quartzite, supposably of Potsdam age, followed by about 300 feet of partly compact, partly shaly, glauconitic sandstone, and about 400 feet of blue, impure, thin-bedded and partly shaly limestones, both belonging to the Quebec Group. These limestones yielded a few small Trilobites. They are followed by about 600 feet of a heavy-bedded, drab to light buff, vesicular, magnesian limestone, containing no fossils except small fragments of crinoid stems, but referred with little doubt to the Niagara Group. This is followed immediately by over 2000 feet of compact, gray to drab, Carboniferous limestone, often quite cherty and mostly rather barren, though a few beds are rich in fossils.

Among the metamorphic rocks of the axis of the range, the most interesting bed is one of trap, some 60 or 70 feet thick, regularly bedded between layers of granite, laminated rather than columnar, and supposed to have been deposited by outflow over the ocean bottom during the accumulation of the original sediments of which the granites were formed. The great age of the bed, at least, is proved by its outcrop being covered, at one point, by the Potsdam quartzite, which shows no sign of disturbance; so that it *cannot* have taken its present place as an *intrusive* rock, since the commencement of the Paleozoic. The metamorphic rocks are exposed throughout an area about thirty miles long and perhaps four miles wide. From this, the newer beds dip away in every direction, at angles varying from 15° to 30°. No disturbance of the porphyries at the foot of the range was observed, which should have given evidence of any upheaval of the range continued to modern times.

The Big Teton, named Mt. Hayden by our party, in default of any previous specific title, was found, by angular measurement, from well-determined barometric bases, to be 13,858 feet high. An attempt to carry a mercurial barometer to the summit failed of success: the reported reading of a good aneroid, at the highest point attained, indicated an elevation of 13,400 feet.*

The summits of the range are far from being "snow-covered," as reported; but huge banks of snow must last through the summer, in the various hollows of the mountain; and, in a few places, incipient glaciation was observed, though no true glacier was found, and probably none exists at the present day. In former years, however, glaciers of great size formed on these flats and in these hollows, and swept down the valleys on either side of the range, as is shown by the polished and striated rocks in the heads of the valleys, as well as by the numerous large and small boulders which line their lower courses.

Leaving the Tetons, after far too brief an examination to be at all satisfactory, though as complete as the general interests of the survey would permit, the party turned back to the valley

---

* This is said to have been at the summit. The writer, who reached only 12,000 feet, is not prepared to decide whether the summit was reached or not. The description of a rude building upon the crest will give the means of deciding the question, whenever the ascent shall be made by trustworthy parties. There are great discrepancies between the statements of the two persons who claim to have reached the summit. Published descriptions of the ascent are evidently enormously exaggerated, at least. (See *Scribner's Magazine*, June, 1873.) For instance, a small pond, along the route of ascent, is said to have been covered with "twelve or fifteen feet of transparent ice." Snowy ice certainly appeared over a considerable part of it, but looked so rotten that those in advance, on the outward trip, thought it not safe to attempt to cross it; and, on our return, about 4.00 P. M., Mr. Stevenson and the writer went down to the edge of the pond and dipped out cup-fulls of water for drinking. Sharp ears must those have been which heard the "hollow murmur of a creek" which "must have been twelve hundred feet beneath the surface of the snow!" The ratio of statement to fact is not constant, in the report referred to; since an eruption of Giantess Geyser, in the Upper Firehole Basin, is therein reported at "two hundred feet or more"; whereas the writer took angular measurements of that particular eruption, and found it to be a few inches less than sixty-three feet. How Grand Geyser can eject a solid column of water, "eight feet in diameter," from an orifice less than two feet in diameter, is an interesting question in hydraulics! Our author probably holds that a magazine writer should aim at *astonishing* rather than *instructing* those who are "verdant enough to confide in his stories of mountain life;" but it does not yet appear how his publishers could allow an article which in so many points plainly contradicts itself to appear in so respectable a magazine.

of Henry's Fork, and followed the general course of that stream to its source in Henry's Lake. The central portion of the valley is constantly floored with basalt, which was finally traced to its source in Sawtelle's Peak, which stands on the south side of Henry's Lake. The crater of this ancient volcano is still from 1200 to 1500 feet deep, about a half mile wide and something less than a mile and a half long. The range running west from this point appears to consist of volcanic rocks; and probably a row of similar craters will be found along its summit.

The foot-hills and mountains along the east side of the valley of Henry's Fork, after we pass the northern termination of the Tetons proper, consist of porphyries and obsidian-sandstones, until we reach the very head of the valley, a little north of east from Henry's Lake, where the same series of limestones and quartzites that we saw at the Tetons again appears in the divide between the waters of the Snake and those of the Madison; but, instead of the conformity before observed, the Quebec Group limestones apparently lie unconformably over the upturned edges of the Potsdam quartzites. Beneath these, metamorphic rocks form the face of the ridge to the westward and northward. The ridge west of the lake is mainly composed of metamorphic limestones with quartz bands, which are supposed to be of Carboniferous age. These include a sixty foot bed of trap, standing conformably between the upturned layers of the limestone.

The divide toward the Madison rises into a rather lofty range, whose height was not ascertained, but which must reach at least a thousand feet above the average level of the plateau of volcanic rocks which fills the broad depression toward the Tetons. In crossing here to the waters of the Missouri, one has the choice of three easy passes, all level enough for a horse to cross with a buggy, at full trot, and only one of them at all obstructed by timber. Henry's Lake was found to have an elevation of 6492 feet; from its southwestern side, Red Rock Pass crosses to the head of Beaver Head Fork of the Jefferson, at an elevation of 7271 feet; from its northern extremity, Reynold's Pass leads to the lower Madison, with an elevation of 6911 feet; Tyghee Pass, with an elevation of 7063 feet, led our party eastward into the basin of the Upper Madison.

The upper cañon of the Madison shows some grand scenery—vertical walls, projecting cliffs and deep amphitheaters alternating on either side of the swift flowing river of transparent water, bordered by grassy banks, and overhung by dense groves of pine and spruce. At the mouth of Gibbon's Fork, the party saw the first of the boiling springs which are so abundant in this region; and, in a few miles more, the Lower Geyser Basin of the Fire-hole Fork was reached, at about 3.00 P. M., of August 14th. Dr. Hayden's party had arrived at this appointed rendezvous, from Bozeman, about five hours earlier, a strangely close connection for trips of a month, without communication.

The geysers of the Fire-hole have been so fully represented in this Journal, that it seems best to pass them with but brief mention, and that rather upon generalities than upon particulars.

The bedding of the volcanic sandstone which forms the mountain boundaries of the basin indicates this as probably the site of an old crater of huge dimensions, whose eruptions long since ceased, but whose fires still heat the rocks at depths accessible to the waters which readily permeate these porous strata, and which escape in springs of various temperatures up to 200° or a fraction above the normal boiling point at this elevation.

At several points, masses of this volcanic sandstone are found perforated by irregular holes, evidently formed by solution of the siliceous ingredients in the escaping hot waters. By this process, degradation of the hills and enlargement of the basin are in progress. On the other hand, the deposition of various forms of geyserite from the siliceous waters is raising the floor of the basin, in some places; though, even here, the disintegration of the laminated deposit, by the combined action of sun and frost, and its erosion by large and small streams, will, on the whole, more than equal the increase. The deposition of the solid geyserite, which is far less soluble than the silica of the surrounding rocks, gradually stops up the vents below; and the flow is thus forced back to higher levels, and so constantly removes more and more of the bordering beds.

Besides the pretty regularly laminated deposits of the more quietly flowing water, there is great variety in the forms of deposition in the more turbulent portions. The immediate orifice of a geyser is almost universally beaded; and this character extends to greater or less distances, according to the distribution of the falling water. Surfaces that 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. Surfaces constantly bathed in water, without much disturbance, are commonly covered with prickly points. In the little pools about the geysers, there are many concretions, more or less rounded below by constant attrition, and sometimes rounded also above, by constant rolling; but, more generally, the upper surfaces, and occasionally all, are roughened into very various beads and points. In nearly every pool, except where ebullition is so strong as to break up such tender tissues, there are gelatinous vegetable forms, sometimes in broad thick sheets, sometimes in clumsy branching forms resembling sponges, sometimes in long waving fibers. The former kinds are generally either green or rusty-brown, and are most abundant in pools of comparatively moderate temperatures; while the more slender forms are commonly white, and are most abundant in the rapidly-flowing outlets of the hot pools, where they are continually reproduced as the channels fill up with newly deposited silica which buries the older fibers, so that, in breaking the crust, we frequently find laminæ filled with moulds of the fibers, sometimes so closely set as to resemble the grain of silicified wood. The only other living forms seen in the hotter pools were a few larves of *Helicopsyche*, which were found in a pool of the temperature of 180°. Very numerous skeletons of Diatoms occur in the sediment of even the hottest pools; but no living ones were found in springs of much over 100°.

The process of silicification of wood and other tissues is well shown in many cases: all stages of the process may frequently be seen in the same pool.

The eruptions of a few of the larger geysers are accompanied by violent subterranean pulsations, from 70 to 73 per minute: while others give no sound, except that of the mere rush and splash of the water.

Neighboring vents exhibit various degrees of sympathy. In some cases, a large vent is surrounded by several small ones, which are active when it is quiet and quiet when it is active. Again, the large and the small may be active together and quiet together. Large vents side by side are sometimes in full sympathy and sometimes totally independent.

Dr. Hayden's party passed down the Madison on the 20th of August; but the rest of us remained in this neighborhood while supplies were brought from Virginia City. On September 1st, we started up stream, on our return to Fort Hall. About eight miles above Old Faithful, we came unexpectedly upon another basin of hot springs, with one large geyser mound, whose observed eruptions did not exceed about seventy feet in height. On the 4th, we reached the head of the stream, and spent the next day in camp, being detained by a snow storm. On the 6th, however, it cleared; and we crossed the divide to the eastward. In approaching the head of the Madison, we had expected to find within its basin the lake seen by Dr. Hayden in 1871, and named to him by his guides as Madison Lake; but we were disappointed. We found the source of the stream, however, in a pond covering about sixty acres, to which we were obliged to transfer the name Madison Lake. Upon crossing the divide to the larger lake, we found it to belong to the Snake River drainage, and therefore called it Shoshone Lake, adopting the Indian name of the Snake.

At the western extremity of the lake, we found the valley of its principal tributary occupied by a large number of hot springs, including several geysers of moderate size. One of these showed more plainly than common how dependent the eruptions are upon the supply of water. In this, which was called the Minute Man, a series of eruptions commences with strong jets reaching from 30 to 40 feet in height. These are repeated, at intervals of from one to three minutes, for two or three hours, gradually losing force and lengthening their intervals, until the supply of water is exhausted, when they cease for about the same period. The basin and crevices having become filled again, another series of eruptions commences. Part of the water erupted, instead of flowing away, is conducted by surface channels to the back of the geyser mound, where a large opening admits it again to the inner cavities; and, as soon as, by its flow, these are again filled to a certain point, another eruption takes place. As the supply of water gets low, eruption takes place by both vents, which indicates the end of the series of eruptions. From this it appears probable that the *constant* eruption of Steady Geyser, in the Lower Firehole Basin, is due to its standing in a large pool which keeps its cavities constantly full. The *rationale* of geyser action, as given by theorists, is not satisfactory to the writer, but he is not now prepared to fully present his own views, formed solely from observation of the phenomena. It is to be hoped that means may be found, ere long, to locate a small corps of observers in this region for an entire season, so that the details of the different forms of eruption may be fully studied. If their force and period are found to be in all cases dependent upon supply of water, as above suggested, it would be an interesting experiment to surround one of the larger geysers with a water-tight retaining wall, so that erupted water should be constantly returned, and the eruption be made continuous or dependent upon the will of the exhibitor.

Shoshone Lake is surrounded by the remnants of an old gravel terrace, reaching 112 feet or more above its present level. About the mouth of the Geyser Creek, the sand and gravel materials of this terrace are more or less firmly cemented into conglomerate, porous sandstones and perfect quartzite, by deposits from the hot springs evidently made while the lake covered the terrace, the pressure of its waters probably being sufficient to check the flow of the springs which, if not so checked, would have removed the sands instead of consolidating them. Since the decline of the lake to its present level, erosion by the springs has gone on quite extensively, and is still progressing. Perforated bits of the terrace rocks and of the surrounding volcanic sandstone, like those before mentioned as occurring in the Firehole Basins, are abundant in the crater-like hollows north of the principal springs, which also show many sulphur-vents.

Shoshone Lake is about eight miles long; and its form resembles the outline of a well-filled purse. It is apparently quite deep; but its depth was not ascertained. From its eastern extremity, a large stream flows eastward, about three miles, to another lake, hitherto unnamed so far as known, which was now called Lake Lewis, in memory of Capt. Merriwether Lewis, who would otherwise be without memorial in the region which he was the first to explore, since "Lewis's Fork" of the Columbia has now reverted to its Indian name of Shoshone or Snake River. This is about two and a half miles long and from one to one and a half miles wide. The greatest ascertained depth is 108 feet. From its southern extremity, its outlet, which was called Lake Fork, flows directly south.

Leaving the main train to move southward, a surveying party passed eastward to Mt. Sheridan, the culminating point of the Red Mts. This is about 10,420 feet above the sea, and is surrounded on all sides by deep valleys, so that wide views are attainable from its summit; 475 distinct mountain summits were counted around the horizon. It also gave fine views of all the surrounding lakes, of which a small one, Lake Riddle, lies in the summit of the divide between the Yellowstone and Lake Lewis, at an elevation of 7999 feet, while Lake Lewis itself is 7750 feet, and Yellowstone Lake is 7788 feet above the sea. The lowest point of the actual divide was located at 25 feet above Lake Riddle, or 8024 feet above the sea.

Moving southward from Mt. Sheridan, the region about the ultimate sources of the main Snake was pretty thoroughly examined, the principal streams being named, for convenience in describing and mapping. Here, at length, we escaped, for a time, from the volcanic rocks which had surrounded us ever since leaving Tyghee Pass, and found ourselves among fine-grained Tertiary sandstones. Along the waters of Barlow's River, these strata include some thin seams of coal, but of no value.

The ultimate source of the main stream of the Snake is a small pond on a flat divide between that stream and Buffalo Fork. On the west side of this divide, a sharp ridge, rising about 500 feet, shows a face of quartzite gravel reaching to its very summit, where the deposit is just pierced by an outcrop of the gray trachytic lavas and red basalt, which form the nucleus of the ridge. This is one of the highest points in the immediate neighborhood, being about 8654 feet above the sea; and there was nothing to indicate, with any certainty, what had been the source and course of the large river which had distributed such immense amounts of gravel. Only the general levels imply a southern source and a northward flow. Erosion has taken place since on so grand a scale that one is compelled to consider the deposit very ancient.

Between this point and the great valley along the eastern front of the Teton range there lies a heavy body of mountains, which appears to be the "main range" of the Rocky Mts. at this point, *if such a thing exists*. At least, it is a part of the *highest mass connection* between the Wind River and Big Horn Mts. on the east, which form the northern termination of what is the main range further south, and the range west of the Three Forks of the Missouri, which there bears the name of Rocky Mts., and whose continuation really appears to be the main range further north, so far as the best maps indicate. This, of course, does not coincide with the water-divide, which curves far north above Lake Lewis and far south around the heads of the Jefferson.

After an examination of the sources of the tributaries further west, the main Snake was again reached, about twelve miles from its source, where it is already a large stream with high gravel terraces along its banks, and was followed to its junction with Lake Fork, where the main party were in camp. A few miles above this point stratified rocks were again found, consisting of Triassic? red shades and sandstones, followed by a nearly white limestone, probably of Carboniferous age. These are at one point crossed by a huge bed of basalt, filling what had probably been a stream valley through the older rocks before the eruption of the volcanic material from some vent of the Red Mt. range. At the upper edge of this belt of basalt there is a small basin of hot springs, once of considerable importance, but now nearly extinct. Other groups were found near the mouth of Lake Fork.

In descending from Lake Lewis, the Lake Fork was found falling rapidly through a narrow cañon, whose nearly vertical walls in some places reach the height of 700 or 800 feet, while not over 400 feet apart at the top. These are all of dark-colored volcanic rock.

The low divide toward the valley of Henry's Fork was examined with some care. A large stream, Falls River, bursts full-grown from the slope of the high terrace of porous obsidian-sandstones lying north of the divide, passes through the more northern of the two Beulah Lakes, and rushes rapidly downward toward Henry's Fork. From any one of several points along the first two miles of its course, this stream might easily be turned eastward into the main Snake; and the divide on the east side of the Beulah Lakes is only eight feet above the surface of the more southern one. The rocks of the divide are all volcanic.

This pass probably affords the best line of approach to the Yellowstone from the southwest. The average grade from Henry's Fork to the summit is about 54 feet to the mile.

From the mouth of Lake Fork, the valley of the Snake widens rapidly and soon spreads out into the basin of Jackson's Lake, a body of water about eight miles long and from two to three miles wide, shallow in its eastern portions, but deepening rapidly toward the west, where the foot slopes of the Teton range descend sharply into its waters. The deepest of a very incomplete set of soundings was 258 feet.

A few miles north of the north end of the lake, the Tetons begin to rise from the flat divide of Falls River; and their slopes show Silurian and Carboniferous limestones overlying the central mass of metamorphic strata, as on the western side of the range. The Potsdam quartzite was not seen here, but is probably in place. The knobs of the central portion of the valley still show some of the volcanic rocks, though these occupy less and less space as we pass southward.

The outlet of Jackson's Lake is at its southeastern corner; and the outflow escapes into the valley of Buffalo Fork, instead of following what was evidently its natural channel through a terraced valley running from the southern extremity of the lake directly south through Jackson's Hole. This change of outlet was found to have been consequent upon the influx into the old channel of the sediment-bearing stream escaping from beneath the glacier which then filled a large two-pronged valley that here opens out of the mountains. A small lake, hemmed in by the terminal moraines of that ancient glacier, now fills the mouth of the valley. A similar lake lies before the valley which receives the entire drainage of the western side of the principal peaks of the Tetons; but it is not surrounded by any conspicuous moraines; and it is questionable whether the more abundant flow of water from beneath this glacier swept away the materials as fast as they were deposited, or whether they have been eroded by the stream since the glacier melted. Two other lakes of similar character lie in the mouths of cañons farther south, and are surrounded, the first by five and the second by three large moraines.

The Teton range, as seen from the west side of Jackson's Lake, is a grand one, rising as a wall to heights varying from 5000 to 7000 feet above the level of the plain. The snow patches were already on the increase (Sept. 24th,) and occasionally squalls would make the range really snow-*covered*, for a few hours.

Just below Jackson's Lake, Buffalo Fork emerges from the mountains, a deep rapid stream, with a broad open valley bordered by rounded hills for several miles. Fine-grained gray sandstones, probably of Tertiary age, appear near the mouth of the stream, for a short distance; but no rocks are then visible, until the point is reached, about twelve miles up stream, where the hills on either side close in to sharp cañons, 400 feet deep by 200 feet wide, with coarse gray sandstone walls. These also are supposed to be of Tertiary age. At the head of the basin, a few miles farther on, there are high rugged walls of thin-bedded limestones and sandstones, probably of Quebec Group age, though possibly capped with Carboniferous.

The valley of the Gros Ventre, which is the first stream south of Buffalo, is narrow, with precipitous slopes on either hand, walled near its mouth by Carboniferous limestones and sandstones, which are followed above by Triassic (?) red shales and sandstones, Jurassic (?) gray and buff magnesian limestones, and Tertiary (?) white friable sandstones. A large butte which stands on the bank of Snake River, opposite the mouth of the Gros Ventre cañon, shows Carboniferous fossiliferous limestones, followed below by limestones apparently destitute of fossils, which are referred to the Quebec Group, and quartzites which are referred to the Potsdam. The southern portion of the butte shows only the soft Pliocene whitish sandstones and marls, which cover the place where we should naturally look for metamorphic rocks beneath the quartzites; but, from the strike of the upper rocks, it is probable that a metamorphic axis runs across here from the Tetons *toward, if not to*, the metamorphic nucleus of the Wind River Mts. A short distance south of this point, the metamorphics of the Teton Mts. disappear beneath the limestones which come forward from the western slope and which now form the mass of the range for several miles.

The South Gros Ventre Buttes, which stand on the bank of the Snake just below the junction of the Gros Ventre, contain the last outcrop of volcanic rocks seen in this basin. The upper slopes were not examined, in this neighborhood; and it is possible that, at a higher level, these rocks may continue southward: but the general appearance of the country gave the impression that this was their southern limit,—that, before their eruption, the drainage of the region flowed northward and escaped westward through the broad and deep valley which then existed beyond the northern end of the Teton range; that that eruption dammed up the waters over Jackson's Hole, so that the Pliocene sandstones and marls were deposited beneath the lake thus formed; and that the southern outlet across the southern continuation of the Teton range was subsequently eroded to its present level, during the progress of which erosion the terraces were formed which are here exhibited on a grand scale.

At the South Gros Ventre Buttes, the party again divided, the main train crossing the Teton Pass to Pierre's Hole, and striking the Snake again where it emerges from the mountains about twenty miles from Taylor's Bridge, while a surveying party followed the river through the so-called Grand Cañon.

This had previously a reputation for being a very difficult passage, but was found to be really very easy, compared with much that the party had already passed through. A railroad could be built here with very little difficulty. Triassic sandstones appear at the upper end of the cañon; but it is mostly walled by Carboniferous sandstones and limestones, until we pass the mouth of Salt River, a little below which the volcanic rocks of the outer basin make their appearance and follow the stream closely to the Columbia. The reunited party reached Fort Hall on October 11th, and soon after broke up. Its scientific members were the following: F. H. Bradley, geologist; G. R. Bechler, topographer; R. Hering, astronomer and meteorologist; Dr. J. Curtis, surgeon and microscopist; J. M. Coulter, botanist; C. H. Merriam, ornithologist, together with several assistants and collectors.

Art. XXIII.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXVII.—*On the Minerals found at the Tilly Foster Iron Mines, N. Y.;* by E. S. Breidenbaugh, M.A.

The Tilly Foster mines in Putnam Co., N. Y., near Brewster's station, on the Harlem R. R., have for a number of years been furnishing a considerable quantity of magnetic iron ore. In the spring of 1872, Prof. O. D. Allen, of the Sheffield Scientific School, in examining some of this ore at the steel works in Bridgeport, Conn., found traces which indicated that at the mine there might occur a variety of interesting minerals. On subsequently visiting the locality, Prof. Allen found specimens of a number of mineral species; and of the most interesting of these, during the past winter I have made analyses.

During the fall I paid a brief visit to the locality, finding, in the main, specimens of the same species as those found by Prof. Allen.

Formerly the mines had been worked by means of shafts, but for the past year ore has been taken principally from near the surface, and it is far less rich in minerals than that previously mined. Nearly all the specimens procured were found in a large pile of rubbish, which has been accumulating since the opening of the mine.

Except where the contrary is stated, the ordinary methods of analysis have been employed. The silica was always re-fused with carbonate of soda to ensure purity. Special care was taken to effect a complete separation of lime and magnesia from iron and alumina.

Mica.—The variety of mica most common at this locality is of a dull pearly lustre, and of a dark brownish-gray color by reflected light, but gray, with a honey-yellow tinge by transmitted light. It is in thin foliæ, transparent and quite tough, with slight elasticity ; H.=3. The plates are compact, irregular and show a somewhat wavy structure. It occurs lining the wall rocks. Small particles of magnetite and pyrite distributed through the plates render it quite impure. Mr. C. S. Hastings, of this School, examined this mineral for the determination of the optical characters. But on account of the wavy character of the best specimens he could only approximate to the axial divergence, finding it to be from 4°–8°. Analyses gave the following results:

	I.	II.	III.	IV.	Mean.	Oxygen.
SiO_2	40·10	40·06	----	---	40·08	21.70
Al_2O_3	14·21	14·21	----	----	14·21	7·04
Fe_2O_3	11·51	11·51	----	----	11·51	3·35
MgO	21·86	22·19	----	----	22·03	8·47
Na_2O	----	----	·39	·05	·22	
K_2O	----	----	9·73	9·74	9·73	1·63
H_2O	----	----	1·69	1·69	1·69	1·39
Fl	----	----	----	----	*tr.*	
					99·47	

Giving as the oxygen ratio for $\dot{R}$, $\bar{\bar{R}}$, $\dot{Si}$, 1·11 : 1 : 2·1 ; which is approximately that of biotite, 1 : 1 : 2.

Chlorite.—A chloritic mineral is found very abundantly, usually in the fissures and cavities of the rock ; it is of a bright grass-green to pea-green color by reflected light ; by transmitted light, lighter green ; and in thin plates almost colorless. It has a pearly luster and is quite transparent. Thin plates are flexible but not elastic. H.=2·5. Crystals are often quite perfect, being frequently grouped in rosettes and accompanied by crystals of chondrodite. Some of the specimens show a slight opalescence. Between the plates are found small particles of magnetite. The surface plates and edges generally show evidences of decomposition, which fact will be referred to under the white serpentine.

Mr. Hastings found the axial divergence to be 12°–14°.

Analyses gave the following results :

	I.	II.	III.	Mean.	Oxygen.
SiO_2	32·30	32·36	----	32·33	17·22
Al_2O_3	14·57	14·55	----	14·56	6·78
FeO	5·29	5·29	----	5·29	1·17
MgO	33·70	33·78	----	33·74	13·5
CaO	1·04	1·04	----	1·04	·29
K_2O	----	----	·87	·87	·14
Na_2O	----	----	·54	·54	·13
H_2O	12·01	12·04	----	12·02	10·68
				100·39	

Making for the oxygen ratio of

$\dot{\mathrm{R}}, \overset{\cdots}{\bar{\mathrm{R}}}, \ddot{\mathrm{Si}}, \dot{\mathrm{H}}$, 5·00 : 2·85 : 6·07 : 3·92, or for $\dot{\mathrm{R}}\overset{\cdots}{\bar{\mathrm{R}}}, \ddot{\mathrm{Si}}, \dot{\mathrm{H}}$, 4 : 3·09 : 2.

The corresponding ratios of ripidolite are 5 : 3 : 6 : 4 and 4 : 3 : 2 ; and hence the mineral is that species.

Associated with the above, in several specimens from this locality, is a hydrous mineral, composed of quite small foliated scales very compactly united; by reflected light it is of a dark bright green color, in the mass almost black ; but by transmitted light, light pea-green. In thin plates it is translucent. The luster is pearly to resinous, and it is greasy to the feel. H. = 1·5 to 2. Before the blowpipe it exfoliates, and at 4½ to 5 fuses to a grayish glass. On ignition it assumes a dirt-brown color. It is partially decomposed by hydrochloric acid. The mineral is easily crumbled into small fragments, but further reduction to a powder is accomplished with difficulty in an agate mortar. The result of an analysis was

		Oxygen.
SiO_2	37·33	21·00
Al_2O_3	7·58	3·53
FeO	9·62	2·13
MnO	*tr.*	
MgO	33·56	13·4
H_2O	11·63	9·91
	99·72	

The oxygen ratio for

$\dot{\mathrm{R}}, \overset{\cdots}{\bar{\mathrm{R}}}, \ddot{\mathrm{Si}}, \dot{\mathrm{H}}$, is 15 : 3 : 21 : 9, or for $\dot{\mathrm{R}}, \overset{\cdots}{\bar{\mathrm{R}}}, \ddot{\mathrm{Si}}, \dot{\mathrm{H}}$, 6 : 6·6 : 3.

It approaches the ratio of pyrosclerite, in which this ratio is 4 : 2 : 6 : 3 or 6 : 6 : 3. It seems to be perfectly homogeneous, and not the result of decomposition.

Serpentine.—Several varieties of serpentine are found at this locality differing much in color and structure; they usually occur in the fissures of the ore bed, either alone filling up the fissures, or in connection with chondrodite or chlorite.

In color the varieties vary from dark green to pure white. Variations in structure will be described in speaking of the several varieties. They all present a smooth, polished surface, and are generally greasy to the feel. Hardness varies from 2 to 4.

White Serpentine.—This variety is opaque white, soft (H. = 2), possesses a dull pearly luster, and has a fibrous to columnar structure. Small grains are found disseminated through the ore, but it usually appears in the fissures, when it forms the matrix for rounded crystals of chondrodite and magnetite and crystals of chlorite. The chlorite and serpentine occur in all proportions not only united by contact, but in intimate admixture ; and in the latter case, there is a gradual shading of color from bright green to pure white, and in texture from the foliation and transparency of the chlorite to the compactness and opacity of the serpentine. Results of analyses are—

	I.	II.	III.	Mean.	Oxygen.
SiO_2	42·27	42·30	----	42·28	22·53
Al_2O_3	·85	·87	----	·86	·40
FeO	2·58	2·56	----	2·57	·69
MgO	40·29	40·30	----	40·29	16·11
CaO	1·41	1·29	----	1·35	·36
K_2O	----	----	*tr.*	*tr.*	----
Na_2O	----	----	·48	·48	----
H_2O	12·58	12·47	----	12·52	11·13
				100·35	

The oxygen ratio for $\dot{R}$, $\ddot{Si}$, $\dot{H}$ is 17·26 : 22·53 : 11·13, or 3·1 : 4·03 : 2 ; that of serpentine being 3 : 4 : 2.

Green Serpentine.—This variety sometimes presents a quite peculiar appearance; light green and greenish white alternate in thin layers parallel to the walls of the fissure. Across the layers at a considerable inclination to them run traces of a fibrous structure; neither the layers nor fibers are separable. The layers assume a wavy appearance, depending probably on the character of the fissure. On thin edges this variety is translucent. Sometimes the color is quite dark green—again very light—with more or less distinct structure such as is described above. Analyses of this variety were made in this laboratory, by Mr. C. A. Burt, with the following results:

	I.	II.	Mean.	Oxygen.
SiO_2	41·29	41·57	41 43	22·08
FeO	2·13	2·07	2·10	·46
MgO	40·56	39·79	40·18	16·07
CaO	1·08	·82	·95	·27
H_2O	13·61	14·00	13·81	12·28
			98·47	

This likewise gives the ratio of serpentine.

A third variety was analyzed, of which only a few specimens were found. It occurs as a group of nodules, formed of radiated fibers, and is of a light grayish color with a greenish tinge and a pearly luster. Fuses at 5. H.=3. Sp. gr.=2·4. Analysis gave—

		Oxygen.
SiO_2	39·38	21·00
Al_2O_3	1·56	·73
FeO	13·87	3·08
MnO	*tr.*	----
MgO	32·25	12·9
K_2O	·17	----
Na_2O	----	----
H_2O	11·90	10·59
	99·13	

Oxygen ratio for $\dot{R}$, $\ddot{Si}$, $\dot{H}$ is hence 3 : 3·9 : 2.

One other variety of this species deserves a passing mention; it is massive, of an olive-green color, with a porcelain-like luster on the smooth fractured surface. No analysis was made.

Amphiboles.—Several varieties of the amphibole group of bisilicates appear at this locality, and are quite abundant, occuring usually along the walls of the ore bed. Of two varieties I have made analyses.

Enstatite.—This occurs massive, having a slight fibrous appearance with a pearly to vitreous luster on a broken surface, and is of a light grayish-brown color, with a yellow tinge by transmitted light. In thin pieces it is translucent. It is quite free from impurities. There is no distinct cleavage. H.=5·5. Infusible. Sp. gr. 3·29. The results given by analyses are—

	I.	II.	III.	Mean.	Oxygen.
SiO_2	54·16	54·19	----	54·17	28·87
Al_2O_3	3·35	3·25	----	3·30	1·40
FeO	9·90	9·98	----	9·94	2·19
MnO	·24	·24	----	·24	----
MgO	32·22	31·77	----	31·99	12·5
CaO	1·01	·98	----	·99	·28
K_2O	----	----	·16	·16	----
Na_2O	----	----	·32	·32	----
Ignition	---------	----	·13	·13	----
				101·24	

Oxygen ratio for $\dot{R}$, $\ddot{S}i$, 16 : 29, approximately the $\dot{M}g\,\ddot{S}i$ of enstatite; the composition shows it to be this mineral. If the Al_2O_3 be considered as replacing SiO_2, we have a ratio of 15 : 30·9.

Actinolite.—This variety of hornblende occurs in considerable abundance, and is generally crystalline, often only obscurely so. A few fine crystals were found. The crystallized specimens have commonly a bladed structure, H.=5·5. The color is dark green, the luster vitreous; and when free from impurities, the specimens are quite translucent—almost transparent. Small particles of magnetite and pyrrhotite are so widely disseminated through the specimens examined, even in fine crystals, that it was with great difficulty enough was obtained to make an analysis. The results obtained are—

	I.	II.	III.	Mean.	Oxygen.
SiO_2	57·39	57·50	----	57·44	29·61
Al_2O_3	1·13	1·14	----	1·13	·52
FeO	4·36	4·30	----	4·33	·85
MnO	·15	·16	----	·15	----
CaO	13·22	13·36	----	13·29	3·83
MgO	22·56	22·63	---	22·59	8·92
K_2O	----	----	*tr.*	----	----
Na_2O	----	----	*tr.*	----	----
H_2O	----	----	1·52	1·52	1·34
				100·45	

Al_2O_3 being considered as replacing SiO_2, the oxygen ratio for $\dot{R}$, $\ddot{S}i$ is 14·8 : 30·1.

Chondrodite.—Of the mineral species found at this locality by far the most interesting, with respect to both occurrence and chemical constitution, is the chondrodite, which occurs in very great abundance, small grains being widely and generally disseminated through the ore, forming what the miners term "the sand." But, approaching seams in the ore bed, the proportion of chondrodite increases, until, in the seams, fissures or cavities, chondrodite occurs crystalline with rounded crystals of magnetite and crystals of chlorite, imbedded in the white serpentine described above.

When undecomposed the chondrodite is clear, translucent, in very thin edges transparent, and possesses a vitreous luster, particularly on fractured surfaces, which are always irregular. When decomposed, as is frequently the case, it becomes opaque, grayish white, loses its vitreous luster and is easily broken, passing even into a crumbling condition.

In color, it varies from dark-brown and cinnamon-red to a light grayish-brown or yellow. Although the intermediate shades of color are found, still several varieties are so easily distinguished by color that three may be noticed. H.=5·5–6·5.

Brown Chondrodite.—This is of an amber-brown color, having by transmitted light a red tinge; the powder is light gray, and it seldom shows marks of decomposition. Disseminated through the piece which was analyzed were some small but very perfect crystals of actinolite, showing under the microscope sharply defined angles. Sp. gr. 3·2.

Red Chondrodite.—The second variety is cinnamon-red by reflected light; transmitted light gives it a yellow tinge. The powder is reddish-gray. This is the prevailing color of the crystals and crystalline specimens which were examined.

Grayish-brown Chondrodite.—The third variety has a grayish-brown color, shading into a honey-yellow, which is the prevailing color of the grains disseminated through the ore. It was found impossible to separate from the magnetite enough for an analysis, but it was proved to be chondrodite by its pyrognostic characters. This variety may be merely an altered form of the red variety. Analysis of the brown variety gave—

	I.	II.	Mean.	Oxygen.
SiO_2	35·21	35·64	35·42	18·86
FeO	5·73	5·71	5·72	1·17
MgO	54·23	54·21	54·22	21·49
Fl	----	----	9·00	----
			104·36	
Equivalent of oxygen replaced by fluorine,			3·79	
			100·57	

Analysis of red variety gives—

	I.	II.	Mean.	Oxygen.
SiO_2	----	----	35·42	18·86
FeO	9·77	9·70	9·73	2·14
MgO	51·70	52·07	51·88	20·75
Fl	5·33	5·42	5·38	----
			102·41	
Oxygen replaced by fluorine,			2·26	
			100·15	

The brown variety gives $7{\cdot}3\ \dot{\mathrm{Mg}}$ and $3\ddot{\mathrm{Si}}$, in which part of the oxygen of magnesia is replaced by fluorine, or $MgFl_2+3\dot{\mathrm{Mg}}^2\,\ddot{\mathrm{Si}}$.

The red variety gives $7{\cdot}5\ \dot{\mathrm{Mg}}$ and $3\ddot{\mathrm{Si}}$.

The fluorine on the above analyses was determined by the method of Wöhler, modified by Fresenius.* The silica and bases were determined according to the method given by Rammelsberg. A large number of experiments made on these methods confirmed their superiority to others suggested during the progress of this investigation.

Mr. C. A. Burt made an analysis of a dolomite found at this locality, obtaining—

	I.	II.	Mean.	Oxygen.
FeO	·91	·49	·70	·15
MnO	·13	·64	·39	·07
CaO	30·30	29·98	30·14	8·61
MgO	20·78	20·80	20·79	8·31
CO_2	46·97	47·05	47·01	10·02
	99·09	98·96	99·03	

This corresponds to $FeCo_3$ 1·13, $MnCo_3$ 0·63, $CaCo_3$ 53·82, $MgCo_3$ 43·66=99·24.

The ratio of $CaCo_3$ and $MgCo_3$ is 1 : 1 nearly.

Besides the minerals mentioned above, there occur at this locality *pyrite*, chalcopyrite, *pyrrhotite*, calcite, quartz (small crystals), a few specimens of fluorite and apatite. I found also two specimens of molybdenite.

I gladly take this opportunity of expressing the obligation which I am under to Prof. Allen for his kindness in furnishing me with material for my work and advice during the progress of it.

Sheffield Laboratory, New Haven, Ct., May, 1873.

---

* Fresenius's Quantitative Analysis, American edition, p. 404; Zeitschr. Analyt. Chem., v, 190. Pogg. Ann., liii (1841), pp. 130–9.

ART. XXIV.—*The discovery of a new Double Star, β Delphini;* by S. W. BURNHAM.

EXAMINING *β* Delphini with my 6-inch Alvan Clark refractor on the evening of August 8th, I saw at once that it was a very close double star, and with a power of 410 it was well seen, although too close to be separated with an instrument of that aperture. The secondary appeared to be nearly two magnitudes the smaller. The distance I estimated to be 0·″5, and the position angle about 355°. I am inclined to think the distance is slightly underrated, to the extent, perhaps, of one or two tenths of a second. It is a pretty difficult object for a 6-in. refractor; although within the last two months I have discovered a good many new double stars much more difficult, and one this same evening where the components were at least 0·″2 closer.

β Delphini has long been known as a wide double star from a 11th magnitude star at a distance of 32·″48 (Struve), and was first observed in 1781 by Sir William Herschel and catalogued as No. 35 of his Class IV. Struve measured it in 1829, and entered it in the great Dorpat Catalogue (*Mensuræ Micrometricæ*) as No. 2704. Sir John Herschel also noted it in his Fourth Catalogue (*Memoirs of the Royal Astronomical Society*, vol. iv), and added a more minute companion, rated by him as 14 mag., at a distance of 18″; and both were measured still later by Admiral Smyth (*Cycle of Celestial Objects*). The well known double star observer, Baron Dembowski, measured the principal companion in 1864, giving its distance as 34·″64. None of these observers seem to have even suspected the duplicity of the bright star notwithstanding very much larger instruments were used than the one from which it was detected. Possibly it may prove to be a binary of long period, and single during the earlier observations. It would be very desirable to get measures of it during the present season.

Chicago, Aug. 12, 1873.

ART. XXV.—*Apparatus for Rapid Filtration;* by E. W. MORLEY.

I HAVE had in constant use for some months an apparatus that lessens considerably the time which it is necessary for the analyst to devote to a quantitative filtration. The device has become so indispensable to me, and has been so favorably received by other chemists, that an account of it may be of some value to those who employ Bunsen's method of filtration.

After fitting the platinum cone and filter in the funnel (*a*), a second funnel (*b*) of the same diameter, with a rather wide neck, is inverted over the first. A strip of thin vulcanized rubber (*c*), two or three centimeters wide, is stretched around the rims of the two funnels, so as to make a nearly air-tight joint. An elastic band (*d*) secures this strip. A syphon (*e*), inserted in the neck of the upper funnel, is made to reach below the rim of the filter, and the joint at the neck of the upper funnel is made tight by a piece of rubber tube (*f*). The outer arm of this syphon should be a few centimeters longer than the inner. The beaker (*g*) containing the liquid to be filtered is placed upon a support whose height admits of easy adjustment, so that the syphon reaches nearly down to the precipitate. A vacuum being now produced in the flask, the liquid in the beaker is drawn over into the filter, and keeps it filled to a level which depends on the amount of air entering between the rims of the funnels. If the liquid rises above this level, more liquid and less air pass the filter, the degree of exhaustion in the funnel is lessened, and the flow through the syphon is retarded. If the liquid falls below this level, the degree of exhaustion in the funnel is increased, and the influx of liquid by the syphon quickened. The oscillation of level while a clear or nearly clear liquid is passing from the beaker is only one or two millimeters. If the rubber surrounding the rims of the funnels is about twice as thick as the paper on which this page is printed, and is stretched one third or one half its length in applying it, and if the ends of the strip are pressed tightly by the elastic band, no further adjustment is needed than is made in putting the apparatus together as rapidly as is possible. In sixty seconds after moistening the filter, one may have completed the arrangement of the apparatus, and have left it to itself, to require no more attention till all the liquid above the precipitate shall have passed over.

If the precipitate is to be washed by decantation, the liquid from which the precipitate has settled is removed in the same way. When the precipitate is ready to be transferred to the filter, the beaker is raised so that the syphon reaches to the bottom of the precipitate. The precipitate then passes over, and may be completely removed from the beaker by the use of the rubber and wash-bottle, drawing the wash-water through the syphon. During this process, the action of the syphon may be hastened by closing the air passage (at *h*) by pressure, and may well be suspended at times by loosening the joint (*f*) at the neck of the upper funnel, so as to prevent particles of liquid holding precipitate in suspension from being thrown upon the sides of the funnel. If the bulk of the transferred precipitate is not too large, its washing may now be completed by adding to the beaker a sufficient quantity of water. No further attention is required till the operation is completed by removing the upper funnel and washing its inner surface, together with the outer surface of the short arm of the syphon; on which some drops of liquid are often thrown by the bursting of air bubbles, when the level of the liquid in the beaker sinks below the end of the syphon.

The advantages of this method of filtration are—that any amount of liquid can be passed through a small filter without attention; that liquid and precipitate can be transferred with less liability to loss than by the usual methods; that the apparatus can be adjusted for use in less than a minute; and that it is composed of parts which may be said to involve no additional expense; also, that if the precipitate is not too bulky, its whole washing may be effected without attention during the passage of the wash-water.

In an experiment which was a fair sample of the use of the apparatus, the moistening of the filter and adjustment of syphon took 1¾ minutes; the passage of 380 c.c. liquid, 11¼ minutes; the transferring of the precipitate (hydrate of aluminum), using 70 c.c. water, 8½ minutes; the passage of 85 c.c. wash-water, 10¼ minutes. Attention was given during 10¼ minutes, while the filtration lasted 31¾ minutes. In a second experiment, on the same precipitate, the apparatus was adjusted in 2½ minutes; 500 c.c. liquid passed through in 16½ minutes; the precipitate, with 25 c.c. of water, was transferred in 11½ minutes, of which 6½ minutes needed no attention; and 105 c.c. wash-water passed through in 18½ minutes. Attention was given during 7½ minutes, while the filtration lasted 49 minutes.

Western Reserve College, Hudson, Ohio, May, 1873.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS AND CHEMISTRY.

1. *On the reflection of Solar heat from the surface of Lake Geneva.*—L. DUFOUR, in a communication to the French Academy of Sciences (June 30, 1873), states that he has used the method proposed by Gasparin, of hollow blackened bulbs with a central thermometer. Three such bulbs were used; the first protected by suitable screens gave the atmospheric temperature; the second protected from the direct rays of the sun received the heat reflected from the water; the third, entirely exposed, indicated both the direct and reflected heat. Resting on the indications furnished by the three bulbs at the same moment, it is possible to fix the ratio between the heat reflected from the lake and the direct solar radiation. The calculation requisite to determine

this ratio rests on numerous preliminary experiments and upon considerations, the details of which are out of place here.

Observations were made at five stations, situated at different distances from the lake, and at various heights above its level. The two nearest stations are close on the borders of the lake; the most remote is about 400 meters in horizontal distance and at an altitude of 263 meters; all are on the northern slope of Lake Geneva (Leman), between Lausanne and Vevay.

Many circumstances unite to impair the perfect accuracy of such researches as these:—the necessity of operating in the open air, never perfectly calm; the constantly variable surface of the water; the unequal diathermancy of the air in spite of its apparent serenity; the partial absorption of reflected heat by the lower strata of the air, before the ray reaches the instrument, etc., are among the causes which prevent one obtaining perfectly regular results. These results are, however, sufficiently sharp to justify certain inferences of interest to physics and meteorology.

(1.) The highest proportion of reflected heat was 0·68 of the incident heat. This maximum was twice observed with a solar elevation of 4° 38′ and 3° 34′. A proportion between 0·4 and 0·5 of incident heat occurred a number of times at solar elevations less than 7° 27′. The proportion of 0·3 to 0·4 was frequent at solar elevations under or about 11° 56′. The proportion 0·2 to 0·3 is very naturally more frequent for elevation under or about 16° 35′. The proportion of heat reflected from water when the sun is above 30° elevation is inappreciable.

(2.) The law determining the proportion between the heat reflected and the elevation of the sun has not been satisfactorily established, owing chiefly to the changing state of the water surface, and the partial absorption of the reflected rays while traversing layers of air of variable thicknesses before reaching the apparatus.

(3.) The proportion of reflected heat arriving at distant stations does not always increase with the fall of the sun toward the horizon. For very slight solar elevations this proportion was many times less than it was at those more considerable, for the reason probably that when the sun is low its rays are reflected from distant areas of the lake, and before reaching the station have passed a thick stratum of air. The absorption which it suffers between the point of reflection and the station compensates therefore for the higher intensity due to an increase in the angle of incidence.

(4.) The proportion of heat reflected, almost without exception, is greater as the lake is calmer.

(5.) The *actual quantity* of heat reflected may be determined by taking account, at each instant, of the intensity of the direct ray and of the proportion reflected by the lake. The proportion reflected increases as the sun falls; but the intensity of the ray diminishes directly. The combination of these two opposite influences meet at a maximum corresponding to a certain elevation of the sun, which fact has been verified by many observations.

(6.) The sum total of heat which at any given station is furnished by the reflection of the lake, starting from the moment when their reflection becomes sensible, until the sun sets, may be compared to that which is presented directly by the line during a shorter period. Thus, for example, we find at the Dézaley station, on the 28th of September, reflection furnished a total of heat almost equal to that which the sun's direct rays gave during three-quarters of an hour before his setting. At the Tour-Haldimand station, Oct. 5th, this total is nearly equal to that which the sun furnished during his last half hour, etc.

(7.) Comparative observations made with the bulbs used in these experiments have served to convert their relative indications into absolute values, expressing the absolute quantity of heat reflected by the lake from one square meter of surface, normal to the ray, from the moment this reflection began to be sensible until the sun was almost set. We have the following values at—

Station:	Ouchy, Sept. 12,	104	calories.
"	Tour-Haldimand, Oct .5,	84	"
"	Dézaley, Sept. 28,	112	"
"	" Oct. 18,	134	"

These numbers are somewhat in error from the disturbing causes before named. This error certainly does not exceed a fourth of the values given, and it is very probable that the true quantity of heat furnished by reflection is greater rather than less than that stated. * * *

(8.) This action of reflected heat has no probable connection with the absence of salt in the water, and the same effects will no doubt be observed at the surface of the sea. This reflected heat is not without its influence on favorably situated plains, and it ought to affect favorably their vegetation. The loss of heat passing out of the atmosphere into the celestial spaces should by these experiments be considerable, and especially in the Austral regions where the oceanic areas are wider than at the north pole.—*Comptes Rendus*, lxxvi, 1572. S.

2. *Thermodiffusion.*—W. Feddersen has confirmed by experiment on various porous substances the theoretical proposition assumed by Carl Neumann,* that if a limited portion of a gas enclosed in a tube of unlimited length (or one that returns into itself) be different in density from the rest of the gas, an artificially-produced difference of temperature at the two ends of this portion must occasion a continuous motion throughout the endless cylinder of gas in a determined direction, and, indeed, from the cooler to the warmer end through the limited portion in question, if the gas in this be in the state of condensation. The experiments of Feddersen were performed in this manner. A substance in the form of powder was stuffed tight into a glass tube so as to form an immovable plug; this tube was fixed in a horizontal position, and the two projecting ends were each connected air tight by means of caoutchouc, with another horizontal glass tube, which

* Berichte der Königl. Sach Gessell. der Wissen., Sept. 15, 1872.

was stopped by a drop of liquid at any place in its bore. In this manner, every displacement of the air cylinder contained in the middle portion of the tubes must displace the two drops of liquid at its extremities in the same direction. One end of the plug was now exposed to a constant source of heat, the other being left cold or artificially cooled. Then without exception there appeared a slow displacement of the air column in a direction through the plug, from the cold to the heated end, sometimes quicker, sometimes slower, sometimes stronger on one side and sometimes on the other. Spongy platinum, spongy palladium, gypsum, charcoal, silicic acid and calcined magnesia, were the subject of experiment in the manner described. The detail of these experiments is given by the author in full, which cannot well be presented in abstract. From these experiments, made with the most heterogeneous substances, it appears to follow that it is a universal property of porous bodies, when in the form of diaphragms, to draw gases through them in the direction from the cold to the hot side. We have thus a phenomenon of diffusion, which, contrary to ordinary diffusion, occurs even when the same gas under the same pressure is found on both sides of the diaphragm. This is a singular, hitherto unknown phenomenon; and is properly called by the author *thermodiffusion*. Dufour* has already made diffusion observations the converse of these and in harmony with them. He states that when gases diffuse, there is a *rise of temperature* on the side where the more quickly diffusing gas enters the porous diaphragm, and *a fall of temperature* on the opposite side; so that in Dufour's experiments diffusion produces a change of temperature; in Feddersen's experiments a change of temperature causes diffusion, and the latter in a direction such that the artificially-produced difference of temperatures, if we apply the laws discovered by Dufour, is diminished by the process of diffusion itself. Accordingly there appears to be between thermo-diffusion and Dufour's discovery a reciprocity analogous to that between heat and electricity in the ordinary thermo-electric current and Peltier's phenomenon.—*Phil. Mag.*, July, 1873, p. 55, and *Pogg. Ann.*, clxviii, pp. 302–311. S.

[The influence of heat on the diffusion of gases has an illustration on a grand scale in the coking of bituminous coal in the clay retorts now so generally used in gas works. That diffusion of hydrogen and hydrocarbon and carbonous oxide gases outward into the furnace occurs is well known, and is arrested in great measure by the atmospheric exhauster, under the influence of which atmospheric air and effete gases sometimes find their way into the retorts. How far the thermo-diffusion of our author may enter as a factor into the operation of the clay retorts—which are huge porous diaphragms—remains yet to be determined.—S.]

3. *A Cyclopedia of Quantitative Chemical Anaysis;* by FRANK H. STORER, A.M. Part II. pp. 113–224. (John Allyn, Boston, 1873.)—This second part of Professor Storer's important

---

* Archives de Genève, Sept., 1872, pp. 10, 11.

work carries the subject in the alphabet from "*Carbonate of Sodium*" to "*Cyanide of Silver.*" In January, 1871, we noticed the appearance of the first part of the Cyclopedia in terms which appears to be equally applicable to the present fasciculus.

The alphabetical order adopted appears not to hamper the author's freedom of scientific classification in the treatment of his subject. The only regret we have is the length of time, perhaps unavoidable, which is consumed in the preparation of the work, which at the end of two and a half years has not completed the letter C.

4. *Sull' Ozono, Note e Riflessioni di* Giuseppe Bellucci di Perugia. 656 pp. 12mo. 1869.—A notice of Professor Bellucci's work is deferred to another number. Other recent papers of his on ozone are—Sulla pretesa emissione dell 'Ozono dalle piante. 22 pp. 8vo. Palermo, 1873; and Nova sorgente di Ozono gl'ipocloriti. 8 pp. 8vo., Firenze, 1873.

II. Geology and Natural History.

1. *The Calorific Value of the Lignites of Western America;*[*] by R. W. Raymond.—The important question of the metallurgical value of the coals of the Rocky Mountains and the Pacific Coast is to be settled, of course, by practical experiment. Meanwhile, as I have had occasion to point out, the proximate analysis of these coals throws little light upon it, and is, indeed, likely to mislead the metallurgist, if he compares it with the results of similar analyses upon bituminous and semi-bituminous coals. With the view of showing how large a proportion of the material usually classed as "volatile matters" consists of combined water, or oxygen and hydrogen presumably in chemical combination, I have collected a number of ultimate analyses from various sources, in the following tables. The numbered analyses in the first table are as follows:

No. 1. Monte Diabolo coal—Analyst, H. S. Munro, Columbia College School of Mines, New York City.

No. 2. Weber Cañon, Utah—Analyst, H. S. Munro, Col. School of Mines.

No. 3. Echo Cañon, Utah—Analyst, H. S. Munro, Col. School of Mines.

No. 4. Carbon Station, Wyoming—Analyst, H. S. Munro, Col. School of Mines.

No. 5. Carbon Station, Wyoming—Analyst, H. S. Munro, Col. School of Mines.

No. 6. Coos Bay, Oregon, Wyoming—Analyst, H. S. Munro, Col. School of Mines.

No. 7. Alaska—Analyst, H. S. Munro, Col. School of Mines.

No. 8. Alaska—Analyst, H. S. Munro, Col. School of Mines.

---

[*] A paper read before the American Institute of Mining Engineers, at Philadelphia, May 21, 1873; being also a chapter in the forthcoming Report of the Commissioner of Mining Statistics.

No. 9. Cañon City, Colorado—Analyst, Dr. T. M. Drown, Philadelphia.

No. 10. Baker Co., Oregon—Analyst, Dr. T. M. Drown, Phildelphia.

No. 11. Block Coal, Sand Creek, Ind.—Analyst, Prof. E. T. Cox.

No.	Carbon.	Hydrogen.	Nitrogen.	Oxygen,	Sulphur.	Moisture.	Ash.	Combined Water.	Calorific Power I.	Calorific Power II.	Calorific Power III.	Temperature, Deg. C.
1	59·72	5·08	1·01	15·69	3·92	8·94	5·64	17·65	5900	6472	5757	2520
2	64·84	4·34	1·29	15·52	1·60	9·41	3·00	17·46	6056	6685	5912	2536
3	69·84	3·90	1·93	10·99	0·77	9·17	3·40	12·36	6515	7172	6400	2603
4	64·99	3·76	1·74	15·20	1·07	11·56	1·68	17·10	5892	6662	5738	2512
5	69·14	4·36	1·25	9·54	1·03	8·06	6·62	10·73	6679	7264	6578	2630
6	56·24	3·38	0·42	21·82	0·81	13·28	4·05	24·55	4768	5498	4565	2313
7	55·79	3·26	0·61	19·01	0·63	16·52	4·18	21·38	4814	5766	4610	2375
8	67·67	4·66	1·58	12·80	0·92	3·08	9·28	14·40	6522	6729	6428	2532
9	67·58	7·42	-----	13·42	0·63	5·18	5·77	15·10	7439	7845	7330	2683
10	60·72	4·30	-----	14·42	2·08	14·68	3·80	16·22	5768	6760	5602	2497
11	72·94	4·50	1·79	11·77	-----	4·50	4·50	13·24	6938	7208	6843	2654

This table affords some suggestive comparisons, to facilitate which a remark or two, explanatory of its construction, will be useful. In the ultimate analysis of coals, the proportions are frequently calculated (as, for instance, in the report of 1872 of Prof. Cox, State geologist of Indiana) upon the dry coal—that is to say, excluding the percentage of moisture. Thus the analysis (No. 11 above) of the Sand Creek block coal is given in that report (p. 18) as follows: Carbon, 76·38; ash, 4·71; hydrogen, 4·71; oxygen, 12·32; nitrogen, 1·88—the previously given proximate analysis having shown 4·50 per cent of moisture. To secure uniformity in the table, I have reduced these results to the basis of a full analysis, including the moisture. The justice of including the moisture of the coal in calculations of its calorific power would be unquestionable, if the moisture were a constant element. This it is not; it varies in amount, according to the local conditions affecting the samples taken. But, on the other hand, some moisture is always present; and an amount not exceeding 5 or 6 per cent is scarcely too great to be included in an estimate of average quality. Prof. Frazer's proximate analyses of New Mexico coals give an average of 3 per cent; of the Boulder Co. coal of Colorado, 16 per cent; of the Evanston coal, 5·83 per cent; and the average of 93 analyses of Indiana coals, made by Prof. Cox, gives 5·87 per cent of moisture. Now this moisture is a greater detriment to the heating power of the coal than an equal amount of ash, since the water requires to be evaporated, while the ash does not. I have therefore included in the above table the percentages of moisture, as a basis for calorific calculations, though in several instances (notably Nos. 4, 6, 7, and 10) the amount of moisture is perhaps abnormally great, and the calorific power resulting from the calculation may be less than the average of the coal would give. There are, it will be noticed, three columns of calorific powers. In each of these the amounts are expressed in centigrade heat units, and therefore indicate directly the pounds of water which could theoretically be raised from zero to the boiling point by the combustion of one hundred pounds of fuel. The first column is obtained in the following manner: The amount of combined water is found by adding to the oxygen one-eighth its weight of hydrogen; the remaining hydrogen is multiplied by 34,462, the number of heat units evolved in the combustion of hydrogen; and the amount of carbon is, in like manner, multiplied by 8,080, the calorific modulus for carbon. The sum of these two products is the number of heat units generated by the complete combustion of one unit of the fuel, containing the given proportions of carbon and available hydrogen. The heat units due to the combustion of the sulphur are disregarded, in view of the small amount of sulphur, its low calorific capacity (about 2,240 units), and the circumstance that it exists partly in the form of pyrites, the decomposition of which still further diminishes the amount of heat from this source, and partly as sulphuric acid, causing a net loss.

The second class of calorific powers is obtained by a similar calculation on the supposition that the moisture is absent. The third column gives the closest approximation to the available heat, and is obtained by deducting from the figures in the first the amount of heat units required to vaporize the moisture and combined water. This is 537 units of heat for each unit of water.

The last column gives in centigrade degrees the maximum theoretical *temperature* to be obtained by the perfect combustion of the fuel. It is calculated in the following manner: The quantity of carbonic acid, sulphurous acid, water and nitrogen, resulting from the combustion of one unit of the fuel in atmospheric air is determined, and the quantity of each of these substances is multiplied by its specific heat. The sum of these products, which we may call the temperature unit, is the number of heat units required to raise the mixture one degree in temperature. Dividing the number of heat units given in column III by this temperature unit, we obtain as a quotient the number of degrees centigrade through which the temperature of the fuel will be raised, or, in other words, the average temperature of the products of combustion, on the supposition that the initial temperature is zero, that the combustion of carbon and hydrogen is complete, that no superfluous air is admitted, and that there is no loss by radiation and conduction during the process. The calculation may be illustrated by displaying a single example in detail.

We have in analysis No. 1 of the table the following constitution of the fuel: Carbon, 59·72; hydrogen, 5·08; nitrogen, 1·01; oxygen, 15·69; sulphur, 3·92; moisture, 8·94; ash, 5·64. To find the combined water, we add to the amount of oxygen the proportional amount of hydrogen, or one-eighth, since water consists of one part hydrogen, and eight parts oxygen. This gives us 17·65 combined water, leaving 3·12 of hydrogen available for the generation of heat. But the moisture and combined water must be evaporated by the combustion of the rest of the fuel; and the heat aborbed in this evaporation is 537 heat units. Hence, to evaporate 26·59 hundredths of water, will require (temperature apart) 142·78 heat units, which must be subtracted from the calorific power in column I, leaving 5757·22, as per column III, the available amount of heat.

We now proceed to determine the temperature of the products of combustion. A simple calculation based upon the chemical equivalents shows that those products will be as follows:

59·72 carbon will unite with 159·28 oxygen, forming 219·00 CO_2
3·92 sulphur “ 3·92 “ “ 7·84 SO_2
3·12 hydrogen “ 24·96 “ “ 28·08 HO
26.59 combined water and moisture, - - - - - - - - - - - - - - - 26·59 HO
Total oxygen required from the air, - - - - - - - - 188·16
Amount of nitrogen corresponding to
this amount of oxygen in the air, - - - - - - - 629·86
Amount of nitrogen already in the fuel, - - - - 1·01
Total nitrogen in the products of combustion, - - - 630·87 N

The specific heat of carbonic acid—that is, the number of heat units required to raise a unit of this gas one degree of temperature—is 0·216; the specific heat of sulphurous acid is 0·155; that of steam is 0·475; and that of nitrogen is 0·244. Applying these numbers, we have for the heat rendered latent by each substance in one hundred units of the above mixture of gases:

CO_2 219·00 × 0·216 = 47·304
SO_2 7·84 × 0·155 = 1·215
HO 54·67 × 0·475 = 25·968
N 630·87 × 0·244 = 153·932
228·419

That is to say, it will require 228·419 units of heat to elevate the total products of combustion of 100 units of fuel one degree centigrade; or, 2·28419 is the specific heat of the products of combustion of one unit of the fuel. Dividing 5757·22, the number of available heat units from the combustion of one unit, by 2·28419, the heat absorbed for each degree of temperature, we have 2,520, which is the temperature in degrees centigrade of the products. It need scarcely be said that the unit of weight employed is immaterial to this calculation. The temperature is the same, whatever the quantity of fuel, provided the combustion takes place as above supposed, and the gases are not compressed.

It should be remarked, finally, that the oxidation of iron in the ash has not been taken into account in the foregoing calculations. The analyses give no means of determining it; but it is certainly insignificant as a source of heat, and its contribution to the resultant temperature would be reduced by the diluting effect of an additional quantity of nitrogen in the air required for its oxidation.

Pure carbon yields by combustion to carbonic acid 8,080 heat units; and the theoretic resultant temperature of the carbonic acid is 2,720°. It will be seen that some of the coals in the table, particularly the lignites of Cañon City in Colorado, and Carbon Station in Wyoming, approach the calorific power of carbon.

Moreover, several of the lignites nearly equal, and that of Cañon City surpasses, the "block coal" of Sand Creek in calorific power. Yet the latter is successfully used in the smelting of iron. We are therefore led to conclude that high metallurgical temperatures can be obtained from the best lignites of the Rocky Mountains, and that only their physical behavior, which hinders a complete combustion, prevents their use, even in shaft furnaces. That they can be utilized by means of gas producers, I think there is no room to doubt.—*Engineering and Mining Journal, May* 27, 1873.

2. *The Mineral Region of Lake Superior.*—At the meeting of the Montreal Natural History Society, held on Monday evening, Feb. 24th, Prof. R. Bell, of the Geological Survey of Canada, read a paper on the Huronian and mineral-bearing rocks of Lake Superior, of which the following is an abstract.

In addition to the sandstones of the south shore of the lake, which are unaltered sediments, in which traces of organic life have been detected, there are three well-marked groups of rocks on the Canadian side. These are the Laurentian, the Huronian, and the Upper Copper-bearing series of Lake Superior. Recent researches have shown that Huronian rocks occur, to a much larger extent than was formerly supposed, as bands alternating with Laurentian beds on both the north and south shores of the lake.

To the northward of Lake Superior the Laurentian rocks for the most part consist of gray and reddish gneiss, with micaceous belts and mica schists. No minerals of any economic value have yet been found in these rocks at this particular locality, nor do there seem to be any crystalline limestones.

In the same region the Huronian rocks are mostly of a schistose character, the most common of which are greenish schists and imperfect gneisses, the whole formation being rich in useful minerals.

In these latter deposits almost every conceivable variety of schist is to be met with. Among them are micaceous, hornblendic, dioritic, porphyritic, siliceous, cherty, chloritic, felsitic and argillaceous schists; more rarely dolomitic schists, and occasionally bands of magnetic iron ore and hematite. The lecturer stated that in this region gold and silver veins are always associated with dolomitic schists. The principal vein to the southwest of Shebandowan Lake, and others, were referred to as bearing out this statement. In the Hastings series of rocks gold is also associated with dolomitic schists.

Various isolated patches of granite and syenite, some a few yards and others many miles in extent, but always connected wiht Huronian rocks, were pointed out on the map. In these masses there is no stratification.

In the Nipigon Basin, the Upper Copper-bearing rocks of Lake Superior attain their maximum development in Canadian Territory. This area has the shape of an arrow-head, with the apex pointed to the true north. The basin floor consists of marls, sandstones, &c., often covered with trappean outflows. The lecturer was disposed to think that this trappean outburst originated from some point in Lake Superior. The direction of the flow, as indicated by wrinkles on the surfaces of beds, is from the center outward. The occurrence of these traps on all sides of the lake, and their general arrangement, which presents an appearance as if the masses had been pressed against the rocky margin of the lake basin, are supposed to favor this view. The overflow in the Nipigon Basin too becomes exhausted in receding from Lake Superior.

Unlike the Laurentian rocks, in which, as before stated, no useful minerals have been found, the Huronian beds contain ores of iron, copper, lead, gold, silver and nickel. Copper is most frequent in quartz veins which intersect dioritic schists of Huronian age. The silver and gold veins near Shebandowan occur in similar schists, and were discovered by Mr. P. McKellar in the spring of 1871. A letter from Mr. McKellar to Prof. Bell was then read, which gave a description of the details. The principal vein, Mr. McKellar writes, is of quartz, and is from two to six feet in thickness. In addition to gold and silver it contains ores of all the metals we have cited above as occurring in Huronian rocks. At this locality, in addition to the dolomitic band associated with intrusive granite, a great variety of Huronian schists occur. A vein of calc spar and quartz cutting through Huronian schists on mining lot 3 A, on the north shore of Thunder Bay, and containing native silver and nickel ore, was next described.

The main silver vein of Silver Islet belongs to the Upper Copper-bearing series, and although it has been worked to a depth of 150 feet below the surface, no trouble has yet been experienced from flooding. Up to the middle of last summer about one million dollars worth of silver had been taken from this mine. Various other silver-bearing veins and mines in rocks of this age were described briefly, but the space at our disposal will only allow of the bare mention of their names. Suffice it to say that the Algoma, Silver Harbor, Thunder Bay Silver Mine, Shuniah, Jarvis Island, McKellar's Island and McKellar's Point deposits were each noticed. In conclusion, the lecturer said that the silver veins which intersect trappean rocks belong to two sets, one of which have a N.E. and the other a N.W. direction.—*Montreal Gazette.*

J. F. W.

3. *On the Carboniferous Myriapods preserved in the Sigillarian Stumps of Nova Scotia;* by S. H. SCUDDER. 10 pp. 4to. From the Mem. B. S. N. H., vol. ii, 1873.—To the species of Myriapods described by Dr. Dawson others are here added by Mr. Scudder, and the whole subject reviewed. The species include *Xylobius Sigillariæ* Dawson, *X. similis* Sc., *X. Dawsoni* Sc., and *Archiulus xylobroides* Sc. They appear to be all of the Iulus tribe, and for the family the name *Archiulidæ* is proposed. Mr. Scudder mentions the discovery of a *Xylobius* by Mr. Henry Woodward in the British coal measures at Kilmaury, Ayrshire, and Cooper's

Bridge near Haddersfield, and proposes for it the name *Xylobius Woodwardi.*

4. *Dr. Dawson on the Post-pliocene Geology of Canada.*—The four numbers of the Canadian Naturalist for 1872, contain the successive parts of an elaborate review of the facts connected with the drift and other post-tertiary deposits in Canada, by Dr. Dawson, and mostly from his own observations. The number of species of fossils collected from the post-tertiary beds of the St. Lawrence and those of the coast of Labrador, enumerated with a mention of localities in this paper, is 205; of which 24 are Radiates, 140 Mollusks, 26 Articulates and 5 Vertebrates, besides 10 of plants. Dr. Dawson observes that all, with three or four exceptions, are northern or Arctic species, belonging in the case of the marine species to depths from the littoral zone to 200 fathoms, and identical with those of the northern part of the Gulf of St. Lawrence and the Labrador coast. The shells show some amelioration of climate from the epoch of the oldest of the deposits to that of the latest, and yet but little, as the cold Labrador current continued to flow into the St. Lawrence Gulf and River.

In connection, Dr. Dawson brings out the various arguments which appear to him to sustain the Iceberg-theory, and all who are studying the subject will be interested in reading them. He closes his arguments with one of a personal nature: that certain views (which he does not discuss) of the advocates of the glacier theory, Dana and Geikie, have by their extravagance "contributed largely to the overthrow or modification of the theory." The writer would add that he has no objection to the challenge, and will only refer the reader to a paper on the subject in this Journal for March, 1873. In this recent paper, and also in the earlier referred to by Dr. Dawson, it is observed that the glacial scratches over the rocks of Canada directly north of New England correspond in direction with those south and southeast over the higher parts of all New England; showing that the ice-mass which did the work of abrasion to the north continued on its southeastward course to the ocean; and proving, therefore, that the ice was that of a glacier. This conclusion was further sustained by reference to the fact, that while the glacier-mass had a general southeastward course over New England, its under-surface often followed the courses of various New England valleys, going ways impossible for icebergs. It was added that if all was the work of a glacier, the upper surface of the glacier must have been higher about the mouth of the St. Lawrence (lat. 48°–50°) than it was far up stream (lat. 45°–48°), or else the glacier would have moved northeastward down stream. Now Dr. Dawson mentions as one strong argument in favor of the iceberg-theory, that the scratches and drift transportation in the vicinity of the St. Lawrence River were made by a movement *up stream* (such a one as might in his view have existed if the continent were deeply submerged and the St. Lawrence valley opened over the Lake region into the Mississippi valley). His facts thus prove that there was *no movement down stream*, and therefore that, if the ice existed as a glacier, it *was* highest about the mouth of the St. Lawrence. He thus sustains the statement made in that paper, that any valley movement of the bottom ice along the St. Lawrence valley must have been one directed southwest or up stream. J. D. D.

5. *Report of the Geological Survey of the State of New Hampshire, showing its progress during the year* 1872; by C. H. Hitchcock, Ph.D., State Geologist, etc. 16 pp. 8vo. Nashua, N. H., 1873.—This report is a brief statement to the Secretary of State of New Hampshire, of the plans of the State geologist with regard to the Final Report on the Survey. The volume, according to the statements, will treat first of the Physical Geography, and include in this part a chapter by Professor Quimby on the facts relative to the terrestiral magnetism of the State from his own observations; and, secondly, of the Stratigraphical Geology. The latter part is to be followed by observations on the elevation of mountains, on Agricultural Geology, etc. Prof. Hitchcock presents as the subdivision of the rocks of the State—(1) Fossiliferous *Helderberg* limestone near Littleton; (2) The Coos group consisting of quartzite, staurolite schist, mica schist, clay slate, etc., situated for the most part near the Connecticut river, and extending nearly continuously from Massachusetts to Canada, but occurring isolated in some other parts of the State—which are referred by Prof. Hitchcock to the *Cambrian;* (3) Areas of the hydro-mica slates, conglomerates and quartzites, one north of Columbia and the other south of Stratford, and extending south along the Connecticut to Charlestown, supposed to be *Huronian;* (4) Gneissic, granitic and labradoritic rocks of the White Mountains and other areas, made *præ-Huronian.*

6. *The Fourth Annual Report on Mines and Mining;* by Rossiter W. Raymond. 566 pp. 8vo. 1873.—On page 146 of this volume is a notice of Dr. Raymond's third Report of Mining Statistics, erroneously stated for 1871. The writer was misled by the title and also by the fact that the volume was transmitted by an official from Washington, as the new volume of the current year. The contents are correctly stated, only the *third* was mistaken for the *fourth* report, the title of which is here given.

The same subdivisions are adopted in this report as in the preceding. California, Nevada, Idaho and Oregon, Montana, Utah, Arizona, New Mexico, Colorado, and Wyoming, form each a separate chapter in Part I. The smelting of argentiferous lead ores in Nevada, Utah, and Montana—Economical results in the treatment of gold and silver ores by fusion—The amalgamation of gold ores—The amalgamation of silver ores in pans with the aid of chemicals—The treatment of ores of native silver in Chihuahua—The reduction of silver ores in Chili—The metallurgical value of the lignites of the West, and finally the metallurgy of native sulphur, are the titles of several chapters in Part II. The most important chapter in Part III, is devoted to American schools of Mining and Metallurgy, in which the organization and plans of instruction are given in detail of twelve of the most important science Schools of the United States, a timely and permanently useful thing to do.

7. *Birds with teeth.*—The first example of a bird with teeth was described by Prof. MARSH, in the last volume of this Journal. At the meeting of the Geological Society of June 25th, Prof. R. Owen read a "Description of the Skull of a dentigerous Bird," which he named *Odontopteryx toliapicus*, that was obtained from the London clay of Sheppey.

8. *The Human Skeleton of the cave near Mentone.*—A brief notice of a memoir on this skeleton and its mode of occurrence by A. Rivière is given in vol. iv, at page 241. The memoir has been issued the present year by J. B. Baillère et Fils, Paris. It extends to 64 pages 4to, and contains two excellent photographs, one of the skeleton, and the other, more enlarged, of the cranium with the upper part of the skeleton. The author states that the height of the man of Mentone was about 1·85m., or 6·08 feet. It closely resembles the man of Cro-Magnon (Perigord district of France), whose height was probably over 1·80m. (5 ft. 11 in.), and also that of Grenelle whose height was about 1·70m. Calling the length of the humerus 100, that of the tibia was 76·90, while the same in the negro is 79·43 for the male, 79·35 for the female; and in the modern skeleton of the laboratory of Anthropology 73·61. The forehead is full and high, and the facial angle 85°. The skull is strongly dolichocephalic, because long, and not because narrow; and there is no prognathism or projection of the jaws.

9. *Footprints in the Middle Coal Measures at Osage in Kansas.*—Prof. Mudge has found at Osage about twenty different slabs with footprints. The impressions were made by four different species, one or more Labyrinthodonts, and others apparently true Reptilian. One of the former is about five inches broad. Two of the latter had long slender toes, and one of the two was eight inches long. The bed of rock—an excellent flagging stone —contains also some marine fossils, showing that, when the tracks were made, there was there a mud flat or shoal.—*Kansas Commonwealth*, *Topeka*, July 6, 1873.

10. *Geological Survey of Kentucky.*—The announcement will be received with great satisfaction that a Geological Survey of Kentucky is to be carried forward under the direction of Prof. N. S. Shaler, of that State, now Professor of Geology in Harvard College. Prof. Shaler will make the work tell on the progress of geological science, and not less on the welfare of the State.

11. *Geological Survey of Illinois.*—Mr. A. H. Worthen, the able head of the Geological Survey of Illinois, writes to the editors that the fifth volume of his Geological Report is in course of publication. It is paleontological, like the three preceding, and will contain many admirable plates of Crinoids, etc., with descriptions of species by Mr. Meek.

12. *Stromatopora.*—Dr. A. H. Nicholson, in the Ann. Mag. N. H., IV, xii, 89, has described as new four species of *Stromatopora*—one Upper Silurian and three Devonian—from Canada West, and gives reasons for regarding these coral-like fossils as calcareous sponges.

13. *Descrizione Geologica dell' Isola d'Elba*, per sevire alla Carta della medesima, di IGINO COCCHI, Presidente del R. Comitato Geologico d'Italia. 172 pp. 4to, with many plates. Firenze, 1871.—Prof. Cocchi in this memoir describes at length the geological structure of this most famous of iron-bearing lands, gives various facts respecting its productions, and illustrates the subject with a colored geological map of the island.

14. *The European Lobster, Palinurus vulgaris, in the Brighton Aquarium.*—The tank containing the Spring Lobster or Sea Crayfish, *Palinurus vulgaris*, at the Brighton Aquarium, No. 26, is invested with special interest at the present moment, on account of the appearance, during the last few days, of innumerable young. Until within late years, the early condition of this, the largest of our British Crustacea, was regarded as a distinct species, allied to *Squilla*, representing the Stomapodous instead of the Podopthalmous order of their class; it was thus described by Leach under the name of *Phyllosoma commune.* The celebrated Belgian naturalist, Prof. Van Beneden, was one of the first to establish the identity of these two forms, and the result of his praiseworthy investigations was simply and amply confirmed by the recent arrivals at the Brighton tanks. In this "*Phyllosoma*" phase, the ovate body is so remarkably transparent and flattened out, that even when several inches in length they can scarcely be distinguished at the surface of the sea, where they often float in countless numbers. Some very fine examples of these Crustacea, illustrating this interesting stage of their development, are exhibited in the typical invertebrate series in the Royal College of Surgeons. The specimens at the Brighton Aquarium just excluded from the egg are very small, scarcely exceeding half an inch in total length, and although swarming in their tank are, on account of their extreme pellucidness, only visible on the closest inspection. The "berried hen" producing this large brood of young was added to the collection about a month ago. An adjoining tank, No. 28, is teaming in a similar manner with the young of the Common Lobster, *Homarus vulgaris.*—*Nature*, July 17.

15. *Mexican Myriapods.* Mission Scientifique au Mexique, etc., Ouvrage publié par ordre du Ministre de l'Instruction Publique. Sixième partie, 2de section: *Etudes sur les Myriapods* par MM. HENRI DE SAUSSURE et A. HUMBERT. 212 pp. 4to, with 6 plates.—Messieurs de Saussure and Humbert have made in this work, as in other parts of the same series, a very important contribution to North American zoology. A previous memoir on Mexican Myriapods was published by de Saussure in 1860, and to that the reader is referred for the descriptions there given. The present volume discusses the classification and fundamental characters of Myria-

pods, enumerates the species before published, and adds descriptions of new species from other parts of America which are complementary to the Mexican fauna, and which may serve to illustrate the subject of geographical distribution. An extended catalogue of American Myriapods is added to the work.

16. BENTHAM'S *Notes on the Classification, History, and Geographical Distribution of Compositæ;* an elaborate and most interesting memoir. This commentary of the order *Compositæ*, as recently worked up in the new Genera Plantarum, fills nearly 250 pages of the 13th volume of the Linnean Society's Journal, and is also separately issued, has table of contents, and four plates. One of these illustrates the corollas, one the stamens, and a third the styles of *Compositæ*; the fourth exhibits the affinities of the tribes by a diagram. A. G.

17. A. S. OERSTED'S *System der Pilze, Lichenen und Algen.* A translation from the Danish into German, by A. GRISEBACH and J. REINKE; illustrated with 93 wood-cuts. 194 pp. 8vo. Leipzig; Engelmann. 1873.—An excellent compendious text-book of the Lower Cryptogamia, adapted to the use of ordinary classes or individual students desirous to find their way to a good general knowledge of the structure and classification of *Fungi*, *Lichenes*, and *Algæ.* The wood-cuts are very striking and tell their story with great clearness. It is much to be wished that we had something of the sort in this country, in which there is an increasing desire to study the Lower Cryptogamia, but hardly any appliances for it. A. G.

18. *Catalogue of the Phænogamous and Vascular Cryptogamous Plants of Canada and the northeastern portion of the United States;* by ALLEN H. CURTISS, Liberty, Bedford Co., Virginia, July, 1873.—The portion of the U. S included is that comprised in Gray's Manual, with the addition of Missouri and Minnesota. By careful management in plan and typography, the whole catalogue is comprised in eight large quarto pages, each of six columns, and the geographical range is indicated by noting the occurrence or not of each plant in the three most dissimilar districts, viz: 1. Canada; 2. Illinois; 3. Virginia. The varieties are enumerated, and the main synonyms. It is prepared especially for use in botanical exchanges, by one of our most active and keen botanists, has evidently cost very much time and care, and it appears to be admirably adapted to its end. A. G.

19. *A Botanical Index to all the Medicinal Plants, &c.;* by ALLAN POLLOCK, druggist. 137 pp. 8vo. New York, 1873.—This is a new edition, evidently prepared with great care and thoroughness, of a truly useful work, intended for druggists; but the botanist can hardly find elsewhere so full a collection of popular names. There is first a list of officinal plants with the popular names appended, the more proper one italicized; then one of popular names with reference to the botanical name. In one instance a name is wrongly given, evidently through a reliance on very old authority,

as when the Black Cherry or Rum Cherry is referred to *Prunus Virginiana* instead of *P. serotina*. A. G.

20. *On a new method of observing the rate of growth in plants;* by E. ASKENASY, Flora, 21st May.—This is a brief preliminary communication in which the author, after alluding to Müller's use of a transparent net, and Sach's Auxanometer, describes a simple device for reaching the same end. He employs a glass tube, of convenient size, to be placed in the field of a microscope, and allows the root or other part of the plant to grow in this. Of course the part must be fixed at some point, either with cork or with damp bibulous paper. The free end of the root has now room for growth either in water or in moist air, preferably the latter. The tube can be subjected to a known degree of heat by the use of Sach's hot-air chamber (described on page 644 of the Lehrbuch). The tube having been fixed on the stage can be accurately observed every few minutes, or after a longer time, a micrometer being all that is needed for determining distances. The errors which may result from these observations are frankly alluded to. This simple method is particularly adapted to the investigation of the effect of light on growth, as the whole apparatus is completely under control of the observer. G. L. G.

21. *On the general occurrence of Starch in Sieve-cells;* by Dr. BRIOSI (Bot. Zeit., May 16th.—A brief recapitulation of previous researches by Hartig and Hanstein, is followed by an account of recent original observations. In all plants examined, when a violet color is produced in sieve-cells, by iodine in iodide of potassium, the requisite magnifying power shows that there are always minute granules which present a sharply defined spherical outline. Even in the so-called solutions of starch in cells, these minute granules can be detected. They remain unchanged after treatment with alcohol and ether. In sections treated according to the method of Böhm-Sachs (that is, heating with a solution of potash, washing, and neutralization with acetic acid, and then addition of a dilute tincture of iodine) the starch granules of the sieve-cells are colored deeply violet, even when the large starch granules of adjacent cells have become broken down into a paste. If the sections are placed in dilute acids (hydrochloric, or nitric) and then treated with iodine in iodide of potassium, the starch granules are colored blue, or deep violet. The minute granules swell up, but still preserve their spherical form, even when the other granules have become a paste. G. L. G.

22. *The influence of Temperature on the development of Penicillium glaucum, Blue Mould.*—Prof. WIESNER presented to the Vienna Academy, on the 24th April, a memoir on the above subject, an abstract of which appears in Bot. Zeit., May 30th. The germination of the spores (conidia) occurred between 1·5 and 43° C., the development of the mycelium between 2·5 and 40° C., the formation of spores between 3° and 40° C. Near the upper and lower limits, the germination, the growth of mycelium and the production of spores were uncertain The rapidity in the rate of

germination increases steadily up to 22° and above that diminishes, at first steadily, then without regularity. The rapidity of mycelial growth rises continuously from the lower limit up to 26° C., and then falls with more or less regularity. The maximum rapidity of the production of spores is reached at 22° C. G. L. G.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On the sudden cooling of melted Glass and particularly on "Rupert's Drops;"* by V. DE LUYNES.—The bursting produced in "Rupert's drops" the moment the thin end is broken off has been hitherto attributed to the state of forced dilatation of the interior. It is supposed that the external layer, suddenly solidified by cooling, while the inner portions are still hot and much expanded, compels the latter, to which it remains adherent, to retain a volume greater than that to which they would be reduced if the whole drop had been cooled slowly; hence a state of unstable equilibrium, which is only maintained by the resistance of the outer layers; so that when this resistance is destroyed by breaking off the thin end or another portion of the drop, the state of equilibrium ceases and bursting takes place.

The experiments whose results I have the honour to present to the Academy seem to prove, on the contrary, that the effects in question are chiefly due to the peculiar condition of the exterior layers, and that the interior play no part, or only a secondary part, in the phenomenon.

The mechanical actions by means of which the drops are ordinarily broken necessarily produce vibrations in the glass, the effect of which it is impossible to appreciate. That is why, in this investigation, I have preferred to make use of fluohydric acid, the action of which can be moderated at pleasure, and which permits us to destroy at will, and without any shock, any portion we wish to attack.

On suspending a Rupert's drop by a thread over a platinum vessel containing fluohydric acid, in such a manner that the extremity of the thin end dips into the liquid, we find that we can always dissolve the whole of the thin end without destroying the drop; but when the acid touches the origin of the neck (that is, the point of divergence of the pair), equilibrium is always broken; the drop then separates into a great number of fragments, and in most instances without explosion.

Reciprocally, the swollen part may be immersed in the acid, the origin of the neck and the whole of the thin end being kept out of the liquid; in this case the drop is completely dissolved without rupture, and the thin end remains intact. If with different drops the experiment is arrested at different stages of the dissolution, it is found that the nucleus which remains presents no longer the properties of the original drop; it no longer breaks up when the thin end is broken off—which shows clearly that the interior mass of the glass does not intervene in the phenomenon.

These two experiments prove at once that the stability of the drop is bound up with the existence of the origin of its neck, since whenever it is preserved no disaggregation of the drop takes place.

Now it is known that chilled glass remains more expanded than if it had been cooled slowly; the exterior layers of the drop, more strongly chilled, are more expanded than the interior layers, which have occupied more time in cooling. We may therefore regard the drop as formed by the superposition of layers of glass unequally chilled and expanded, cemented to one another. The exterior layers, kept by the resistance of the interior ones, can only yield to the force of elasticity which solicits them if, through any cause whatever, they are all at the same time set free to return to their normal state of expansion.

It results, moreover, from the form of the drop, that all these layers, unequally stretched, meet together at the origin of the neck; so that on destroying this the common point of resistance vanishes, and these layers, the actions of elasticity of which are added together, are displaced along the same directions and produce the disaggregation of the system.

If this supposition is correct, one might make a drop burst by cutting it at the large end, in such a manner as to set free at one of their extremities the unequally chilled layers of glass. This is, in fact, what takes place when the large end of the drop is ground off in a lathe, or when we attempt to saw it; the explosion always takes place as soon as a little more than half of the thickness has been attacked.

Another consequence of this hypothesis is, that the vitreous molecules will be displaced in a direction different according to the manner in which rupture takes place. This displacement should be greater for the exterior than for the interior layers, which are less expanded; and it is almost *nil* for the central portions, which have not been chilled at all or but very little. Consequently, on considering the molecules in a plane transverse section of the drop, the eccentric molecules, belonging to the more expanded layers, will be more displaced than those situated nearer to the center, which will be less and less so as they are farther from the surface, so that after the rupture this plane section will have the appearance of a conic surface formed of little needles of glass, arising from the shrinkage on all sides; and the direction of the summits of these sorts of cones will indicate that in which the displacement of the molecules has taken.

If the thin end be broken off, the shrinking will be toward the bulb, and all the summits of the cones will be directed toward the thin end. If the explosion be caused by sawing the big end of the drop, the cones will have their summits directed toward the big end.

That this is what in fact happens I have ascertained by operating in the following manner. I fit some Rupert's drops in plaster, covering only a little more than half of their thickness. The thin end, which is left protruding, I immerse in fluohydric acid. The moment the neck is attacked the drop is disaggregated, with or without explosion; and the fragments constitute, by their grouping, a series of conic assemblages encased one within another and having their summits toward the thin end. On sawing the big end, the summits have the opposite direction; and if the drop is sawn in the middle, the two opposite arrangements are observed on the two sides of the incision. Operating while the plaster is fresh, we can easily detach the fragments of the drop and establish all the results I have stated.

These facts demonstrate that in the drop the glass is in no peculiar condition other than that which arises from the unequal expansion resulting from the difference of cooling.

Analogous phenomena are presented by thick glass rods which are chilled naturally by cooling in the air at the moment of their fabrication. When these rods (which have always some curvature) are heated at one end, it sometimes happens that they break along their whole length. the fracture being conic and acicular. I am indebted to the kindness of M. Friedel for a fine specimen of this kind. The tubes obtained by letting melted glass flow in threads of more or less thickness into water possess in a high degree the explosive properties of Rupert's drops. They have almost always the form of cork-screws, on account of the extreme expansion of the upper layers; and dipping the extremity in fluohydric acid is sometimes sufficient to cause an instantaneous explosion, with the same characters as in the fracture. In fine, the lumps of glass which remain at the extremities of the canes by means of which the tubes are drawn have the form of large Rupert's drops, and are of considerable weight. When these are detached from the cane they are in the condition of a drop of which the bulb has been sawn; during their cooling in the air they break up, throwing off splinters with violence; and their fracture is identical with that of the small drops broken at the big end. A fragment of one of these large drops, which I had brought from the works of MM. Appert at La Villette, presented an interesting phenomenon: on slightly squeezing it between my finger and thumb, a considerable disengagement of heat was produced; the temperature rose to about 40° C. This confirms the results obtained by M. Dufour concerning the heat disengaged during the explosion of Rupert's drops.

The existence of layers cooled with unequal suddenness in the thickness of the glass affords an explanation of the brittleness of chilled glass. In fact we may suppose that, on account of the low heat-conductivity of glass, a very thin layer at the surface is, from whatever cause, cooled with sufficient suddenness to be in a very different state of expansion from that of the layers beneath. The least shaking, or the slightest change of temperature, will cause it to break; and the fissure will be propagated in the mass of the glass: exactly the same thing takes place when a crack shows itself on pottery the glaze of which has been ill compounded.—*Comptes Rendus de l'Académie des Sciences*, vol. lxxvi, pp. 346–349.—*Phil. Mag.*, June, 1873.

2. *Deep Sea Exploration on board "The Challenger."*—*Nature* of July 24 and 31 contains No. IV and V of letters from Wyville Thomson. A sounding on the 15th of March of 450 fathoms, off Sombrero, brought up Globigerina mud, with broken shells principally those of pteropods. In other soundings between this and 1,000 fathoms similar results were obtained. Several sponges of the Hexactinellidæ were procured, closely allied to those in moderately deep water off the coast of Portugal; among stoney corals, a *Stylaster* near *S. complanatus* of Pourtales; crustaceans referred to the Astacus family, totally destitute of eyes, one named *Astacus zeleucus* nearly 5 inches long. Leaving St. Thomas on the 24th of March toward the Culebra passage, and sounding the next morning in 625 fathoms, the ooze brought up was like that before obtained, but closer and more free from shells. They secured also the little Crinoid, *Rhizocrinus Lofotensis* and the sea-urchin *Salenia varispina*, besides many corals, the most of which were species described by Pourtales, and the sponge *Hyalonema toxeris* (new) resembling the *H. Lusitanicum* and *H. Sieboldi* in general appearance and the arrangement of its parts.

March 26, nearly 90 miles south of St. Thomas, in lat. 19° 41′ N., long. 65° 7′ W., they sounded again in 3,875 fathoms. The bottom brought up in the tube was reddish, the upper layer of it the most so. The dredge was also used; it brought up a gray ooze mottled with red; the whiter portion effervescing freely with acid, the rest but little. No animals were found in the mud excepting a few small foraminifers of both the calcareous and arenaceous kinds, showing the paucity of life at extreme depths. The next day, the 27th, they sounded in 2,800 fathoms, on the 28th in 2,960, and on the 29th in 2,850 fathoms, with the same results as to paucity of life, but in the last bringing up only the red clay, the calcareous element being nearly wanting. This red clay extends for 1,900 miles between the Canaries and the West Indies.

April 4th, the expedition reached the Bermudas.

3. *Petroleum of Upper Burmah.*—This mineral oil is found at Yeynangyoung and Pagan. There are at present about one hundred and fifty wells worked at Yeynangyoung; the quantity of oil estimated as deliverable from these wells is 15,000 viss daily, of which 10,000 viss is taken by the contractor who supplies British Burmah, and 5,000 viss by the contractor who supplies Upper Burmah. The total yield of these wells is 6,000,000 viss per annum, or 9,375 tons. There are many abandoned wells, and wells that produce very small quantities of oil. At Pagan there are about fifty wells: they yield daily 1,500 viss of oil, which the earth-oil contractors, at present the Lay-myo-woon and one Moung Tsanwah, are allowed to purchase. The oil from these wells is obtained in a more liquid state and more resembles naphtha. It is of a brackish nature, and is better suited for lighting purposes than the Yeynangyoung oil. The total supply of earth-oil in Upper Burmah now per annum is 6,600,000 viss or 10,312½ tons.—*G. A. Strover*, *Rep. to Gov. of India, Dept. of Agriculture Revenue and Commerce*, January 22, 1873.

4. *India-rubber or Caoutchouc of Upper Burmah.*—The estimated number of trees, which are chiefly situated in the Bhamo and Mogoung districts, is 400,000. They thrive best in damp, moist soil, and in thick forests, shady and cool. The trees attain to a height of from 50 to 100 cubits, being from 15 to 20 cubits in girth at the base (full-grown trees) and with roots creeping over the ground for some distance. They are fit for tapping when from 6 to 10 years of age, at which time they are from 15 to 20 cubits in height and 3 cubits in girth.

When the time for tapping arrives, incisions are made in the trunks of the trees and in the roots above ground. Hollow bamboo cups, about 1½ foot in length, sloped and pointed similar to a prepared pen, are then inserted in the incisions and receive the oozing juice or milk. Three or four hundred of these bamboo receptacles are inserted in each tree. The tapping is continued for about a month, after which time it is discontinued and the wounds allowed to heal. At the expiration of another month the trees have regained strength, and tapping is re-commenced.

In preparing the India-rubber the following crude method is observed.

Water is boiled in large iron pans, and the juice of the tree is thrown in, when it gradually thickens, and subsequently is dried. The India-rubber so obtained is being brought into local use for covering water-buckets, baskets and boxes as a substitute for dammer.

The existence of the India-rubber tree in Upper Burmah does not appear to have been known, or, at any rate, it did not attract attention, until somewhat recently, when three Europeans, Messrs. Miller, Marshall and Henri, who were employed at the jade stone mines, were forced to look and search about in the forests for a substance that would effectually repair a diving apparatus that they used in working for jade stone. They found India-rubber and repaired the apparatus. The existence and value of the juice was then brought to the notice of the King, and Mr. Henri is now employed in tapping the trees and preparing the juice. Some 70,000 viss of India-rubber was brought from Mogoung last year. I myself saw 30 or 40 cart-loads of it entering the palace one day. Upper Burmah could produce 2 or 300 tons of this useful substance per annum.—*Ibid.*

5. *The Lalande Medal to Prof. Watson, August 1st.*—Prof. James C. Watson, of the University of Michigan, who has charge of the Observatory at Ann Arbor, has received a gold medal awarded him by the Institute of France for valuable astronomical discoveries. The Ann Arbor ***Register*** gives a description of it, and says: "The medal was awarded to Prof. Watson by the Institute of France, in July, 1870, but on account of the war its completion and transmission were delayed. It was made at the French Mint, and accompanying it was the certificate of the Director of the Mint as to its fineness and weight, as well as 225 francs in bills of the Bank of France, being the unexpended

balance of the sum appropriated by the Institute for the medal. It is exquisitely wrought and has on one side a bust of Minerva in half relief, surrounded by the words: 'Institut Imperial de France, Constit. Art. lxxxviii.' The other side has inclosed in a massive wreath the following words: 'Académie des Sciences, Prix d'Astronomie, fondation Lalande, James Craig Watson, 1869.'"

6. *Meteoric iron.*—The mass of meteoric iron which was found at Neuntmannsdorf, in Saxony, in December last, weighing twenty-five pounds, has been bought by the Museum at Dresden.

7. *Pre-Historic Races of the United States of America;* by J. W. Foster, LL.D. 8vo, pp. 415. Chicago, 1873: D. C. Griggs & Co.; London: Trübner & Co.—This interesting volume reached us in the same week which brought the sad tidings of the death of the author, already announced on page 160 of this volume. It is no doubt much the most important of Col. Foster's works. The subject had long engaged his attention, and his own researches have added important facts and conclusions respecting this department of ethnology. The subject is treated in twelve chapters: I. Antiquity of Man—Evidences in Europe. II. The same—Evidences in the United States. III. The Mound Builders—The Geographical distribution of their works. IV. Shell-banks—Their Geographical distribution. V. Mounds and Enclosures. VI. The Mound Builders—Their Arts and Manufactures. VII. Ancient Mining by the Mound Builders. VIII. Crania of the Mound Builders. IX. Manners and Customs as the basis of Ethnic relations. X. Who were the Mound Builders? XI. The Unity of the Human Race. XII. Chronometric measurements as applied to the Antiquity of Man. There are 72 illustrations on wood, largely drawn from materials now for the first time brought together. The style of the text is animated and generally in good taste. Ample references to contemporary literature are given, and while the volume is avowedly only a compendium, it is not a mere compilation, but bears the marks of the hand of an original observer. The mechanical execution of the work does credit to new Chicago. Had the author lived to revise his work for a second edition, he would undoubtedly have eliminated some errors of the press and some slips of the pen, which the careful reader will note in perusing the volume.

9. *Mittheilungen der deutschen Gesellschaft für Natur und Völkeskunde Ostasiens.*—Herausgegeben von dem Vorstande. 1st Heft. 26 pp. Small fol. May, 1873. Yokohamā, Japan.—This publication is the first number of the Transactions of a scientific Society in Japan—a Deutsche Gesellschaft. The number contains meteorological observations, observations on a large cephalopod of the genus *Ommastrephes* found in the Japan seas, and various historical papers. The length of the Ommastrephes, from the point at the hinder extremity, to the front edge of the mantle was 186 centimeters (6 feet 1 inch), and 41 cm. (1 foot 5 inches) more

to the mouth. The longer of the eight arms measured 197 centimeters or nearly 6½ feet.

10. *Bulletin of the Buffalo Society of Natural Sciences*, Vol. I, No. 2, 1873.—The contents of this second number of the Bulletin, are, Descriptions of new species of Fungi by C. H. Peck, (occupying 32 pages); Contributions to a Knowledge of N. A. Moths, by A. R. Grote; A study of N. A. Noctuidæ, by A. R. Grote. The number contains two excellent lithographic plates containing figures of Moths.

The President of this Society is GEORGE W. CLINTON, LL.D.; the Vice-Presidents, H. CHANDLER, G. E. HAYES, and S. S. ROGERS; the Corresponding Secretary, L. F. HARVEY, M.D.

11. *Academy of Sciences of France.*—Of the elections mentioned on page 159, the first was in place of Prof. Agassiz, who had been advanced from the list of Foreign Correspondents to that of Foreign Associates; the second, in place of M. Pictet of Geneva, deceased, and the third in place of M. Pouchet, deceased.

12. *German Association of Naturalists and Physicists.*—The 46th meeting of this association will be held this year at Wiesbaden during the week commencing September 18th.

13. *British Association for the Advancement of Science.*—Dr. JOULE, of Manchester, the president-elect of the year, being unable to be present at the coming meeting of the Association, owing to the state of his health, Dr. A. W. Williamson of University College will probably be chosen to the office of President.

14. *The French Association for the Advancement of Science.*—The annual session was appointed to be held at Lyons, during the week commencing August 21.

OBITUARY.

GUSTAV ROSE.*—This distinguished mineralogist died at Berlin, July 15, in the 76th year of his age. In him Germany and the world have lost a wise and noble man,—conceded by all to be the first in his science among the learned men of Germany. He was the younger brother of Heinrich Rose, the chemist, and the youngest of four sons of Valentin Rose, who was Assessor in the "Ober-Collegium Medicum" of Berlin; and grandson of Valentin Rose the elder, discoverer of the "Rose'schen" metals. He early lost his father, and his excellent mother looked after the culture of four sons, whose youth fell upon hard and trying times. All four brothers served their country in the war for freedom. Gustav, born on the 18th of March, 1798, and 17 years old at the date of the battle of Waterloo, did not go into that battle, but made the march under arms from Berlin to Orleans.

At first devoting himself to engineering, he fell sick of lung fever. During his convalesence he gave himself to scientific pursuits, and this, as well as the influence of his brother Heinrich, led him to leave engineering and devote himself entirely to science. He went to Stockholm where Heinrich was already working under

---

* From the German of Prof. vom Rath, of Bonn.

the immortal Berzelius. In 1823 he took up his residence in Berlin. In 1826, he became "Extraordinary," and in 1839, "Ordinary" Professor of Mineralogy in the University of Berlin, and, after the death of Weiss, Director of the Royal Mineralogical Museum.

It was the privilege of Gustav Rose to travel extensively, in Scandinavia, England and Scotland, Italy and Sicily, France and Austria. In the year 1829, he made, with Humboldt and Ehrenberg, the famous tour to the Ural and Altai Mountains and the Caspian Sea, and beyond to the borders of China, a journey which first made known the mineralogical resources of the extensive Russian Empire. His researches on his native soil were confined to the Silesian Mountains.

G. Rose was the first in Germany to use the reflecting goniometer in accurate measurements of the angles of crystals. He took an active part in the researches which led Mitscherlich to the important discovery of isomorphism. His work covered all departments of mineralogy, the form and combinations of crystals, physics in its applications to crystallized substances, the chemical constitution of minerals, and their artificial formation. He was the great master in the art of crystallographic drawing. The science of the association of minerals in rocks, petrography, originated with him. He was also the first to teach us the method of studying rocks by means of thin microscopic sections mounted on glass slides, in which minerals invisible to the unaided eye are disclosed.

With a special predilection he devoted himself to the study of meteorites, those wonderful bodies which reach the earth from the depths of space. With his keen penetration he discovered the structure of the iron meteorites and the mineral components of stony meteorites, and studied out the striking differences between rock-making in a cosmic atom, and in the solid crust of the earth.

It is worthy of remark that his best mineralogical discoveries were made not always on rare bodies, but often on those which had been long familiar and were common in collections. An example of this is his recognition of right and left-handed quartz crystals by their exterior forms; the complex twin crystals of the same species, etc. The secret of his success was that he did not observe simply form, but all the physical characters of the species; when searching into nature's work, his mind grasped whatever in the wide range of facts could serve as a key to the solution of the difficult problem before him. During his later years his researches were devoted to the "king of stones," the diamond. Few mineralogists would have thought that the diamond yet offered unsolved problems. In his anxiety that his work should not be lost to science, only twenty-four hours before his death he dictated to his son the results of his latest researches. Perhaps the final solution of the problem of the crystallization of the diamond was not attained by him; but he was near reaching his aim. His life, in thought and action, reflected Bacon's maxim "Pertransibunt multi, sed augebitur scientia." He was a true student of nature, an eminent and effective worker for the progress of science and the exposition of the system of nature.

We can scarcely find a better example than in Gustav Rose of the joy from a growing knowledge of nature lasting to the evening of life. Looking back over his long life, he saw how many dark paths of science had been followed out and made clear. This filled him with delight and high hope. "You will yet have more light," he said to the young. "Much must perish, but science will continue to increase." He saw his co-workers and best friends, Mitscherlich, Magnus, Haidinger, above all, his brother Heinrich, called from their work. Their departure and his increasing loneliness filled him with pain. Still he rejoiced in the thought of how much science had been advanced by the common efforts of his departed friends. Thus his spirit exhibited the uncommon spectacle of augmenting cheerfulness to life's close. Three years since it was decided to celebrate his "Doktor-Jubiläum," on the occasion of his completing a half century as an instructor. He never sought honors, but nevertheless all honors fell to his share. When he was made Knight of the Order *pour la mérite*, he considered the distinction too great for him.

Imperishable is the memory which Gustav Rose has left. Not only imperishable, but a memory that is living and active in the hearts of all who knew him. In his science and his many-sided relations to life, he had no enemy, no opponent, no envy, no evil-wisher to disturb him. He lived in a profound peace, of which his eyes were the speaking witness, whose peculiar soul-full outlook astonished all with whom he spoke. What is often so hard to the best men, to live in peace and friendship, was allowed to him. As he always strove to judge from a sense of the good, the true and the beautiful, so he expected the same judgment from others. He recognized in the efforts of others only the good. If words and deeds did not accord with his views, he did not attribute to others evil motives—and thus he won to himself the love and respect of all who came in contact with him.

Gustav Rose, in his life, as well as in his science, has left us an example hard to imitate. Until the 11th of July he still gave his lectures. Notwithstanding his great debility,—feeling, he says, "as if I had climbed the "Hummerich" and the "Löwenburg,"—he wrote in the evening a long scientific letter, closing with the words "Rest will do us good; we will go again to our old quarters in Friedrichshafen; would we were there now!" Scarcely had he closed the letter when he was seized with a chill, the premonitory symptom of pneumonia, which, in less then four days, ended the life of the best of men.

Now rests from its work the hand which wielded the hammer with strength, and with exquisite delicacy drew the finest lines of crystal figures; and from their work rest the eyes which saw the snowy summits of the Altai, and distinguished the "matt" and the "glänzend" on the surfaces of rock-crystals. Peace to his ashes! Blessed are the peacemakers!

Bonn, July 16th, 1873.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXVI.—*Anniversary Address of the President to the Linnean Society, May* 24, 1873.

THE anniversary address this year before the Linnæan Society was devoted to some considerations growing out of "the recent progress of the study of Vegetable Anatomy and Physiology." It is interesting to notice how topics of this sort are handled by a consummate systematic botanist who has never paid attention to vegetable anatomy and physiology, either for their own sake or as a professional expounder, but who appreciates their bearings upon his own department of the science. Mr. Bentham's address opens with the following passages:—

"I have been struck with the observation made by more than one critic in this country, and commented upon in some foreign journals, that we in England are in this respect some way behind our continental neighbors—that, for instance, the most important investigations and consequent discoveries relating to sexual propagation, and the incipient history of cryptogamic plants and microscopic animals, have been made in France and Germany—and that we are, in short, comparatively deficient in what the Germans are pleased specially to distinguish by the name of Scientific Botany and Zoology. Without admitting for a moment that there is less of science in the study of the comparative anatomy, the mutual relations and consequent natural arrangement, and the geographical distribution of the higher animals and plants than in that of microscopic structure, we may acknowledge that there may be some truth in the remark that, with few exceptions, we have not excelled in that long, patient, and tedious devotion to one subject of limited extent from which such discoveries have usually resulted; and the fact may be, in some measure, the result of our social habits and ideas. Our early education, the whole tendency of our lives, is generally directed to the means of advancement in the world, if not always to the increase of income, at any rate to the raising of our social position in the eyes of those amongst whom we live. If the enormous increase in our commercial and industrial wealth be carefully investigated, it will be found to be in many respects deeply indebted to the recent progress of pure natural science; and yet the necessary study of that pure science will neither enrich the one who would devote himself to it, nor yet raise him in the estimation of his neighbors and associates, whilst it may seriously interfere with his means of bringing up his family, reduced as they become by the rapid increase in the expense of living. We have not in this country those numerous small professorships, or government or municipal places in provincial towns, which give to a man of modest requirements sufficient leisure steadily to carry on his researches year after year without interruption. Content with what he has thus secured, many a continental naturalist looks for no further advancement; he requires no relaxation but perhaps a few weeks in summer spent at a bathing-place; he seeks his reward in the publication of the results of his labors in Transactions or Journals, or a favorable report, without having to calculate on pecuniary results. If we had any such places in this country, few Englishmen could be found to sit down in them to rest and be satisfied; and it has required some moral courage in those of our young men who, having enough to live upon, with a passion for science, have for its sake renounced all attempts to climb round after round on the social ladder. We have had, however, and still have such men. With all our social drawbacks we have contributed our fair share to the progress of natural as well as of physical, mathematical, and other sciences. We have had our Robert Brown, and long before him our John Ray. Among our living zoologists and comparative anatomists I could name those who yield nothing to any of their continental rivals; and above all we must remember that it is an Englishman who has, in this nineteenth century, brought about as great a revolution in the philosophic study of organic nature, as that which was effected in the previous century by the immortal Swede. With such names as Linnæus and Darwin, the northern nations can well hold their own in the presence of any scientific celebrities of Central Europe."

"In considering these observations it may not be uninteresting to keep in mind a perceptible difference between our two great scientific neighbors, the French and the Germans. Excelling in method, the French are unrivalled in clearness of exposition in Natural History, as in Mathematics, Jurisprudence, Philosophy, and other abstruse subjects. With a great readiness to seize the general bearings of the several facts or points they have before them, they will at once organize them into systems or theories, often successfully; but they may be sometimes apt too readily to admit into these systems and theories elements which they have not verified, or not to wait for a sufficient confirmation by repeated observations of the original facts upon which they were founded. On the other hand, method and exposition are not among the distinguishing characters of German naturalists; they have had no Jussieu, no De Candolle, no Cuvier, nor, in earlier days, had they a Tournefort or a Buffon; but they are beyond all competition in laborious and patient investigation of details upon which all reliable conclusions must be founded; to them also we practically owe the greater number of important compilations, Genera and Species, Nomenclature and indexes, Records, &c., equally requiring steady labor, with results not brilliant, but useful. Again, if the French are good theorists, the Germans are great speculators. If French theories may sometimes be found defective in detail, so German imagination is apt to wander too far from the facts from which it started. And this comparison of French method and German detail, of French theory and German speculation, will probably be found exemplified not only in their physiological researches and elementary works, but also in their monographs and other systematic publications. You learn more rapidly from a Frenchman; the German supplies you with more materials for study; and thus you derive equal benefit from both."

The most important portion of the address is that which relates to

The questions of Gymnospermy and Genealogy.—"An important question in vegetable morphology, first brought forward by Robert Brown, and a subject of much controversy in later times, the gymnospermy of Conifers and their allies, has recently been placed in a somewhat new light by a German physiologist. The nucleus and, later, the seed proper (that is, the embryo and its albumen) are in these plants enclosed in fewer envelopes than in any other phænogams. Many Monochlamyds or Monocotyledons have no perianth or stamens round their female organs; but in all, except these Gymnosperms, the nucleus or embryo is enclosed in a simple or double integument within, but distinct or distinguishable from, a carpellary envelope. In Conifers and their allies the simple or double integument alone covers the nucleus. R. Brown, after a long series of careful observations, published, in 1825, his conclusions that this simple or double integument corresponded to that of the ovule and seed in other Dicotyledons, and that Conifers have no ovary, style, or stigma.* Lindley observed, in 1845 (and left the observation unaltered in 1853), that 'about the accuracy of this view there is at this time no difference of opinion.' Since then, however, Payer, and his disciple Baillon, founding their conclusions upon organogenesis, have asserted that it is the seed-integument, not the carpellary envelope, that is deficient—a view which has been supported by Parlatore and others, refuted by Hooker, Caspary, Eichler, and others, and again taken up by Prof. Strasburger, of Jena, after a series of careful and detailed organogenetic observations, combined with genealogical, or, as they term it, phylogenetical considerations, in a remarkable essay entitled 'Die Coniferen und die Gnetaceen.' In the attempt to reconcile views apparently so opposite, taken by naturalists whom we should all consider of high authority, we must, perhaps, in some degree, take also into account a certain bias which may be observable on either side. From the well-known accuracy of Brown's observations and the soundness of his views in every department of botanical science he entered into, there is a great disposition on the one side to rely absolutely on his conclusions; whilst on the other hand, French organogenesists, having broached theories which have proved of great importance in various homological questions, have been but too ready to set them up against all authority, without sufficient verification of detail. In the present case this verification of detail has been supplied by Strasburger, who has combined it with general considerations now first brought to bear on the gymnospermy of Conifers. He proves to be an ardent disciple of Häckel, the greatest amongst Germanizers of Darwinism. The testimony in favor of the derivative origin of forms and organs has certainly received large accessions from the German accuracy and copious details of Häckel and his followers, but at the same time has been the occasion of a free display of German imagination, as I hope presently to show, in considering Strasburger's views of the homologies of Conifers, in conjunction with some parts of Häckel's last great work, the Monograph of Calcisponges.

"In the first place, we must be careful to consider what we mean by homologies of organs. They are of two kinds:—(1) the homology of the several appendages to the axis of one and the same plant, which in zoology may be compared to the homology of the front and hind limbs or of the several vertebræ

---

* Strasburger, in an historical sketch of the progress of the question, points out that Targioni-Tozzetti in 1810 enunciated views very similar to those afterwards developed by Brown. Published, however, in a journal which had but very little circulation, his notes remained almost unknown till attention was called to them by Caruel in 1865. Strasburger quotes the passage (with some typographical errors), p. 174 of his "Coniferen."

of one and the same animal; and (2) the homology of the organs of two different plants, corresponding to the homology, for instance, of the wing of a bird with the fore-leg of a quadruped. To the former class belong the various much-vexed questions on the distinction between axis and appendages, arising in the consideration of the flowers of Conifers as of many other orders; but it is the latter class with which we are now more specially concerned in relation to Brown's gymnospermous theory. In his time this homology of organs was determined solely by their similarity in position, development, structure, and other characters, as observed in the plants compared: in the present day physiologists have to take into account the evidences, either of their hereditary derivation from a corresponding organ in a common parent, or of their being an early stage of development of organs which have further progressed in plants to which their own race are supposed to have given birth. It is in this respect chiefly that the arguments put forth by Strasburger differ from those of his predecessors. But whilst giving him every credit for his patient and persevering elaboration of details, we cannot but see in his derivative arguments much of purely imaginary mixed up with well-attested evidences. When in the higher races of phænogamous plants we meet with staminodia, carpidia, or other rudimentary or anomalous productions, we may justly, with Darwin, conclude that they are the hereditary representatives of organs normally perfect in some parent race, but which, in consequence of other adaptations of the general economy of the plant, have, in the course of successive generations, become useless and gradually reduced or almost obliterated, if not modified so as to perform different functions. So when we find in a species, or group of species, some one organ specially modified in adaptation to special purposes, and thus differing or progressing from the forms prevalent in the genus or order to which it belongs, without retrogression in other respects, and if we allow no fallacy to creep in as to what we mean by progress or retrogression, we may perhaps conclude that we have at the same time a specially modified race and unmodified descendants of the race it has sprung from. But it is hard to believe that Strasburger had any such solid foundations for his argument that the envelope of the nucleus of Conifers is genetically the same as the carpellary envelope of the higher Phænogams. He does not, as far as I can learn, pretend that this envelope is the reduced representative of organs more perfect in previous races; for the presumed ancestors of Conifers are cryptogamic. He rests solely upon the supposition that this envelope in Conifers is the first appearance of an organ further developed in the outer integument of their descendants, the Gnetaceæ, and perfected in the carpels of their ultimate progeny, the higher Dicotyledons. But there seems to be very little beyond pure imagination upon which to found such a supposed pedigree; and many reasons present themselves against the belief that the higher Dicotyledons can have descended from Gnetacæ or Gnetaceæ from Conifers, or that Conifers ever produced any races now existing out of their own order. As a postulate under the Darwinian theory, we may allow all to have had their origin in a common parent. We may also, from the scanty evidences supplied by Tertiary and Cretaceous remains, believe that the parent races of some of our species, or perhaps genera, may have remained unchanged to the present day in company with their modified offspring. Even of two nearly allied orders one may be more altered from the common stock than the other, and may be thus in a vague sense said to be derived from it and therefore more modern. Thus Cycadeæ may be supposed to be more ancient than Conifers, Araucariæ more ancient than other groups of Conifers; but the common parent of Conifers, Gnetaceæ, and other low Dycotyledons belong to an age so remote as to have left no visible trace to guide us in our conjectures.

"From such conjectures, however, as have been indulged in by phylogenesists, I gather that the supposed earliest progenitor of the plant-races was a simple organism multiplying by internal growth and division, that at a later stage, besides growth in various directions with a tendency to radiation, sexual elements had arisen, at first, perhaps, without other arrangement than their proximity. From that stage the progress toward the more perfect plant became multifarious, some of the principal courses followed being the differentiation of the indefinitely growing axis and its definite appendages—the respective arrangement of the male and female element, of the female at the end of an axis or of one of its branches, and of the male on the appendages—the adaptation of the appendages to the various purposes of vegetation, of protection to the sexual elements, or of assisting them in their functions—the separation of the male from the female element, &c. I see no arguments to oppose to these different modes of gradual progress by means of natural selection through a long succession of untold generations; but they cannot have followed the same sequence in all races of plants. In some the separation of sexes may have long preceded the development of floral envelopes; in most of the higher Phænogams the reverse has been the case. Phyllotaxy has become highly developed in several Cryptogams, while in some Phænogams, far advanced as to sexual apparatus, the foliar system has remained in arrear. But in none of these courses have we any evidence of retrogression. We have no more reason to believe that sexes once separated are brought together again in future generations than that cellular plants should descend from those in which the vascular system has been perfected.* And yet we must believe this if we admit Strasburger's pedigrees. We must suppose that races, after having once secured the advantages of a total separation of the two sexes and undergone modifications suited to their separate requirements, have again returned to their primitive state of sexual proximity, and commenced a totally different series of modifications destined to counteract the evil effects of that proximity. A much more simple hypothesis would be that Conifers separated from the common stock before the development of floral envelopes, the higher Dicotyledons before the separation of the sexes. The arrangement of the vegetative organs, or phyllotaxy, had probably acquired considerable perfection before the separation of either of these primary classes of Dicotyledons; for we have the verticillate arrangement in alternating whorls in *Frenela*, *Ephreda*, *Casuarina*, *Calycopeplus*, *Hippuris*, and many others belonging to the most widely separated natural orders—the opposite and decussate leaves in various genera of Conifers and Gnetaceæ, as well as in numerous orders, whether of Monochlamydeæ, Gamopetalæ, or Polypetalæ; and in Conifers, as in the higher Dicotyledons, the whorled or decussate arrangement is variously broken up into the spiral, the alternate, or the scattered. But the reproductive organs having at that early stage taken the two directions of total separation of the sexes in the one and their union in the other within a set of floral envelopes, their progress was thenceforth in different directions, and homology in a great measure disappeared. In Coniferæ this complete separation of the sexes and fertilization through the agency of wind being established, natural selection would only promote the development of such floral envelopes as might be required for protection and would not interfere with the fertilizing process, and would necessarily be very different in the male and in the female flowers. Accordingly one great point established by Stasburger and others is, that in Coniferæ and Gnetaceæ there is no homology between the male and the female flowers. In the higher Dicotyledons the male elements took their place around the females, and axial appendages would be early established or modified for the various purposes of assisting, protecting, or controlling fertilization or maturation, all of which arrangements would become more and more complicated as the plants came to be benefited by cross fertilization through insect and other external agencies, or again simplified by partial abortions

---

* The apparently exceptional case of unisexual flowers, supposed to have descended from perfect hermaphrodite ones by the gradual abortion of one of the sexual elements, in which the abortive element is occasionally again perfected, is no real retrogression. An occasional perfect stamen in a female Euphorbiaceous flower cannot be said to be a real return to hermaphroditism.

as the same purposes came to be answered by more or less perfect unisexuality or other means.

"If, then, we are right in concluding that Gnetaceæ cannot have descended from Conifers nor the higher Dicotyledons from Gnetaceæ, though all may have descended from a common stock, we cannot but think that Strasburger has failed in proving any genetic homology in their floral envelopes. The question returns, therefore, to its old phase, to be determined by morphology, position, and functions.

"First, as to morphology. In phænogamous plants, immediately around or among the sexual elements the outgrowths from the floral axis are of two kinds, either continuous and uniform or oblique all round the axis, or arising in several separate parts: the former are regarded sometimes as mere axial developments, sometimes as exceptionally single and one-sided foliar organs; the latter as appendages or leaf-organs, forming part of the general phyllotaxy of the plant. To the former class would be referred discal excrescences and ovular integuments, to the latter carpellary elements. Strasburger shows that the disputed envelope in Conifers most frequently, though not always, appears at an early stage in the shape of two more or less distinct opposite protuberances, that it is consequently foliar, partaking of the phyllotaxial system of the plant, not axial nor exceptionally monophyllous and unilateral, and that it is therefore carpellary, not ovular.

"But here we have another element of uncertainty, which has recently been the subject of much controversy, and to which I shall presently revert. The limits between axial dilatations and regularly formed appendages are not always definite, and occasionally are wholly obliterated; and the present case may be included amongst those in which the distinction is ambiguous. Morphologically the seminal envelope of Conifers shows a tendency to enter into the general phyllotaxial system of the plant; but in several genera it retains the characters of an axial dilatation, or, as Strasburger interprets it, a single leaf. In *Gnetum* there is a double inner integument, which he considers entirely ovular or seminal and monophyllous, whilst the outer one is, according to his view, carpellary, consisting of two leaf-organs in conformity with the general phyllotaxy; but he admits (p. 119) that the outer one of the two ovular integuments is traversed by bundles of vessels similar to those of the external carpellary envelope, and "only affords a further proof of the morphological connection of the two.

"In position, the integument of the Coniferous nucleus appears to me to be similar to that of the ovular envelope of the higher Dicotyledons, close around and on the axis terminated by the nucleus, not that of the carpellary leaves, which are on a different axis. Whatever be the theoretical origin of the ovule of the higher Dicotyledons, on the margin or in the axil of the carpellary leaf, or on a prolongation of the central axis, its funicle, which bears the integument as well as the nucleus, is a branch, and therefore a secondary axis, and not the main axis of the flower, on which are placed the carpellary leaves.

"In function, the integument in question is purely ovular and seminal, the protection of the nucleus and embryo, not that of the carpellary leaves of the higher Dicotyledons, which bear each a separate stigmatic apparatus for the reception and transmission of the pollen-tubes to the nucleus. This, however, is a purely adaptive character, whose chief value is in respect of practical terminology.

"The result of the above considerations as to the homology of the integument of the nucleus of Conifers as compared with those of the higher Dicotyledons, if I have put them fairly, would therefore be, that genetic homology does not exist, morphological homology is vague and doubtful, position indicates rather that of the ovular or seminal than of the carpellary integuments, so also does the secondary and adaptive homology of function. Theoretically, therefore, we should say that the organ in question is not the exact homological representation of either the carpellary or the seminal integument; but practically it is most useful and instructive to treat it as seminal. And as to the name of the two great subclasses of Dicotyledons, as all are agreed that they are essentially distinct, in that the one is deprived of one of the two envelopes (carpellary and seminal) which exist in the other, the received names Gymnosperms and Angiosperms appear to be really appropriate, as denoting a fact admitted by both sides, though differently interpreted; whilst the proposed names Archisperms and Metasperms are founded on a theory which, under the above views, we cannot but qualify as purely imaginary.

"A valuable portion of Strasburger's essay consists in his detailed illustration of the development of the flowers of *Welwitschia*, an important contribution to the completion of that history of this plant so thoroughly worked out by Dr. Hooker, so far as the materials at his disposal admitted, in his now celebrated paper in the twenty-fourth volume of our Transactions. Hooker had then no flower-buds at his command; and it was only some years later that he succeeded in procuring from Mr. Monteiro more satisfactory specimens, in various stages of development. The various works he was then engaged in prevented his resuming the subject himself; but he transmitted a series of these specimens to Professor de Bary; and it was from these materials that Strasburger was enabled to trace the progress of the flowers from the earliest stage. After an evidently most careful examination, he has given the results, pp. 91 and 141 of his 'Coniferen und Gnetaceen.' The accuracy of his observations has been confirmed by Professor M'Nab, to whom Dr. Hooker had also communicated some of Monteiro's specimens, and who, after an equally careful independent examination, embodied the results in a paper read at our meeting of the 16th December last and now in the printer's hands, to which he afterward added a note on the receipt of Strasburger's essay.

"The chief interest attached to this extraordinary plant lies in the probability of its being the nearest approach to (the least modified amongst the descendants of) the original type or parent stock of Dicotyledons which has reached recent geological periods. If, as above, we suppose the original parent race of Dicotyledons to have been one in which phyllotaxy had already become variously modified for the purposes of nutrition, but in which the sexual arrangements remained much in arrear, we may conjecture that amongst its immediate descendants there was a tendency to vary both in the relative arrangements of the sexual elements and in the development of floral appendages amongst and around them, combinations arising in both directions calculated to promote the welfare of the race. In the midst of the varied circumstances in which their descendants were placed in the course of their dispersion through successive ages, some profited by an increasing complexity in their floral developments counteracting the evils of sexual contiguity, others by a total separation of the sexual elements rendering their comparative exposure rather beneficial than prejudicial. From the former may have descended the higher Dicotyledons, from the latter the Conifers;—the former ever increasing in the complexity of their arrangements, so long as they retained their hermaphroditism, simplifying them again, perhaps, in some cases by arrest or obliteration as they become more or less unisexual; the latter retaining rather more of their primitive simplicity. *Welwitschia* does not absolutely belong to either, and may be a race which has come down to us with less of alteration from the early descendants of the common stock than either of the others. Some progress had been made in both directions. Sexual separation predominated, but not until some floral development had taken place; and neither had been carried to the perfection exemplified in the two great subclasses; and the race would probably have become long since extinct had it not been established in a country which has apparently experienced since very early times less of the vicissitudes affecting organic life than any other, and had it not been at the same time endowed with other constitutional peculiarities, enabling it better than any other plant to bear with the physical conditions surrounding it.

"All this may be rejected as purely conjectural; but surely Strasburger's genealogical tree is equally so. My object is merely to show that the supposition that, of the three races now so distinct, *Welwitschia*, after the first variations, has remained the least modified from the common stock, that the Conifers have undergone a greater progressive change in one direction, and the higher Dicotyledons a still greater advance in another direction, is more plausible than the assertion that Conifers are the parent race from which Gnetaceæ have directly descended, and that these, again, have engendered the higher Dicotyledons.

"The establishment of direct pedigrees or genealogical trees, in which the parent and descendant races are supposed to coexist in the present day, is a favorite speculation of the German school, especially since, after Häckel, it has adopted Darwinian views, carried in many instances far beyond what is warranted by the works of the great master himself. In plants at least, such pedigrees appear to be wholly admissible, so long as we have no geological record to justify them. If the image of a tree be really applied to the illustration of the parentage of plant-races, it must be very differently conceived. Taking, for instance, the Dicotyledonous class, we might suppose a tree, in which the trunk represents the common ancestor, forming in successive generations innumerable more or less diverging branches, the greater part of which perish either immediately or in the course of few or many generations, but some remain as branches or common trunks for future ramifications. We may suppose the center of the tree always to consist of those which retain most of the ancestral characters, the lateral branches diverging more and more as they have become more and more modified. These modifications, even the extreme ones, may be for a long time very slight; but in the course of ages (as we may observe in varieties of modern species) some of them may have acquired a more marked character as well as more or less of fixity. We may suppose this to be going on through millions of ages, innumerable branches, whether near the center or more or less distant from it, ceasing to grow or to branch out, leaving gaps in the upper part of the tree, partially filled up, perhaps, in a few instances by returning branches from the circumferential ones, and all decaying at the base, leaving only their upper extremities to continue the process in future ages. We should then have the present races represented by the countless branchlets forming the flat-topped summit of the Dicotyledonous tree—a hundred to a hundred and fifty thousand, perhaps, if we take into account species only, ten times as many if we go into subspecies and varieties; the branches which immediately bore these present branchlets, as well as the lower more general ramifications, will have wholly disappeared from our view, or left only here and there the most fragmentary traces; and the surviving branchlets themselves will be most irregularly placed. Here we should see thousands crowded into compact patches definitely circumscribed at every point (Compositæ, Orchideæ, Gramineæ, &c.); there we should meet with enormous gaps, either quite unoccupied or a few solitary branchlets or small clusters isolated in the middle (*Moringa*, *Aristolochia*, *Nepenthes*, &c.). In other parts, again, irregular masses may be more or less connected by loosely scattered branchlets or clusters, obliterating all boundaries we might be disposed to assign to them (many of the bicarpellary gamopetalous orders, the several curvembryous orders, &c.). In the imaginary construction of such a tree, all we can do is to map out the summit as it were from a bird's-eye view, and under each cluster, or cluster of clusters, to place as the common trunk an imaginary type of a genus, order, or class, according to the depth to which we go. If we believe that this type, or original trunk branch, is exactly represented by (has descended unchanged to) one of the present branchlets, we place it immediately under that branchlet, as having been directly continuous with it, and regard the remainder of the cluster as the persistent summits of lateral offsets. If we consider that the direct trunk-race of a cluster has become extinct in its precise form, and has left descendents only from its branches, we place it under one of the gaps in the cluster or under a vacancy outside the cluster, according to the conjectures we may think the most plausible, as derived from the relative structures, geographical relations, &c., of the present branchlets or other evidences we can bring to bear upon the question. Such circumstantial evidence will always be exceedingly vague and inconclusive; and the assistance we can derive from the geological record is so exceedingly slight, especially if we descend below those tertiary times in which the ramification was not very materially different from that now exhibited, that in the construction of our tree much must be left to the imagination. Still, as real affinities and geographical relations come to be more carefully studied, and as here and there missing links are discovered, either among geological remains or still lingering in some unexplored region of the globe, we may yet hope gradually to obtain a fair outline of the lost ramifications of our dicotyledonous tree, provided we are always on our guard against the common error of treating plausible conjectures as established facts."

The distinction between appendicular and axial organs, i. e., *between leaves and stems.*—"There is no doctrine better established, no one which has been found practically useful in the history of the life and relations of plant-races as well as of individuals, than that of the homology of appendicular organs as distinguished from the axis—a doctrine originally sketched out by

Linnæus,* poetically conceived by Gœthe, and philosophically worked out by several of the most eminent botanists. Upon this depends the whole system of phyllotaxy; and many an important question of affinity must be decided by a due discrimination of appendicular and directly axial organs or parts. There are, however, cases where such a precise determination has proved difficult or impossible. The leaves of *Pinus*, the outer casing of inferior ovaries, the floral cup of *Myrtaceæ*, some parts of Coniferous flowers above alluded to, the stamens of *Euphorbia*, &c., have led to much controversy as to whether they are axial or appendicular. Amongst other arguments it has been endeavored to decide the question by tracing the development and course of the vessels. It has been found, however, that the main principles of growth and arrangement of the vessels are the same in both, and that in fact no positive line of demarcation in this respect can be drawn between an axial development and a true appendage. It is consequently argued that there is no real difference between a leaf-organ (or appendage) and a branch; and Trècul (Comptes Rendus, 1872, lxxv, 655) goes so far as to propose the suppression of the former term, and call all the parts of a plant branches. To ignore in Nature all classification where no positive limits can be assigned, would be to abolish all method in its study. If we treat all the parts of a plant as physiologically the same, and only give them distinct names according to their functions, we put an end to all study of homologies and affinities, excepting such as are based on the very secondary adaptive characters. If a leaf or a part of a leaf is capable of being occasionally converted into an axis, if the end of an axis may occasionally develop into a definite leaf, if there are a few cases in which the exact point where the swelling of the axis terminates and the leaf-organ commences cannot be fixed, if the differentiation of the axis and its appendages is in many Cryptogams imperfect or null, these are not reasons sufficient for ignoring the real, almost constant, and important differences exhibited by the two classes in phænogamous plants generally.

"At the same time, the demonstration of the susceptibility of ramification of the leaf-organ, which we chiefly owe to French naturalists, is a great point gained. If it takes place in a true vegetative leaf, it results in its conversion into a true bud-bearing axis; if in the floral organs, they may still retain the determinate appendicular character."

We should hardly have regarded Gœthe's morphology as "poetically conceived." It seems to us to have been as soberly, if not as "philosophically worked out" by him as "by several

---

* See "Prolepsis Plantarum," in the Amœnitates Academicæ, ed. Schreb. vi, 324, where Linnæus shows by a number of examples the homology of bud-scales, leaves, bracts, calyxes, petals, stamens, and pistils.

of the most eminent botanists," due allowance being made for the time. While criticizing Trécul, we are not clear that Mr. Bentham has sufficiently considered the writings of Van Tieghem, who claims, perhaps too confidently, that he can draw a positive line of distinction between an axial development and a true appendage.

"*Hermann Mueller's* '*Befruchtung der Blumen durch Insecten*' proves to be just such a repertory and digest of recorded facts supported by original observations as is become absolutely indispensable for the further pursuit of inquiry in this direction. The author is brother to Fritz Mueller, of Desterro in South Brazil, so well known as a judicious and reliable observer, and as a warm supporter of Darwinian theories; and Hermann Mueller himself proves to be an equally persevering and indefatigable collector of facts, having for the present purpose the great advantage of being evidently as well versed in entomology as in botany. It appears also that he has been already assisted by his son Hermann. As far as a hasty glance over the work enables me to judge, the principal general facts here first brought prominently into notice appear to be, the variety of insects which visit the same flowers, the variety of flowers visited by the same insects, and the number of flowers which an insect, deceived by false appearances, visits in search of what is not to be found,—all much greater than had hitherto been supposed.

Besides the methodical record of all the facts he has been able to collect from German, Italian, Swedish, and British literature, H. Mueller commences with a short historical introduction, in which he does full justice to his predecessors, and concludes with some general considerations of a remarkably sober character. He justly criticizes the fanciful flights of Delpino's imagination, to which I have myself alluded in former addresses, and Axell's theory that the development of the fertilizing arrangements in Phanerogams has been always an advance, and still continues to advance, in one and the same direction toward perfection; and, as far as I can see, his own conclusions are none but what are fairly deducible from the facts he records.

"With this book in hand, I cannot but strongly recommend the further pursuit of an inquiry, still in a very early stage, to all naturalists residing in the country, and especially to those who may be located in regions which, like the Mediterranean, the South African, the Southwest Australian, the subtropical and extra-tropical South American, and the Mexican, appear to maintain at once a great variety of locally restricted endemic plant-races, and a great number and variety of flower-seeking insects,—in order that we may ascertain how far these two great supposed facts are confirmed by direct observation, and how far they may mutually have influenced each other."

Art. XXVII.—*Chemical Papers from the Massachusetts Institute of Technology.*—No. II. *The determination of Lead as Peroxide;* by W. C. May.

In the account of Luckow's scheme of analysis of copper ores by means of the galvanic battery, which is given by the officers of the Mansfield Mines,* the behavior of many metals toward the electric current is noticed, and the statement is made that lead is completely precipitated as peroxide on the positive electrode. These authors appear to have considered chiefly the case of a solution previously treated with sulphuric acid, which, consequently, could contain only traces of lead, and I have been unable to find any published account of determinations of lead by this process. The experience in this laboratory confirms the statement of the German authorities; and it has been the custom here, for two years past, in the separation of lead from copper, to precipitate by the battery the small amount of lead which remains in solution after the main portion has been precipitated by sulphuric acid. In order to discover whether this method is serviceable for the estimation of larger quantities of lead, the following experiments were made.

The substance operated upon was brass, the per cent of copper and lead in which were accurately known from a large number of analyses made in this laboratory. Various amounts of proof lead were added in order to increase the quantity of that metal. These were dissolved in nitric acid and diluted with water, so that for one gram of copper about 80 to 100 c.c. of water and 3 c.c. of strong nitric acid were present, in addition to the acid combined with the metals. The metals were precipitated by the galvanic current, the copper upon the negative and the lead upon the positive electrode, using for the former a piece of platinum foil about 2½ to 2 inches; and for the latter a narrow strip of foil, about ⅛ inch wide and long enough to reach to the bottom of the beaker. After the precipitation was complete, the copper was thoroughly washed and was then weighed in the usual manner. The oxide of lead precipitate, I satisfied myself, was virtually insoluble in nitric acid of the strength here used, and therefore deemed it unnecessary to continue the current after the copper had been removed from the solution. All chance of error in this respect might be avoided by connecting a platinum wire with the battery, in place of the negative electrode, and immersing it in the solution. After drying and weighing the copper, the lead

---

* Fresenius Zeitschrift, 1869, p. 1.

which remained upon the positive electrode was gently chafed off, with a rubber-coated glass rod, into a small beaker containing water, and the entire precipitate was collected upon a filter, washed and dried, and then transferred to an accurately weighed porcelain crucible and ignited gently, apart from the filter. This treatment brought the lead to the state of protoxide, in which condition it was weighed. From this weight of protoxide the per cent of lead was calculated. I generally found no trouble in completely removing the peroxide of lead from the foil; should any difficulty be experienced, however, the last traces may be converted to the peroxide upon the platinum itself, by cautious heating; and without, in the least, injuring the foil.

Below are the results of several analyses.

I.

Wt. of copper taken=2·3723	Wt. grms. of lead taken=1·7804 grms.	Total 4·1527
" " found=2·379 "	" " found=1·7791 "	
Per cent " " =57·28	Per cent " " =42·84	
Theory =57·13	Theory =42·87	

II.

Wt. of copper taken=0.3988 grms.	Wt. of lead taken=·3857 grms.	Total ·7845
" " found=·4001 "	" " found=---- "	
Per cent " " =51·00 "	Per cent " " =----	
Theory =50·84	Theory =49·16	

III.

Wt. of copper taken=·4740 grms.	Wt. of lead taken=·0907 grms.	Total ·5647
" " found=·4737 "	" " found=·0895 "	
Per cent " " =83·88	Per cent " " =15·84	
Theory =83·94	Theory =16.06	

IV.

Wt. of copper taken=.5461 grms.	Wt. of lead taken=·0246 grms.	Total ·5707
" " found=·5458 "	" " found=·0240 "	
Per cent " " =95·63	Per cent " " =4·20	
Theory =95·69	Theory =4·31	

V.

Wt. of copper taken=·2201 grms.	Wt. of lead taken=·0260 grms.	Total ·2461
" " found=·2205 "	" " found=·0248 "	
Per cent " " =89·59	Per cent " " =10·07	
Theory =89·44	Theory =10·56	

VI.

Wt. of copper taken=·4666 grms.	Wt. of lead taken=·4109 grms.	Total ·8775
" " found=·4695 "	" " found=·4070 "	
Per cent " " =53.50	Per cent " " =46·38	
Theory =53·17	Theory =46·82	

These results were obtained by the process previously described and under the conditions there detailed, and seem quite satisfactory, especially the first three. The plus error of the copper was probably due to slight oxidation of the metal upon the edges.

In a subsequent analysis I added to the copper and lead solution a solution of iron and potash, which, so far as can be judged by a single determination, exerted an injurious effect upon the precipitation. Further investigation must be made to ascertain this more fully. Following is the result of the analysis in this case.

VII.

Wt. of copper taken=·6153 grms.		Wt. of lead taken=·3252 grms.		Total ·9405
" " found=·6126 "		" " found=·3027 "		
Per cent " "	=65·13	Per cent " "	=32·18	
Theory	=65·42	Theory	=34·58	

Art. XXVIII.—*On the Quartzite, Limestone and associated rocks of the vicinity of Great Barrington, Berkshire Co., Mass.*; by James D. Dana.

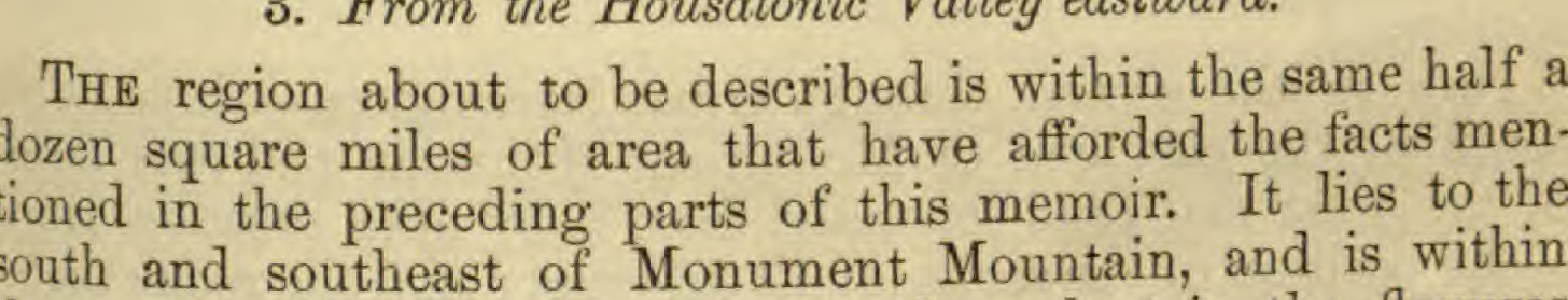
[Continued from page 91, vol. v.]*

3. *From the Housatonic Valley eastward.*

The region about to be described is within the same half a dozen square miles of area that have afforded the facts mentioned in the preceding parts of this memoir. It lies to the south and southeast of Monument Mountain, and is within three miles of it. And yet it is independent in the flexures of its rocks, and exhibits alternations of quartzite, mica schist or gneiss, and limestone beyond what has been elsewhere observed.

It will be remembered that Monument Mountain † crosses the north and south Housatonic region obliquely from northwest to southeast, and that the section along the course of the mountain included on the west a low anticlinal of limestone (l) beneath mica schist (s^1), and then, eastward, in the mountain, a succession of strata of quartzite, (q^1, q^2) and gneiss (s^2, in part mica schist), dipping 20° to 25° to the southeastward, as represented in the annexed section (fig. 8). At the east end there is no change to a westward dip, so as to make the whole a gentle

8.



Section across Housatonic Valley and Monument Mountain.

---

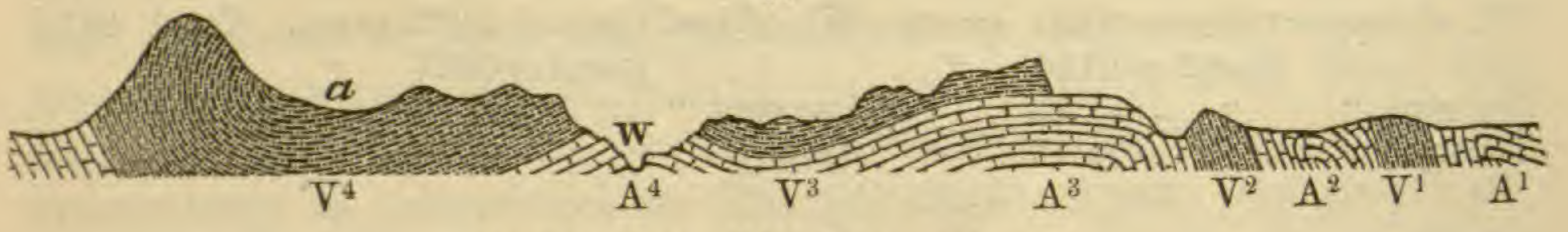
[*] The preceding parts of this Memoir are in vol. iv of this Journal, pp. 362, 450, and vol. v, pp. 47, 84.

† See this Journal, III, iv, 450.

synclinal; instead, the slope continues on and terminates in a fault, as explained beyond.*

While this is the position of the rocks in this Monument Mountain section, there are, but a mile north of the position of the mountain—as shown in the Glendale section—two steep and small synclinals (V^1, V^2, fig. 9) of the same schist and limestone, with intervening anticlinals, the limestone being the prevailing and underlying rock, between whose jaws the schist was pinched up; and, further, these two small synclinals narrow out within a mile to the south against Monument Mt.†—each trough where widest being too narrow to take in much of the overlying schist, and including less and less as it extends southward.

9.



Section from Glendale westward.

Now in the section through Great Barrington,—three miles south of the east end of Monument Mountain and four miles of the west end (and separated from it by open meadow land)—the position of the rocks is still different; and the rocks themselves, although equivalents, are also to some extent different. There is a fault, as in the Monument Mountain section; but instead of a fault at the *east* end of the section, it is near the Housatonic River toward the *west* end (see fig. 10), and east of the fault there extends for three miles a single low synclinal of gneiss, with overlying quartzite at the west end and underlying quartzite at the east: and at the east end there is next—instead of a fault—the beginning of a low anticlinal, whose middle part is occupied by the southern continuation of Muddy Brook Valley, and whose eastern side is a bluff of quartzite overlaid by gneiss, and underlaid by alternations of limestone, gneiss or mica schist and quartzite.

The following are the details with regard to this Great Barrington section.

In my last paper on this subject, in volume v, of this Journal, I give, on page 88 and beyond, some account of the section *west* of Great Barrington, continued eastward through the village to the mountain (East Mountain) bounding the valley on the east, and illustrate it by the following cut (fig. 10). Here the low portion is the position of Great Barrington village, underlaid

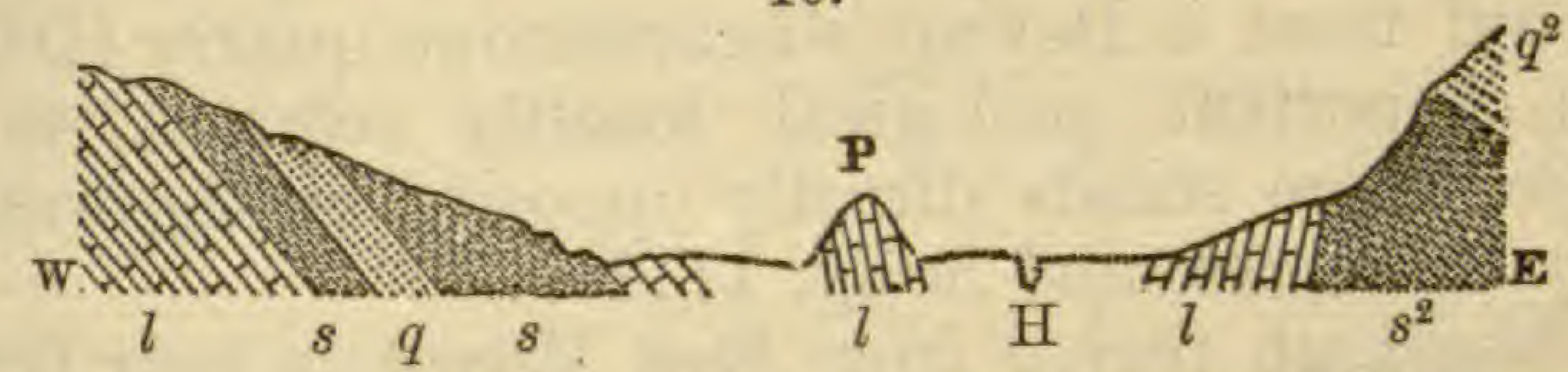
---

* Page 265. The rocks of Monument Mountain owe their preservation as a prominent feature in the region to the cap of hard upper quartzite.

† This Journ., III, v, 48.

by steeply-dipping limestone; the low ridge on the left (west) consists of mica schist (and gneiss) with some intercalated quartzite (q), and, on the west side as well as at top, of the Stockbridge limestone—all conformable to the Great Barrington limestone; the elevation on the east—East Mountain—is made of very firm fine-grained gneiss *unconformable* to the limestone adjoining, with a bed of quartzite at top 100 feet thick. H is the position of the Housatonic River.

10.



Section across the Housatonic Valley through Great Barrington.

Speaking in my former paper of the Great Barrington limestone, I observed that I had been unable to find evidence of its being a continuation, in a fold, of that to the west, and that I therefore supposed it to be a second independent stratum. The importance of settling this point has led to the delay in the publication of this continuation of my memoir. Having been recently over the ground again, I have finally arrived at the conclusion that the ridge of schist west of Great Barrington is actually the course of a synclinal, and that therefore the Great Barrington limestone stratum dips under it and is nothing but the Stockbridge stratum, or the same that covers the great plains of Egremont, Sheffield, Stockbridge, etc. The ridge of schist fades out half a mile south of the center of the village, and has low meadows south of it connecting with those of the river on the east and the limestone plains on the west; and the ridges which rise just south and continue the line southward are all limestone; so that there is no outcropping schist found to the south of it. Again, the connection of the quartzite of this ridge with that of the south end of Tom Ball, explained on pages 87, 88, of vol. v, and the fact that Tom Ball is itself the course of a synclinal, sustains the above conclusion. Hence I now believe that there is in the region no second or upper limestone stratum.

I pass now to the region east of Great Barrington.

The ridge begun in East Mountain (at the east or right end of the preceding section, fig. 10) continues for three miles (with a partial interruption at one place), to Muddy Brook Valley, where stands "Three-mile Ridge" as its terminus. This Three-mile Ridge is in the same line with Monument Mountain and is connected to it by a low ridge, and the whole together forms the west side of the open Muddy Brook Valley, while the much higher Beartown Mountain Ridge forms the east side.

(The map, in volume v, may be consulted for the positions of these points.) The south end of Beartown Mountain stands on a high plateau, 150 feet or more above the level of Muddy Brook; and where this plateau faces Muddy Brook Valley with a bluff front is Devany's hearthstone quarry (D Q on the map), an important geological locality referred to below. Three-mile Ridge stands directly opposite, on the west side of the valley (as represented in fig. 11).*

Along the high region from East Mountain near Great Barrington to Three-mile Ridge on Muddy Brook Valley, the rocks, gneiss and quartzite, form a very shallow synclinal. The dip at the west end of the section (right end of fig. 10) have at first a high dip, or 50° ; but it changes in the course of 30 yards to 40° ; and then a mile beyond becomes nearly horizontal; and in Three-mile Ridge, the low anticlinal which spans Muddy Brook Valley is already begun, its rocks dipping 10° to 15° to the northwestward. The quartzite at the top of East Mountain—a stratified and rather soft quartzite, in some places gneissoid—disappears to the eastward. In Three-mile Ridge the rock above (see fig. 11, left end) is the hard gneiss that prevails to the westward; but the lower part is a very hard, well-characterized quartzite, finely exhibited in the bluff front constituting its foot, but rising to a higher level to the southward. The fact that the formation of quartzite in preference to gneiss, or the reverse, depends only on very small changes in currents or levels is beautifully shown in the bluff; for near the middle of the hard and pure quartzite there is a layer of mica schist ten inches wide which to the southward commences to have a thin center of quartzite, and then, in the course of a hundred feet, is changed wholly to hard quartzite, while in the opposite direction (northward) it retains its mica schist character, but narrows gradually to six inches before passing under cover of the soil.

The rocks in the low synclinal between Three-mile Ridge and Great Barrington are then (1) the lower quartzite, q^1, of Monument Mountain (fig. 8), at the bottom of the front of Three-mile Ridge (fig. 11); (2) the gneiss, s^2 (of the same section), overlying this quartzite and making the mass of the high land; and (3) the upper quartzite, q^2, at the top of East Mountain at the west end of the section.

Three-mile Ridge, as I have said, and as the section in fig. 11 shows,† fronts on the limestone valley of Muddy Brook; and across, and directly opposite, is Devany's quartzite bluff, Q.

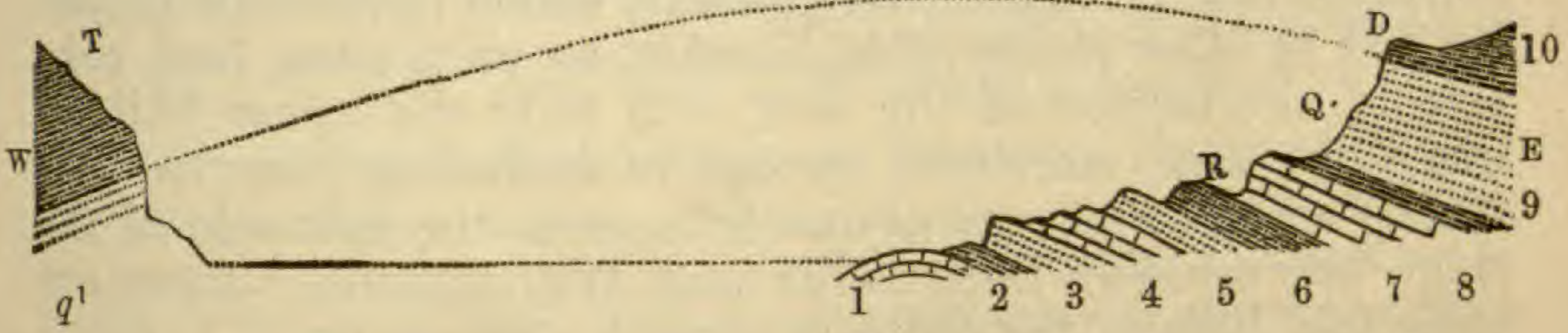
---

* Muddy Brook has its head just north of this point; but the broad valley continues on southward, and becomes the valley of the Konkapot, and at the same time expands eastward, over the lake region of Monterey.

† The diagram here given, to be true to nature, should have the dotted line representing the meadow land of the valley doubled in length.

In this bluff, and in the fields adjoining the road (R in figure) just south and southeast of it, there occur the alternations of limestone, quartzite and mica schist or gneiss, already alluded to. This interesting place—about four miles east of Great Barrington village—was made known to the writer by Mr. R. P. Stevens, of New York, who, many years since, studied the alternations of the rocks and made a section of the region.

11.



The succession is as follows, commencing below, or in the field to the south of the road (R).

1. White granular limestone—that of the valley.
2. Mica schist, a thin bed.
3. Hard jointed QUARTZITE, 30 feet.
4. Same, limestone, 60 feet.
5. QUARTZITE, like the lower, 20 feet.
6. Gneiss, 30 feet.
7. (North of the road, R) bluish granular limestone, crumbling.
8. Mica schist, 6 to 8 feet.
9. QUARTZITE, 100 feet (Devany's quarry).
10. Gneiss (overlying the quartzite at the quarry).

The dip of the beds south of the road (R) is 30° to 35° to the eastward, the strike being N. 10°–30° E. But at the quarry, which is two hundred yards to the eastward, the dip is 20° to 30° to the northeastward. The change of strike and other facts, including the northwestward dip in Three-mile Ridge, show that the low anticlinal opens widely to the south:—the axis being inclined to the northward.

The alternations of quartzite and schist evince the little genetic importance of the distinction between quartzite and schist in Berkshire; and the intercalations of beds of limestone indicate that the conditions for sand or mud accumulations intermitted with those favorable for the shells or corals, or other material, fitted for limestone-making; and hence, that the area of sand depositions changed easily to an area of mud depositions, or of clear waters and abundant life. The lower of the quartzite beds (No. 3 in the section above) has but little lateral extent; for only a hundred yards off in the direction of the strike there is nothing but limestone. The old seas were hence much like modern ones in the irregularities of the bottom and in the outlining of sand-banks.

The thickness of the beds of quartzite and gneiss (or mica schist) between the lower schist (No. 2) and the upper (No. 10) taken together, is very near that of the lower quartzite (q^1) at the west end of the Monument Mountain section (fig. 8), and corresponds to it. Thus that quartzite which is there all quartzite, and in other places all mica schist or mica slate, here consists of alternations of the two, with only the upper half all quartzite; and, moreover, instead of including near its base merely a bed of calcareous quartzite, as in the west side of the ridge between Van Deusenville and Williamsville* there are three thin beds of the ordinary granular limestone.

Devany's Bluff has been stated to be the front of the plateau on which the south end of Bear Mountain stands. Going eastward a mile and a half, and then rising by a rough and steep road to the top of this plateau, the dip of the upper gneiss becomes northwestward, and the limestone formation outcrops on the plateau from beneath it and is the surface rock to the eastward over a large region.

Turning northwestward toward Beartown Mountain, the overlying gneiss is again reached; and the very small dip, 10° to 20°, and that to the northward, together with other observations in the region adjoining, show that the rocks in the southern end of Beartown Mountain, which are all nearly horizontal in position, constitute a shallow synclinal. Hence, east of the low anticlinal spanning Muddy Brook Valley, a little to the north of its line, there is a shallow synclinal like that west of it.

But Beartown Mountain, while having nearly horizontal rocks at its south end, has its beds very steeply upturned to the north, and hence in that direction it is a *deep* synclinal. It is hence like Tom Ball* in being a shallow synclinal at one end and a deep at the other, but the shallow is at the opposite extremity—the south.

The rocks of the mountain all overlie the Stockbridge limestone. They are mainly varieties of firm and well characterized gneiss. Fissile dark-gray gneiss, approaching mica schist, and a firm less schistose variety of similar color, are common. But these vary on one side to a white feldspathic gneiss containing a little black mica, in short interrupted lines; and on the other side to a quartzose variety, which on weathering becomes at surface in appearance a curiously pitted quartzite. Again, the gray gneiss at the north end is an exceedingly firm gnarled rock, owing to the contortions experienced in the period of bold upturning and metamorphism. South of the railroad half a mile west of South Lee, immense blocks of this gnarled gneiss lie like ruins on the slope of the adjoining ridge.

---

* This Journ., III, v, 85.

In some places in Beartown Mountain there are hornblendic layers; and at one ascent of the mountain made from the west side, about midway between the north and south extremities, I found, near the top, a dark-gray, fine-grained layer, exceedingly tough, consisting largely of quartz and massive garnet. In a spur just east of the south end I observed in the gray gneiss a seam three-fourths of an inch wide of magnetite.*

I have stated that the rocks of Beartown Mountain overlie the Stockbridge limestone. Precisely the same kinds of gray, white, and quartzitic gneiss I found constituting the first ridge south of the road that leads up the valley to Washington from near Lenox Furnace. The Stockbridge limestone makes the base of the ridge and outcrops at its western foot; and the marble quarries of Lee are the same stratum two miles to the southwest.

Leaving now the region of the preceding section and Beartown Mountain, we may go west to the low north-northwest and south-southeast ridge that extends from Three-mile Ridge north to the south end of Monument Mountain, and follow the ridge northward.

First, at the notch where the road from Great Barrington passes through Three-mile Ridge, the gneiss is nearly horizontal, with a slight dip, where distinct, to the westward, as in Three-mile Ridge just to the south.

A mile and a half to the north of the notch, a rocky bluff faces Muddy Brook Valley, the rock of which, a hard gneiss, dips westward 10° to 15°. For the rest of the way north to Monument Mountain the ridge is mostly under soil; and along the western slope all is earth-covered. Toward the base of the western slope there are immense numbers of quartzite masses which seem to indicate the presence of a layer of quartzite beneath. As the few dips observed correspond with that in Three-mile Mountain, the ridge is probably, like that, the course of a shallow synclinal, but a narrow one.

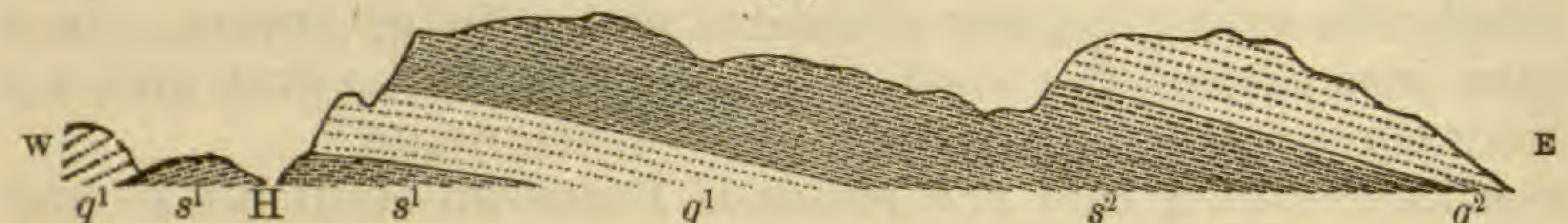
Reaching the notch along which the Stockbridge road passes the south end of Monument Mountain (near the east or right end

---

* I speak, p. 262, of "rising by a rough and steep road to the top of this plateau." Near the point there reached, in the limestone area north and west of the road, I found a loose mass of white limestone consisting mainly of what appears to be rhodophyllite (rose-colored pyrosclerite), but containing also yellow chondrodite in grains; and, later, another smaller loose mass consisting of quartz and dark-green crystallized chlorite, along with large imperfect crystals of a remarkably beautiful rose-colored sphene. Since the first discovery I have been twice over the region in order to find the original site of these specimens, but without success. They suggest the suspicion that there may be an outcrop of Archæan (Laurentian) rocks in the vicinity. But in three ascents of Beartown Mountain, and an excursion along its whole western side, no evidence of any was met with. They may be of drift transportation. Until the minerals are found there in place, I forbear to draw the conclusion—seemingly the most probable—that they are from the rocks of the region.

of the annexed section, fig. 13), there is an exhibition of quartzite under its various contradictory phases. In the first place, on the Monument Mountain side of the road, stands out in some places the intensely hard and enduring quartzite of the mountain, having joints, as usual, but only fallacious signs of stratification. On the opposite side, the rock, when any in place is seen, is also quartzite; but, unlike the mountain kind near by, it is, in the first place, very distinctly stratified; and, in the second, part is so soft or unenduring that much of it has fallen to loose dirty sand. Thin layers of a hard cellular quartzite often stick out from the sand, showing that there are strange alternations in the rock. What is stranger yet, there are also isolated portions, some 10 to 20 feet across, that are intensely hard quartzite, without a trace of lamination, except in some parts of the contour—the layers of which they originally consisted having been locally solidified into the hard massive structureless rock. But for evidences of transition in some parts of their contour these masses might be taken for transported boulders. The dip of the layers of this soft quartzite is 30° to 35° to the eastward, and the strike N. 5° to 20° E.

13.



Section across Housatonic Valley and Monument Mountain.

At one place, 200 yards to the north of the other outcrops, this soft quartzite occurs on the *west* side of the road with the dip reversed or to the westward, the amount 15° to 20°, and with the strike N. 20° W.; and here also there are immense boulder-like masses lying alongside of the crumbling kind, or seemingly imbedded in the soft quartzite. Such a quartzite easily changes to earth and thus makes a region of pseudo-boulders; and this suggests the true explanation, as I think, for the boulders on the west side of the ridge south of Monument Mountain, and shows that all quartzite boulders elsewhere are not drift boulders.

This soft, bedded, rotting quartzite at one place is exposed within forty feet of the massive enduring Monument Mountain quartzite, and with nearly the same dip, the latter not relenting in the slightest as it approaches the former. Are the two, notwithstanding the abrupt transition in texture, parts of the same layer? This is possible. Along the path descending northward from the eastern quartzite summit of Monument Mountain, the quartzite, elsewhere of extreme hardness, is for some yards thin bedded and rather fragile; showing a rapid falling off toward the soft variety. Again, on the south and west parts of the mountain, the same bedded variety in some places occurs. Still, in each of these cases the passage is rather gradual and not absolutely abrupt, as here on the Stockbridge road.

In view of all the facts, it seems most probable that the soft quartzite at this place is really that of the lower quartzite stratum (q^1), and therefore that there is a fault near this east side of the mountain, along which the lower quartzite is brought up to a level with the upper quartzite (q^2). This conclusion is favored by the fact that a mile farther to the north, if not here, a fault actually exists east of the vertical eastern front of Monument Mountain; for the limestone of Muddy Brook Valley outcropping within 200 yards of the foot of the precipice (at *q*, on the map in vol. v), has a nearly vertical dip (75° to 80° to the eastward), although the eastward dip of the beds of the mountain is only 15° to 25°—the strike being N. 15° W. Moreover the stratification of the limestone is mostly indistinct owing to the soldering together of the layers in consequence of the lateral pressure attending metamorphism. The evidence proves at least that there exists here either a fault or a very abrupt synclinal.

The limestone at this outcrop is the Stockbridge stratum; it outcrops at several points along the way to Stockbridge and Glendale; and it is consequently the same stratum that is seen descending under Monument Mountain at its west end near Housatonic village.

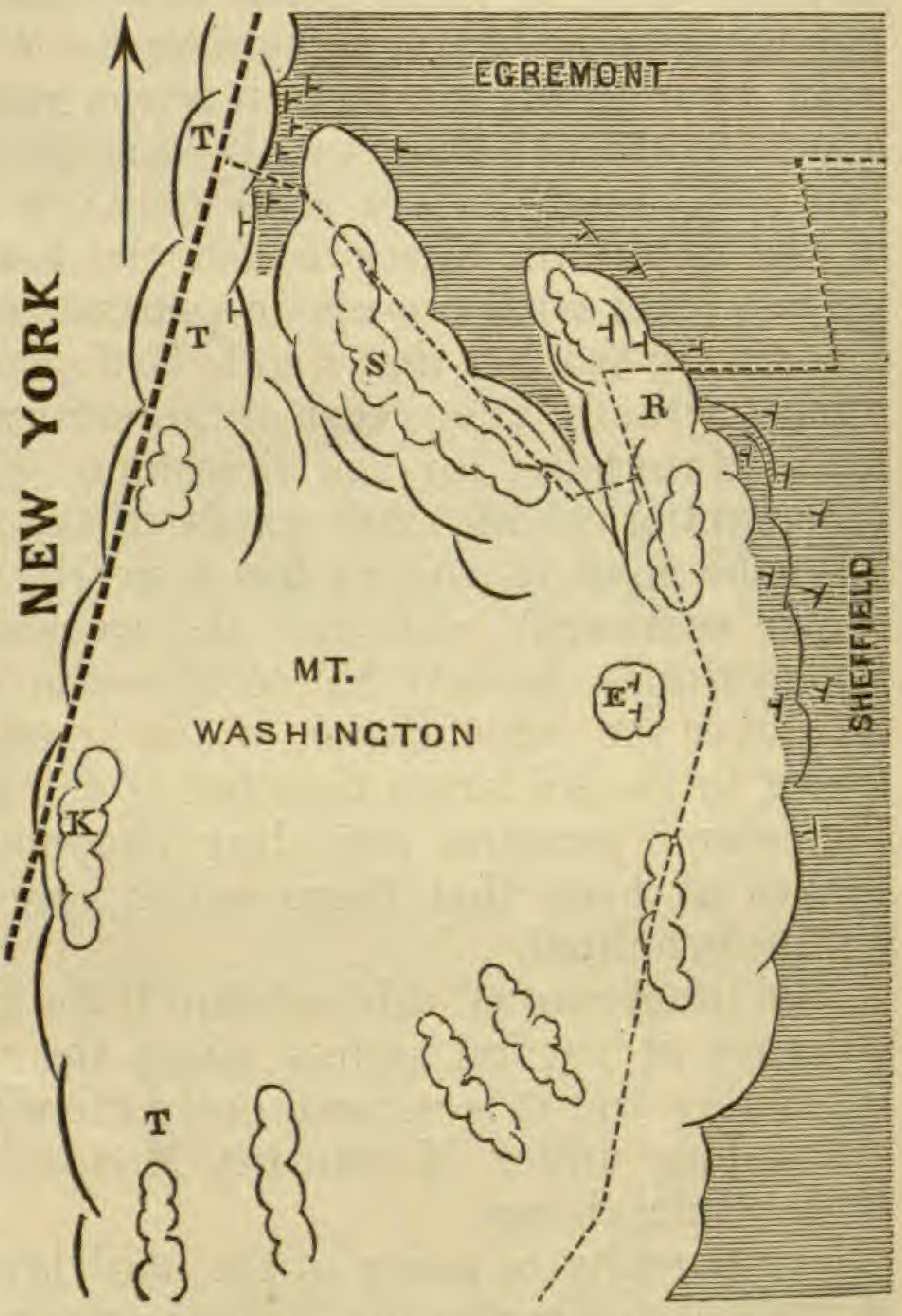
The porosity of many of the hard layers in the soft quartzite is probably owing to the former presence of disseminated carbonate of lime; and the ready disintegration of the other layers may be due to the same fact. Yet the soft quartzite crumbles in other localities without such a cause. The thin-bedded porous quartzite often has on its surfaces minute brown tourmalines.

4. *Observations outside of the Great Barrington Region.*

a. *Mt. Washington and Western Sheffield.*

Mount Washington is a mountain plateau, situated in Southeastern Massachusetts, with its western side in New York and southern in Connecticut. It is about 2,000 feet in elevation above tide level, and four to five miles across at top. Its western side stands in the line of the Taconic Range; but the mass of it projects to the eastward, and is almost wholly within the State of Massachusetts. Mount Everett, the highest point,—2,634 feet high, according to the Massachusetts triangulation,—is on the eastern border. It has the limestone plains of Sheffield on the east, and those of Egremont on the north.

This projection of the mass from the east side of the Taconic Range is shown in the accompanying outline map of the region.



T T is the course of the Taconic Mountains, situated along the boundary between N. York and Massachusetts; while E, more than three miles east of the boundary, is the position of Mount Everett. The part lined over is the limestone region lying to the north and east and covering a portion of the eastern foot of the mountain.

R and S are two ridges extending from the plateau northward into Egremont. The limestone reaches into the intermediate valleys, even into the narrow western, between S and T (the one by which the carriage road leads to the summit of the plateau on the way to Mt. Everett, or to Copake).

The rock of the mountain, and also of the ridges R, S, T, is a fine-grained mica slate approaching (if not really) hydromica slate, and much of it is chloritic. It is the same that constitutes Tom Ball near Williamsville, west of Housatonic, and various ridges of the Taconic Range; at the summit of Mt. Everett it is much seamed with quartz.

Mount Washington is a synclinal with limestone below and slate above. In the plains of Sheffield, near the eastern foot of the mountain, there are two parallel north-and-south roads nearly a mile apart. Along the more eastern the limestone has its usual easterly dip—the amount 35° to 45°. But along the western—the under-mountain road—the dip is *to the west* 25° to 30°, with the strike N. to N. 25° E. (compass course). The limestone extends up the slope of the mountain for 100 to 120 feet above the road (by estimate, 700 feet above the sea level), and retains throughout its westerly dip; and then there follows the overlying slate of the mountain, with the same dip. This plunge of the limestone westward under the slates of Mount Washington may be traced along for four to five miles, even to the north extremity of the ridge R; and it characterizes also the high eastern summit, Mt. Everett, where the westward dip is 35° to 60°. East of the extremity of the ridge R, the strike of the limestone has some westing, becoming first N. 15° W., and then N. 30° W., and the last is the strike just north of it.

The limestone thus dipping under the mountain does not emerge short of the region of Copake in New York, and consequently the Copake and Sheffield limestones are the same stratum—both, the Stockbridge limestone; and the limestone stratum, therefore, makes a synclinal.

But the slates of the ridge S, and also those of the Taconic Range, T T, dip *eastward* 45° to 70°.

Moreover, the limestone of Egremont west of the ridge R takes the steep easterly dip of the ridge S, and the same also is the dip of the extension of it up the valley between S and T, where there are fine exhibitions of the conformability of the slate and limestone—the dip being there 60° to 70° and the strike nearly north and south.

We find thus evidence of a very broad synclinal across the center of Mount Washington. But just north, in Egremont, the structure is totally different; the ridges S and T are the courses of very steep and comparatively narrow independent synclinals, with the axial plane inclined eastward.

We learn then that the trough or synclinal, in the formation of which was involved the making of the mass of Mount Washington, commenced three times farther east than that for the Taconic Range to the north of it; and that thus the mass of enclosed slate is more than three times as wide, and hence it happened that the mountain there made was a lofty one. The lateral pressure, from the eastward, beginning the downward trend a mile east of the foot of Mount Washington, made a trough whose bottom on the east inclines westward at a comparatively small angle, as shown not only in the slates seen near the eastern foot but also in those of Mt. Everett; but over the corresponding region just north, in Egremont, the displacements were small and no mountain synclinal was begun until near the site of the Taconic Mountains; and there the whole force acted on a relatively narrow trough, making it of great depth, and pressing it over until its axial plane, like all the slate rocks enclosed, dipped eastward 50° to 70°. Then, quite near Mount Washington, the second synclinal, S, was made with the same steep inclination. The synclinals S and T become merged in one mass, in Mount Washington; and as the limestone does not appear at the summit, the intermediate anticlinal in the mountain was only an anticlinal of slate. In other words, the synclinal of limestone beneath the mass of the mountain was one great trough with breaks and incipient flexures; while to the north these incipient flexures became two defined synclinals, with the intermediate anticlinal — the synclinals being the courses of the ridges S and T, and the anticlinal that of the limestone outcropping between; and then, farther north there was formed the Taconic synclinal T alone. West of Southern Alford the Taconic slate and limestone have the same steep eastward dip.*

It is to be noted that a limestone as soon as made is as hard and unyielding as at any time afterward. It is hence far more resistant to flexure than the slates. This will account for changes in the flexures within short distances. The limestone of Sheffield and Egremont generally dips eastward at an angle as high as 35°, showing universal displacements; but where are its faults and folds it is for the most part difficult to discover.

The Taconic Mountains hence consist of no older rocks than Monument Mountain, or Tom Ball, and the multitudes of other heights in Berkshire, which are made of strata overlying the Stockbridge limestone. Further, the gray, white and quartzitic gneiss of Beartown Mountain, and the mica schist and quartzite of Monument Mountain, are strict equivalents of the chloritic mica slate of Tom Ball, Mount Washington, and the Taconic Range. It will be remembered that Tom Ball is only two miles from Monument Mountain, and but one from a ridge of the quartzite.

If then the Stockbridge limestone is of the age of the Chazy and Trenton, the *Taconic slates* may be reasonably set down as of the Hudson River or Cincinnati group.

To the eastward of Mount Washington, and half to three quarters of a mile west of the village of Sheffield, there are two narrow ridges of mica schist, each about half a mile long, standing surrounded by limestone. The western, called Bear's Den Ridge (from a deep gorge in its west side), is about 150 feet high, above the plain around; and the other, Barnard's Ridge (so named after President and General Barnard, whose paternal residence is near by), about 120 feet. The schist at Bear's Den and the limestone adjoining dip 60° to the eastward. The western side of the ridge is limestone, and the wearing away of the limestone at the junction has made the gorge, while the tumbling of great masses of the schist has contributed greatly to the wildness and beauty of the place. Each of these ridges is a local synclinal of limestone and schist; the trough of limestone was small, and hence it pinched in but little of the overlying schist. The layer of the schist folded together in the synclinal was probably not over 80 yards thick,

---

* This Journal, III, v, 86, 91.

making the whole thickness of the schist between the jaws of limestone about 160 yards. The schist involved in the synclinal is but a very small part of the great formation that overlay the whole limestone region when the folding began; for the thickness in Mt. Washington, between the top of Mt. Everett and the underlying limestone, is not far from 1000 yards, and this is what is left after ages of denudation.

The mica schist of Bear's Den is a coarse kind, full of translucent garnets a tenth of an inch in diameter, and *some layers abound in dark brown slightly translucent crystals of staurolite.* The staurolite crystals have the planes *O*, *I*, 1-ī, and the garnets are dodecahedrons with the edges deeply truncated.

In the limestone of West Sheffield, two miles east of Mt. Washington, an opening has been made by Mr. Ralph Little of Sheffield, which has afforded some copper pyrites, with traces of galena and blende, and also rutile in crystals one to two or three inches long and an eighth to a fourth of an inch broad.

b. *Canaan, Connecticut.*

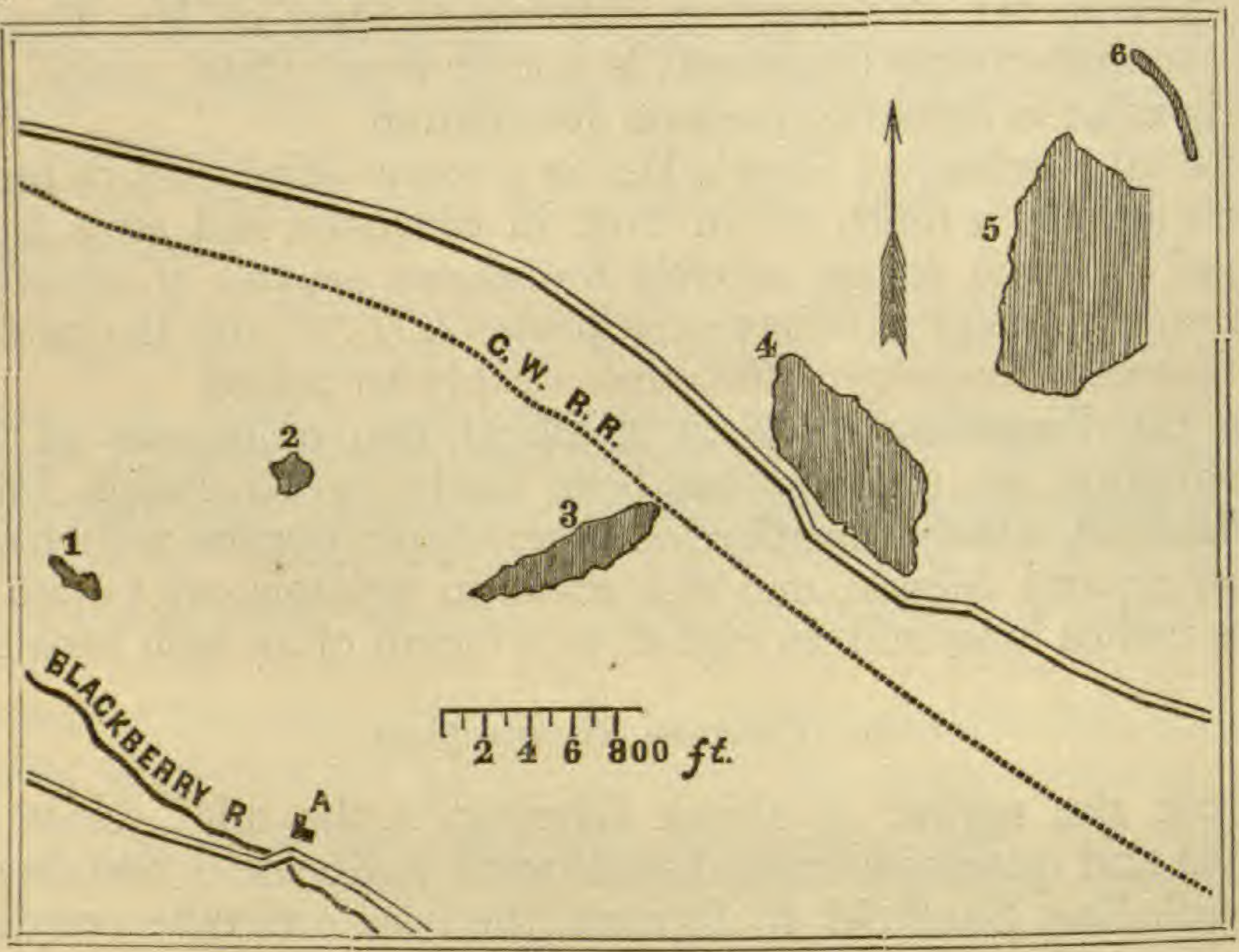
From the region of Great Barrington, the mica schist (or gneiss) and quartzite extend southward to Sheffield, and thence through East Sheffield to Canaan, the hard quartzite constituting long ridges the latter part of the way. At the same time, the great limestone formation of Great Barrington and Egremont stretches south to the same town, with undiminished breadth; there is hence no doubt that Canaan and Great Barrington are within the same geological region.

The patches of quartzite at Canaan, taken by themselves, or even with outcrops of some other localities, suggest strongly and enforce the conclusion presented in my former paper;* for the isolation of the areas with limestone around, the absence of stratification, and the apparent uncomformability and independence, are as I have stated. But, in view of the later observations—that the hard jointed quartzite may pass in the course of a few rods into soft friable quartzite; that it may graduate almost as abruptly into mica schist or mica slate, either firm or decomposable; that the hardest and most massive kind may directly overlie the crystalline limestone, or even be interstratified with it, as well as with the mica schist or gneiss, and the latter not participate in the system of joints that pervade the other; that small beds of quartzite may lie isolated in the upper part of the limestone formation; that consequently, the qualities, thick or thin, of wide or narrow extent, mean nothing, as applied to the hard quartzite—the facts are not at all adverse to the views gathered from the Great Barrington region.

---

* This Journal, III, iii, 179.

The only place in the outcrops of quartzite near Canaan, where the stratification is distinct, is in the northeastern of the patches, Nos. 5 and 6. (I reproduce here the map of the region, prepared for me by Mr. Adam.) I still find, on a re-examination of the region, the uncomformability of strike between the quartzite of No. 6 and the limestone outcrops but a few rods distant strongly marked; and, moreover, directly in its line of strike, but a hundred yards off, there is nothing but limestone. Still, there is much variation in the strike of the quartzite itself, the angle being N. 60°–65° W. at the northwest end, N. 45° W. at the middle, and N. 30° W. at the south end; and much also in that of the limestone at its parallel outcrops 20 to 25 yards to the westward, that to the northwestward being N. 80° W. and N. 70° W.; while only 12 yards west of the southeast end of the quartzite, the dip of the limestone is N. 35° W. Now, noting, in connection, that limestone uplifts are very irregular in their strikes, and also the fact that to the eye, from a little distance, without the use of an instrument, there is apparently a general conformity in the dip of the quartzite and limestone, we may conclude that the limestone does dip conformably beneath the quartzite (No. 6). The fact that there is only limestone to the northwest, in the line of the strike of the quartzite, is proof that the bed is one of small lateral extent, like one observed near Devany's quarry,[*] or that there is a fault. Seventy-five yards farther to the northeast, the limestone outcrops again, with the strike N. 53° W., and dip to the northeastward as in the other



---

[*] No. 3, page 261.

cases, as if it were a bed overlying quartzite No. 6; and this it is, unless there is a fault between the two. The quartzite of patches Nos. 5 and 6, having the dip in opposite directions, may be parts of one bent layer; for the thinness of the bed No. 6 may be only the thinness of the *hard part* of the bed, a soft upper portion having been removed. Hence, while my previous deductions are sustained by Canaan facts, they are wrong only because facts elsewhere observed have proved that the quartzite has no fixed qualities, and is hence the most deceptive of rocks.

Rattlesnake Hill, just north of Canaan, while consisting mainly of a decomposable arenaceous mica schist, has below a stratum of soft quartzite over the limestone. Canaan Mountain, a very prominent feature in the topography of the town of Canaan, rises from the plain half a mile or so south of the above quartzite outcrops, and *stands on a high base of limestone*, outcrops of which are best displayed on the southwest side. The rock of the mountain, over the limestone, four hundred feet or more in thickness, is mainly coarse and fine mica schist, passing into gneiss. I have not found any quartzite stratum, but it is possible that the soft kind may be concealed beneath the high grassy slope of the north side. *Canaanite*, or white augite rock,[*] occurs in many places in the upper part of the underlying limestone.[†]

c. *South Canaan and Falls Village.*

The village of South Canaan is situated to the south of Canaan Mountain, and two miles east of the Housatonic River, where is Falls Village and the railroad station. A few rods to the southeast of the South Canaan Church, there stands what may be called a spur of Canaan Mountain, named Cobble Hill. This hill consists below, to the west, of quartzite, dipping southeastward 40° (strike about northeast). Above the quartzite, 20 to 25 feet of which are exposed above the road, there is a stratum of mica schist and thin-layered gneiss, containing scales of both black and white mica; and above this, and constituting the body of the hill, there is a whitish granite-like gneiss, great blocks of which lie at the foot of the bluff adjoining the road. The quartzite is mostly the soft

---

[*] Both tremolite and white augite occur in the Canaan region. The Canaanite is a massive form of the latter, as first observed by Prof. C. U. Shepard, in his Report on the Geological Survey of Connecticut, 8vo, 1837, p. 135.

[†] In the observations on the rocks at Poughquag (this Journal, III, iii, 255) it is stated that the quartzite and the limestone at outcrops 200 yards apart are unconformable. It is quite possible that within this 200 yards, where the rocks were concealed from view, there is a bend in the limestone, bringing it into conformity of dip with the nearly horizontal quartzite, and that thus it may pass conformably beneath the latter rock; and facts elsewhere observed render this most probable.

bedded kind, and in its upper part it contains, at intervals, some streaks of black and white mica, thus showing its relations to the overlying schist. The dip of the rocks conform to that of the limestone not far distant, and there is no reason to doubt that the quartzite, with the other crystalline rocks, overlie conformably the limestone.

At Falls Village, the limestone outcrops above the river at the falls and over the plains adjoining. Just above the falls, on the west side, there is an outcrop of well characterized mica schist; and half a mile to the northwest the schist forms a ridge, with limestone outcropping in its lower slopes from beneath the schist, both rocks having a dip of but 15° to 20°. The mica schist contains small garnets, and some of its layers *abound in crystals of staurolite.* This locality of staurolite was mentioned to me by Dr. Stephen Reed, of Pittsfield, as well as that at Bear's Den in Sheffield.

d. *Rutland, Vermont, and Graylock in Northwestern Massachusetts.*

Vicinity of Rutland.—I have not attempted to give the Rutland region a careful study, but have made some observations of interest bearing on the relations of the same to that of Great Barrington.

On the eastern border of the Rutland limestone, just east of the road from Rutland to Mendon, there is a portion of that long Vermont range of quartzite, which is marked on the geological map of Vermont as extending from the Massachusetts boundary to a point just north of Mendon, sixty miles, and thence, after a brief interruption, to Rockville, nearly forty miles beyond. This so-called "quartzite" ridge consists, near Rutland, of chlorite slate containing magnetite, and hydromica slate (the so-called talcose slate or talcoid schist), along with quartzite; and, as has been stated (this Journal, III, iv, 69), the hydromica slate graduates laterally by rather abrupt transitions into the quartzite, the same bed being quartzite in one place and hydromica slate 100 yards off. Part of the quartzite looks like gneiss, owing to streaks of silvery mica (hydrous mica?) in largish scales. Another part is a coarse conglomerate.

The rocks in the Rutland ridge, excepting the massive quartzite, are well stratified, and have a dip to the eastward corresponding with that of the Rutland limestone and apparently lying over it. I found no vertical section of quartzite and limestone near Rutland, showing positively that the quartzite with the hydromica and chlorite slates were uppermost. But the dip of the rocks at the nearest outcrops was the same with the limestone; and at one outcrop of the limestone, the upper layer was covered above with a coating of quartzite, confirming the conclusion that the quartzite is the superior rock.

It will be observed that the variations from hard to softer quartzite, and from quartzite to metamorphic schists, are similar to those observed in Berkshire. East of Brandon, a mile or two beyond the limonite, lignite and kaolin bed of "Forestdale," I visited another part of this Vermont quartzite range. There the rock is of the hard jointed kind. But the bedding is in some places distinct, and in a few layers there are slaty portions.*

Graylock.—Graylock, standing between South Adams and Williamstown, in Northwestern Massachusetts, 3600 feet above tide level, while Taconic in system and in the character of its rocks, belongs to a parallel line of elevations about six miles east of the Taconic Ridge. In structure and origin it is closely like Mt. Washington. This is shown as far as relates to the existence of the synclinal, in the section of it published by Prof. Emmons, at page 19 of his American Geology (8vo, 1853), the general truth of which I have verified.

This section commences at South Adams, and terminates at the entrance to the great funnel-shaped valley called the Hopper, where the limestone stratum dips *eastward* under the mountain. The dip of the slates at the summit of Graylock and to the west of it is steep to the eastward.

At the narrow north end of the Graylock range of elevations, abreast of North Adams (5½ miles north of South Adams), the limestone and slate *both dip eastward*, just as with the Taconic ridge in Egremont north of Mt. Washington; and the explanation is, I believe, the same: that the broad synclinal which holds the broad and lofty mountain, is at this place pressed to a steep and narrow synclinal with the axial plane inclined eastward. The very large and deep mountain-girt depression called the Hopper, north and south in trend, suggests strongly the view that two synclinals with an intermediate anticlinal exist in the slates of the broader part of the mountain mass, and that the existence of the Hopper was determined by the position of the anticlinal; while the limestone synclinal may have been a nearly simple one beneath the slates. My own observations over the region have been too limited to make this more than a suggestion.

---

* The Geological Report of Vermont makes the quartzite east of Brandon to extend west over two miles of country which is without outcropping rock and deep in earth, to the bed of limonite and kaolin at "Forestdale." But the kaolin has come from the decomposition of feldspar; and it is probable that a decomposable mica or hydromica schist underlies the earth-covered interval referred to, and that its feldspar was the origin of the kaolin.

CONCLUSIONS.

I close with the following conclusions as a sequel to those mentioned on former pages of this memoir.

XIII. *Lithological evidence as a test of Geological age.*—It is above shown that the mica schist overlying the Canaan limestone is in Sheffield and Canaan *staurolitic*. *The mineral staurolite exists, therefore, in rocks younger than the Stockbridge limestone.*

But the facts which have been presented, besides opposing the idea that staurolite is a satisfactory mark of age, also show that lithological evidence should be used with extreme caution even within a district of a few square miles. For in a distance of three miles or less, a stratum of quartzite has been found to become one of mica schist, or of gneiss, or of mica slate, garnetiferous or not, or of hydromica slate, or of chloritic mica slate, or chlorite slate containing magnetite or not; and in another locality, in the course of two miles, the quartzite stratum changes to a coarse staurolitic mica schist, full of garnets; and in another, mica schist is replaced by a granitoid gneiss. Had I known these facts when I commenced my investigations in Green Mountain geology, I should have had much less difficulty in reaching right conclusions. It is hence evident that, in the present state of the science, we should beware of all conclusions as to the age of metamorphic rocks that rest on lithological evidence alone, whether they relate to præ-Silurian or subsequent time. When every square mile of New England has been investigated *stratigraphically* with thoroughness, we shall begin to know something of its geology.

It should be understood that tracing a formation along from mile to mile by means of the rocks, *after an understanding of their characters and transitions*, is a very different thing from deducing the age of rocks on the principle that a particular kind belongs to a particular age in geological history.

It follows from the facts reviewed, as stated in an early part of this memoir, *that there is not strictly any quartzite formation in the Green Mountains; the formation being made up of various rocks, and quartzite being not always the predominant one.*

XIV. *Age of the Stockbridge Limestone.*—This mass of limestone, as I know from personal study, extends continuously from Pittsfield to Canaan.* Beyond Canaan it stretches on, as shown by Percival, to a point south of Pawling in Dutchess Co., New York—making for the total from Pittsfield southward a length for the formation of 70 miles. To the north of Pittsfield, I have examined the limestone only at isolated points. At these I have found no reason to doubt the conclusions of the geologists of Massachusetts, Vermont and Canada, that the

---

* The one interval not examined when page 52 of volume v was printed, I have recently been over.

rock, all the way to Rutland 80 miles from Pittsfield, and 20 miles beyond, is the same limestone. The evidence consists not only in the apparent continuation and similarity of the limestone throughout, but in the fact that with very small interruptions the quartzite continues to accompany the limestone, especially along its eastern border, just as in Berkshire, and that it undergoes the same transitions to mica schist, mica slate or hydromica slate, along its course; and, further, that the mica slate accompanying the limestone, especially along its western border, is very similar throughout. That the evidence should be conclusive, the actual continuation of the limestone through, from Pittsfield northward, should be ascertained, and also the stratigraphical relations of the quartzite to the adjoining limestone. What is now known is sufficient to render the conclusion exceedingly probable. If so, the age of the limestone at Rutland and other parts of Vermont is approximately that of the rock in Berkshire and farther south.

I have referred to the facts with regard to Chazy fossils found in the Rutland limestone by the Rev. A. Wing. As the facts are of the highest importance, the paragraphs may be here cited. (This Journal, vol. iv, 133, 1872.) Mr. Billings says—

> I received last summer some fossils from Rev. A. Wing, and made the following note upon them before I sent them back.
>
> 15th June, 1871, from the Rev. A. Wing, twenty specimens with the following ticket: "Encrinites and obscure fossils, supposed to be Trenton, collected May, 1870, at the marble quarries, West Rutland, not one hundred yards northwest of an abandoned marble quarry,—the most northern one worked on the southwest side of the valley, say one hundred and fifty rods southwest from Barns' hotel, West Rutland."
>
> This is the description of the locality given by Mr. Wing. My note on the fossils in the book I keep for such purpose is—
>
> "These consist of numerous obscurely preserved forms like *Pleurotomaria staminea*, small *encrinal joints*, and a single plate of *Palæocystites tenuiradiatus*. I think this collection is Chazy. The rock is a gray fragile limestone with white crystalline seams in it."
>
> If Hitchcock's Eolian is Stockbridge limestone, then the latter includes the Chazy. The plate of the Cystidean, *P. tenuiradiatus* Hall, is a never-failing guide to the Chazy; at least it is so on the west side of Lake Champlain.

That all the facts may be before the reader, I quote a page (pp. 418, 419) from the Vermont Geological Report on other fossils from the same limestone.

> Although the Eolian limestone is largely distributed in our country, no fossils have been found in it, except the few which occur in Vermont. We have found the following genera, to which specific names cannot yet be attached: *Euomphalus*, *Zaphrentis*,

Stromatopora, *Chætetes* and *Stictopora*. Two kinds of encrinal plates have also been discovered. These genera were determined by Prof. James Hall.

Euomphalus. This is a genus of univalve mollusks, somewhat resembling Maclurea and Ophileta. It is most common in the Devonian and Carboniferous rocks, though not wanting in the Lower Silurian. This genus has been collected from the Eolian limestone in Whiting and Sudbury. A shell of the same genus is found in the Hudson River limestone in Orwell, which is quite near the locality in Sudbury. There are two species of Euomphalus in the Eolian limestone.

Zaphrentis. The three other genera are of corals. *Zaphrentis* belongs to the family of *Cyathophyllidæ*, and there is no instance in this country where this genus has been found below the horizon of *Atrypa reticularis*, which is an Upper Silurian and Devonian species. The two are found together in great abundance in the semi-crystalline limestone connected with clay slate upon Lake Memphremagog near talcose schist. We cannot ourselves distinguish between the specimens of *Zaphrentis* from Lake Memphremagog and the Eolian limestone. This genus occurs in a dark colored slaty limestone in Sudbury and Cornwall, associated with Euomphalus and Chætetes.

Stromatopora. This is the most common of all the fossils in the Eolian limestone, and it is a genus whose lower limit is in the Niagara group of Upper Silurian rocks. It has been found in Sudbury, Orwell, Cornwall, East Middlebury, Brandon, New Haven and Williston. The specimens from East Middlebury and Williston are referred to this genus with a query. There are probably two species of Stromatopora in the Eolian limestone.

Chætetes. This genus is both an early and late one—that is, it is found from the Lower Silurian to the Carboniferous rocks. Both branching and oval forms of this genus occur in the Eolian limestone of Vermont, and there are two distinct species of it. It has been found in Sudbury, Benson, on M. C. Rice's farm, Cornwall and Williston. A supposed fossil of this genus is quite common at Peck's quarry in Cornwall, and on Dea. Casey's farm; at New Haven on the railroad north of New Haven railroad bridge, and in a loose block of limestone at Middlebury village.

Stictopora. In Sudbury were also collected specimens of the genus *Stictopora.* This genus was remarkably well defined. Prof. Hall did not venture to pronounce upon the species. An obscure coralline form, distinct from any of the others described, has been found in the limestone above Sheldon & Slason's marble quarry, in West Rutland.

Encrinal stems. The large encrinal stems from Sudbury and Cornwall are interesting, because the only cases where encrinal rings of such dimensions have been found in this country are in Devonian rocks. The fragments of small encrinal stems that have been discovered in the Eolian limestone, were found at the marble quarries in East Dorset, upon Mt. Eolus, and in West Rutland, Sudbury and Cornwall.

> One will be struck with the fact that all these fossils have an Upper Silurian or Devonian character, wherever they are of value in identifying strata. * * * *
>
> We incline to the opinion that they must probably be placed as high as that formation, or as low as the Lower Silurian: to which last position Mr. T. S. Hunt assigns them.

With regard to the Vermont quartzite, we have the following facts from page 356, of the same report.

> Several species of fossils occur in the quartz rock. They are a species of *Lingula*, a mollusk resembling the ***Modiolopsis***, a straight chambered shell (?), a few crinoidal columns, the *Scolithus linearis* (Hall), a few fucoids, and some indeterminable forms which are evidently organic.
>
> The Lingula is from the north part of the principal range of quartz rock in Starksboro, near Rockville, at the house of Mr. Hill. The locality was discovered by Henry Miles, of Monkton. The specimens contain scores of fossils, but none of them are very distinct. Prof. James Hall has examined them, and regards them as a new species of Lingula, related to a species contained in the Medina sandstone.
>
> The "Modiolopsis," chambered shell, and encrinal remains are found in hyaline quartz on the west side of Lake Dunmore. The first and last were referred to the same authority by Prof. Adams.

From the above statements it would appear that the limestone is either later Lower Silurian, or younger. But species of Zaphrentis have been described by Billings from the Lower Silurian (Hudson River group, one of them three inches long and an inch and a half in diameter at top); and it has been inferred by Hall, Billings, Hunt and others that the beds are probably Lower Silurian. The encrinal stems, as I learned from Prof. C. H. Hitchcock, were not over three-eighths of an inch in diameter. Putting the facts together, the evidence is strong that the limestone is not older than the Chazy, and that the Trenton limestone is included with it, its deposition having followed that of the Chazy, as in most regions of Chazy rocks. Excepting the *Scolithus*, there is nothing in the quartzite that suggests a Potsdam origin, or anything older than the Hudson River group; and the Scolithus is of no particular age.

The results thus take us back to the old idea of the Professors Rogers, that the limestone is mainly Trenton, and therefore that *the slates of the Taconic Range are of the Hudson River group*. The two make up the true original Taconic system of Emmons.

Before leaving this topic I make one remark of a personal nature. Through the early part of the Taconic controversy—in which the principal contestants were Prof. Emmons on one side, and Prof. James Hall and the Profs. Rogers on the other—I took no part, as I had given the facts no investigation in the field.

At the same time I inclined toward the views of Profs. Rogers and Prof. Hall because of my confidence in them as geological observers. When, thirteen years since, Sir Wm. Logan, after investigations in the Green Mountains of Vermont and Massachusetts, as well as in Canada, brought out his view that the Taconic rocks—those of Taconic mountains and the associated limestone—were identical with the Quebec group,* (an opinion then participated in, I believe, by Prof. Hall,) I gave it acceptance and adopted it in my Manual of Geology. Within the past half a dozen years I have looked to the rocks themselves in order to obtain ground for an independent judgment; and the result is that above presented. It makes the Taconic rocks and the associated limestone one in formation, as held by Logan; and it differs from his view as to the age of the beds—on the basis partly of the older examination of fossils by Hall, and especially on the recent, by Billings; and diverges also as regards the relations of the quartzite.

The conclusion I have presented relates to the *original Taconic* as presented by Emmons in his New York Geological Report published (in quarto) in 1842, and not to the unfortunate additions to it made in his later publications†—unfortunate because they drew off attention from the real Taconic, and became the chief subjects of controversy and prolific sources of error.

XV. *The condition of the Green Mountain region in Berkshire during the formation of the rocks.*—The occurrence of the quartzite along the limestone region, and its passage occasionally into conglomerate, testify to the existence in the Green Mountain seas, during the later part of the Lower Silurian, of great exposed sand flats, such as are made in the face of the waves; and the frequent transition in the quartzite stratum to mica schist, or gneiss, or mica slate, and the like, are good proof that in the shallow waters about the great sand banks, the bottom was of mud. The fact that the quartzite prevails most along the eastern border of the limestone shows that in that portion of the region the water was most shallow, or that there lay the largest amount of emerged land. Whatever the depth of water in which the limestones were made, the depth appears to have diminished in the Berkshire region toward the end of the Lower Silurian era; and this was a prelude to the time of upturning and metamorphism which appears to have closed that era in Western New England.

It is a remarkable fact that the conglomerate accompanying the quartzite contains no pebbles of gneiss or of any of the older crystalline rocks. The pebbles are all of quartz or quartzite.

---

* The views of Logan are to be found in this Journal, II, xxxi, 210, 1861; and also, with additional conclusions, by T. Sterry Hunt, at page 392 of the same volume, in an article entitled "On some points in American Geology."

† See this Journal, III, iii, 468.

ART. XXIX.—*De Verneuil. Eulogy of* M. DAUBRÉE, *June* 4, 1873.

THE distinguished associate of whom the Academy has just been deprived, alike eminent in character and intelligence, affords us an example, too rare among us, of an independent position consecrated with zeal to science and crowned with important discoveries.

PHILIPPE EDOUARD POULLETIER DE VERNEUIL, born at Paris, Feb. 12th, 1805, was destined to the magistracy, and had attained to twenty-five years of age, when the events of 1830 put an end to his plans in that direction.

At the moment when he hesitated as to what pursuit to devote himself, geology was making marked progress. No only was it admitted that the crust of the earth, instead of having always remained unchanged, as the school of Werner demanded, had undergone foldings and fractures which revealed transformations in its structure, but it was becoming possible to determine the relation in age of these phenomena. It was under such circumstances that M. de Verneuil felt himself drawn toward geology, and that he followed with great ardor the lectures in which M. Elie de Beaumont developed these new ideas. The great questions connected with the history of the globe soon took strong hold of him, and he resolved not to remain a mere spectator of the discoveries of others.

Recognizing the fact that in geology, as in all the sciences of observation, the study of nature alone can give a full understanding of her phenomena, he desired to travel. He chose at first the country of Wales, which at that very time the investigations of two distinguished English geologists, Sedgwick and Murchison, were rendering classic, for they were establishing divisions and a fixed order of superposition in the great group of ancient beds which, up to that time, had been confounded under the general name of Transition formations. As has more than once happened, this first journey had a decisive influence upon the future direction of the researches of M. de Verneuil, and upon the character of the services to science by which he was to become distinguished.

His desire to see and compare soon led him to the east. He turned toward Turkey, following down the Danube, on which steam navigation was just then introduced, and, led on by meeting those who sympathized in his objects, he went through Moldavia and Bessarabia to Odessa in the Crimea, and even to the frontiers of Circassia, and later toward the Bosphorus. The memoir on the Crimea which he then published was accompanied by descriptions of new and interesting fossils described by

M. Deshayes. This savant, who now came to the aid of stratigraphical geology by his profound knowledge of fossil shells, took much pleasure in instructing de Verneuil in this important study in a private course rendered illustrious by distinguished auditors, themselves soon to become eminent geologists.

After having made, in 1838, a special study of the lower beds of the Bas-Boulonnais, M. de Verneuil had already become an authority in the determination of fossils. Thus, in 1839, when Sedgwick and Murchison wished to compare the oldest formations of the countries of the Rhine and of Belgium with those of England, they desired de Verneuil to accompany them in their explorations. Absorbed as they had been in the study of stratigraphical relations, they found the necessity of his cooperation, which was the more important to them since M. de Verneuil had already travelled over and studied these countries. In the memoir which they published, these English geologists made full acknowledgment of the assistance their companion had afforded them by generously putting at their disposition the rich collections he had made in person. In connection with M. d'Archiac,—whose name we cannot pronounce without recalling our great sorrow in the loss of this distinguished student, our most excellent associate,—M. de Verneuil published in 1841 a description of the fossils of the older beds of the Rhenish provinces. The work is preceded by a general sketch of the fauna of the so-called Paleozoic formations, and followed by a table of the organic remains up to that time discovered in the Devonian system of Europe.

This journey made apparent the advantage, I had almost said the absolute necessity, in order to carry out such explorations with accuracy, of having always at hand a trained paleontologist like M. de Verneuil. At this time he was in fact almost alone in his knowledge of fossils. So, when Murchison, desiring to study further the geological formation which he had so well defined in the northwest of Europe, formed the project of exploring Russia, he again sought the companionship of M. de Verneuil. The facility with which Murchison could at a glance appreciate the characteristics of strata could never in that way alone have enabled him, able as he was, to reach sure distinctions in a region so vast, where, moreover, the rocks are so seldom uncovered. These two savants supplemented each other in the happiest manner.

The labor of three summers, 1840 to 1842, enabled Murchison, Verneuil, and Keyserling, to explore a region comprising more than half of Europe. It is just to say that the Emperor Nicholas warmly favored this enterprise, the grandeur and utility of which he fully appreciated; and that many learned men, Russians and foreigners, had published papers on various isolated parts of the region. Traveling by different routes, and meeting from time to time to compare their observations, the three savants gave a very wide range to the field of their operations. The nearly horizontal position of all the formations beyond the chain of the Urals is in marked contrast with the manner in which the same groups are upturned and broken in Western Europe; and the great extent of the beds favors a rapid acquaintance with them. The work upon Russia in Europe and the Ural Mountains, accompanied as is well known by geological maps representing each of those countries, appeared in 1845. It is a monument raised to the knowledge of the immense region to which it relates, and at the same time to the fundamental principles of geology. The introduction of the Permian system into science was one of the great results of this exploration.

As the conclusions rest entirely on the exact determination of fossil species, it was essential to give to this part of the work all the care and all the range which it required. The whole of the second volume, which contains, so to speak, the justifying testimony, is, in all that pertains to the Paleozoic fauna, the personal work of M. de Verneuil, assisted by Count Keyserling. The fauna of the secondary formations was intrusted to M. Alcide d'Orbigny, at that time the authority in this department of the science. Viewing together the four Paleozoic systems, the authors show that the succession of organized beings is almost exactly the same as in the other countries of Europe.

The various investigations which have been carried on with so much activity in North America have made us well acquainted with the wonderful development of stratified deposits in that part of the world, remarkable not only for the thickness of the beds, but also for their geographical extent, comprising not less than thirty-four degrees of latitude and fifteen degrees of longitude. But with wise independence, the American geologists did not consider, in laying down the subdivision, the groups that in Europe appeared to be their analogues; moreover, the data were entirely wanting for an exact comparison. When it is possible to follow deposits from one country to another without interruption, it is easy to trace out correspondances among them; but this cannot be done between two continents separated by 3,000 miles.

In the spring of 1846, the publication relating to Russia was hardly completed, when M. de Verneuil undertook to bridge over this enormous interval. He was anxious to follow out and compare for the two continents the sedimentary strata, from the lowest fossiliferous beds up to the coal. Such was the task laid down for himself by this intrepid pioneer in science. His study had exclusively for its base the species which he examined in local collections or those which he himself gathered from the deposits. He established the fact that in countries so remote the first appearance of life was very similar in forms, and that the same types were developed successively and in a parallel manner through all the series of Paleozoic beds; that there is on both sides of the ocean a striking agreement in the succession of life.

De Verneuil has then the double credit, on one hand, of carrying to the United States an intimate knowledge of the divisions in the Paleozoic strata established in Europe, and on the other, of bringing back to Europe the results of American investigations, and the possibility of profiting by them: de Verneuil resolved the complex question by his own labors. His modest presentation of the parallelism of the Paleozoic rocks of the two countries has lost nothing of its merit, notwithstanding the constant advance of the science; it is still a fundamental position. This memoir established the place to which paleontology is entitled in investigations relating to the history of the globe. This is perhaps the crowning labor of M. de Verneuil.

There is, however, another enterprise which bears still higher testimony to his boundless devotion to science and his indefatigable perseverance. Spain had been less studied than any other part of Europe, when M. de Verneuil thought of turning his steps thither. He was also drawn to it by Blainville, who did not believe in the universality of the laws of paleontology. If the succession of the beds, and of the fauna characterizing them, seemed to be established over the northern portions of the two continents of Europe and America, this great naturalist supposed that in Spain, in the south principally, the order of succession of fossil species might be reversed, or at least modified; an idea which was far from being realized.

From 1849 to 1862, de Verneuil made not less than a dozen trips into the peninsula, sometimes alone, and sometimes with M. Edouard Collomb, who was already known by his investigations of ancient glaciers. Sometimes also he was accompanied by young naturalists, who went for the sake of his instructions. The geological map of Spain, and the memoirs published after these laborious excursions, among others that which is rendered signal by the discovery of the Primordial fauna, did not interest Spain alone, where they incited others to labor, but the whole scientific world.

It is greatly to be regretted that the author of so many precious observations did not find time to put them in order and work them out as a whole, as he did in Russia.

In 1854, de Verneuil was made member at large of the Academy of Sciences at Paris. The Royal Society of London and other foreign societies had enrolled him among their associates.

His taste for traveling, which was so important in its results to geology, was not lessened when the increasing failure of his sight deprived him of its chief pleasure. The privations he endured in rough or inhospitable countries had never diminished his zeal, or his good humor. Many times he ran great risks, as when he ventured dangerously near a volcanic eruption at Vesuvius or at the island of Santorin.

A clear judgment, and a complete independence of all preconceived ideas, guided him in his deductions. Far from being absorbed in his own special studies, he interested himself in various other branches of human knowledge. He was perfect master of many modern languages; and this was one of the means which insured him success in the countries he explored. Moreover, the fine arts were not excluded from his pleasures; he had cultivated his talent for music even to becoming a skillful composer. Few persons possessed more natural benevolence than he. His extreme kindness was not only apparent in the ordinary intercourse of society, but was manifested in many generous deeds. He discussed the opinions of his opponents with calmness and good temper. Exquisite loyalty and sincere modesty were the dominant traits of his noble character. He found more pleasure in bringing forward the discoveries of another than his own, and, perhaps for that reason, more than one of his associates failed to appreciate the full extent of his merits.

During the illness which for three months interfered with his activity, he continued to interest himself warmly in all the facts of science as well as in very different questions; through all, his good humor never failed. He preserved his serenity even to the last, and died, as a Christian, on the 29th of May, 1873, having almost completed his 68th year.

M. de Verneuil had called to his aid all the resources of paleontology, particularly those pertaining to the Paleozoic strata. In this respect he held perhaps the first rank among geologists on both continents. Moreover, he was at once the pioneer and the master in the knowledge of North American geology.

It was not only by his published works that de Verneuil contributed to the advance of science. He has raised to himself a monument in his collections, in which he brought together types of the choicest fossils selected from the various regions he had explored. Strangers from all countries, as well as French savants, have availed themselves of his valuable collections, which with the utmost liberality he put at their service, besides aiding them with the results of his own studies. In this way he was a center for the study of paleontology, whence radiated light in every direction.

To continue, even after he had gone, the exercise of his generosity toward all students, he has desired that his collections—certainly unique—should be always at their disposal, and to this end he bequeathed them to the Gallery of the School of Mines.

The memory of our excellent member will always be held in reverence among the geologists and paleontologists of the world.

ART. XXX.—*On Isomeric Sulphosalicylic Acids*; by IRA REMSEN.

IN the hope of finding a simpler method than that at present employed for the preparation of oxysalicylic acid, I turned my attention to the sulpho-acid. The preparation of this acid under the most unfavorable circumstances must be simpler than that of the iodo-acid; and, further, it appeared probable that, if the desired conversion of the SO^2OH group into hydroxyl took place at all, this would be a cleaner change than that which accompanies the action of potassic hydroxide upon iodosalicylic acid.

Sulphosalicylic acid was originally prepared by Cahours,* but was first carefully studied by Mendius.† These chemists prepared it by allowing the vapor of sulphuric anhydride to act upon salicylic acid. On dissolving the product in water, and filtering off from unaltered salicylic acid, an aqueous solution of the sulpho acid was obtained, and from this, by proper treatment, the salts and the free acid.

I found it simpler to treat salicylic acid directly with ordinary concentrated sulphuric acid. Solution took place very readily with the aid of slight heat. The solution was somewhat strongly discolored. On diluting with water and allowing to stand, no unaltered salicylic acid was deposited. The whole was neutralized by means of finely powdered chalk, and then filtered off from excess of chalk and precipitated gypsum. The solution of calcium salts, thus obtained, was treated with potassic carbonate until a precipitate was no longer formed, when the calcic carbonate was filtered off. The filtrate, containing the potassium salts, was evaporated down to a comparatively small volume. On now being allowed to cool slowly, a

---

* Ann. Ch. Phys., [3] xiii, 92.

† Ann. Ch. Pharm., ciii, 39.

deposit of crystals was formed. These were removed and recrystallized. Thus they were obtained in the form of beautiful thick needles, almost colorless. Although subsequently recrystallized a number of times, they retained a slightly yellowish tinge. These crystals, which presented every appearance of a chemically pure substance, were analyzed with the following results:

I. 0·5885 grams of the salt, on being heated to 190°, lost 0·0637 grams H^2O=10·83 per cent.

II. 0·5885 grams of the salt gave 0·3113 grams K^2SO^4=0·13956 grams K=23·71 per cent.

		Calculated.	Found.
$(C^7H^4O^6S)$	216	65·45	----
K^2	78	23·64	23·71
$2H^2O$	36	10·91	10·83
	330	100·00	

The fact that this salt contains two molecules of water of crystallization, together with the fact that it is the principal product of the reaction under consideration, renders it probable that it is identical with the potassium salt prepared and described by Mendius (loc. cit.), as the latter also contains two molecules of water of crystallization.

On evaporating the mother liquor from the crystals first obtained, and again allowing to crystallize, a second deposit took place. This was made up to a great extent of crystals of the same kind as that already described, but, in addition to these, there were noticed others which were larger, more compact and well-formed. The two kinds were separated as carefully as possible by mechanical means, and both recrystallized repeatedly. The larger crystals, after being subjected to this process, were nearly colorless, and presented the form of sections of quadratic (?) pyramids. Some of them attained considerable dimensions; all were well developed; and none possessed the slightest resemblance to the crystals of the first set. They were analyzed with the following results:

I. 0·5258 grams of the salt, on being heated to 180°, lost 0·044 grams H^2O=8·37 per cent.

II. 0·5258 grams of the salt gave 0·2859 grams K^2SO^4=0·12817 grams K=24·38 per cent.

		Calculated.	Found.
$(C^7H^4O^6S)$	216	67·29	----
K^2	78	24·30	24.38
$1\frac{1}{2}H^2O$	27	8·41	8·37
	321	100·00	

The salt is thus proved to be derived from a sulphosalicylic acid; and, further, the difference in form and formula between it and the needly crystals make it appear probable that the two salts are derived from isomeric modifications of the same acid, though, of course, the proof is not given. This supposition is rendered still more probable by the fact that when a substituting agent is allowed to act upon an aromatic body, in almost all cases where it is theoretically possible, two isomeric products are formed; the formation of but one product being, as recent investigations tend to show, a rare exception.

If the ordinary reaction of Dusart, Kekulé and Wurtz could be applied with success to the two salts described, it would be possible to throw some much-needed light upon the constitution of the dioxybenzoic acids, of which we can safely say that the constitution of not a single one of the many varieties described is known. Provided we can once establish the fact that molecular rearrangement does not play an important role in the varied metamorphoses of aromatic compounds; provided, particularly, we can demonstrate that hydroquinone, pyrocatechin and resorcin are not mutually transformable under the influence of heat; and that there is more than a chance connection between the arrangement of the hydroxyl groups in the dioxybenzoic acids and the products which they yield when subjected to dry distillation, then the problem of determining the constitution of these acids becomes a very simple one. A careful consideration of the subject will show that it is only necessary to know in regard to each particular acid: 1st, from which of the oxybenzoic acids it is obtained, and, 2nd, which of the three dioxybenzenes it yields when distilled. From these starting points the conclusions may be easily drawn. There are, according to Kekulé's hypothesis, but six varieties of these dioxyacids possible, most of which are probably known; though they have been prepared in such small quantities, and studied so superficially, that our knowledge of them is exceedingly limited. I hope soon to be able to give this subject further attention. As remarked above, the study of the isomeric sulphosalicylic acids promised reward in the direction indicated. I hence endeavored to convert the sulpho-group of each of them into hydroxyl. Unfortunately, this conversion could not be effected, though, at the same time, another interesting and significant result was attained.

The potassic sulphosalicylate first obtained, viz: that which crystallized in the form of needles, was fused with potassic hydroxide in a silver basin, the mass being constantly stirred with a silver spatula. A change of color accompanied the reaction, resembling that observed in connection with the corresponding reaction between potassic sulphoxybenzoate and potassic hydroxide. As soon as the mass ceased to foam it was allowed to cool; then dissolved in water, acidulated with sulphuric acid, and agitated with ether. The ethereal extract, on being distilled over a water-bath, left behind a brown, thick, oily residue, decidedly unattractive. This was boiled with water, and thus partially brought into solution, while at the same time a portion of the substance was volatilized with the aqueous vapor, and deposited upon the upper walls of the vessel in the form of very delicate, silken needles. The whole was boiled with a large quantity of water, and the vapors which passed over condensed. The distillate was clear with the exception of a few oily drops which floated on the surface. For a long time the vapors continued to show an acid reaction, but, after boiling for several hours, the process was discontinued. On now again extracting the dissolved substance by means of ether, both from the distillate and the contents of the flask, the products were found to be very similar in appearance, and both resembled the original "brown, thick, oily residue." They were allowed to dry over sulphuric acid, when they became compact and hard. Finally, by carefully subliming these products between watch-glasses, through filtering paper, a pure sublimate was, in both cases, obtained, while, also in both cases, an oily residue was left behind. The sublimate consisted of delicate colorless needles of silken luster. These were found to fuse at 156°. They were readily soluble in hot water, and crystallized out on cooling in long needles. Their aqueous solution when treated with ferric chloride turned a deep violet color. These are the properties of salicylic acid, and an analysis was alone necessary to prove that this acid was indeed the principal product of the reaction:

0·2058 grams of the substance, dried over sulphuric acid, gave 0·4606 grams CO^2=0·12562 grams C; and 0·0882 grams H^2O=0·0098 grams H.

		Calculated.	Found.
C^7	84	60·87	61·04
H^6	6	4·35	4·76
O^3	48	34·78	----
	138	100.00	

The other product formed could not by the most varied manipulations be rendered more attractive. It remained a disagreeable, thick oil. This had the odor and other general properties of phenol. Its aqueous solution, treated with bromine water, gave a yellow precipitate; and this yellow precipitate, treated with sodium-amalgam, gave a substance which possessed the odor of phenol.* As nothing else could be detected, these

---

* See Landolt, Ber. Berichte, IV Jahrgang, 770.

two, viz.: salicylic acid and phenol, may be considered the legitimate products of the action of potassic hydroxide upon potassic sulphosalicylate.

It remained to study the corresponding reaction with the second variety of potassic sulphosalicylate. The experiment was performed in exactly the same manner as in the first case; and all the phenomena observed were but repetitions of those already described. Salicylic acid and phenol were the only products. The salicylic acid was not analyzed, as its properties were a sufficient guarantee of its identity. The phenol was detected, as in the former case, by means of Landolt's reaction.

If we consider the phenol as a secondary product, formed by the splitting up of salicylic acid under the influence of heat, we thus see that the effect of the action of potassic hydroxide in the cases under consideration is simply to cause a substitution of the SO^2OH group by H. Similar instances are mentioned in chemical literature, though their number is not great enough as yet to permit of any well-founded general conclusion in regard to this kind of action. It remains to be seen whether any connection can be traced between the positions of the substituting groups, and the occurrence of this retrograde substitution.

Williams College, Mass., August, 1873.

Art. XXXI.—*On the Silt Analysis of Soils and Clays*; by Eug. W. Hilgard, State Geologist of Mississippi.

(**Read at the Portland Meeting of the Am. Assoc. Adv. Sci., August, 1873.**)

Among the objections raised against the utility of soil analyses as mostly made and stated heretofore, not the least serious one is that they do not indicate with any reasonable degree of accuracy, or in a generally intelligible manner, those important points in the physical condition of soils which are practically designated as "lightness," "heaviness," "openness," etc. Indeed, the very idea of what constitutes a sandy soil or a clay soil is exceedingly indefinite; necessarily so, so long as the constituent ideas of "clay" and "sand," respectively, remain so ill defined.

It makes a material difference whether the grains of sand contained in a soil or clay are prevalently half a millimeter in diameter, or the tenth or twentieth part of that amount. Sand (or more properly silt) of the latter size is by no means impalpable; and yet a soil containing 50 per cent of this substance might be exceedingly "heavy," while it would be "light" if the sand grains approached $0{\cdot}5^{mm}$ diameter. And it would make an equally material difference whether or not the impalpable matter usually classed as "clay" were really, in the main, silicate of alumina, or simply silex, or other mineral powder.

Equally important are, of course, the corresponding differences in the properties of clays intended for use in the arts.

In the prosecution of my researches on the soils of the State of Mississippi, I found myself confronted by these difficulties, and by the necessity of providing for some mode of operation, and means of designating the several physical constituents of soils, which should not only insure more accurate results, but should also render these capable of ready comparison all the world over.

I need not recapitulate the often-discussed objections to Nöbel's apparatus, with its four vessels of ever-varying capacity and slope of sides, and variable head of pressure. Not one of the five sediments obtainable by its use is ever of a character approaching uniformity; and even in one and the same instrument, successive analyses of one and the same material differ widely in their results.

Schultze's elutriating apparatus, as modified and used by Fresenius in his investigations of the clays of Nassau—a tall, conical champagne glass, with an adjustable stream of water descending through a tube in the axis—answers a better purpose: but offers the inconvenience of the accumulation of heavy sediments around the mouth of the tube, whereby not only the velocity of the stream is changed, but its failure, at low velocities, to agitate the whole mass of the substance under treatment, allows portions of the latter to escape the elutriating action altogether. And since in soil analysis special importance attaches to these finer sediments, which are carried off at low velocities, this objection is a capital one.

Intending to carry out in a convenient form the idea (already urged by Türrschmidt, Notizblatt, v, 180) of substituting for the accidental and indefinite products usually appearing in the statements of silt-analyses, sediments of known and definite "hydraulic value," I adopted in place of a variable head of water, a constant one (a Mariotte's-bottle arrangement, adapted to ten-gallon carboys), modifiable by means of a stopcock* with a long lever moving on a graduated arc, on which the positions corresponding to given velocities in vessels of known cross-section of mouth, are marked off according to empirical determinations.

In order to obviate the inconvenience arising from the accumulation of sediment around the orifice of the tube delivering the current, I introduced an intermediate conical relay reservoir (R, fig. 2; a test glass, cut short) at the point of the

---

* For figures, see Plate I.

elutriator (inverted) cone. The smallness of the lower orifice of the latter renders the current there sufficiently rapid to prevent any portion of the sediment concerned at a given velocity from falling into the relay; and whatever sediment does accumulate there can at any time be stirred and brought back into the elutriating vessel, by increasing the velocity for a few seconds of time.

Following up with the microscope the character of the sediments so obtained with the apparatus, fig. 2, I soon found that they were throughout of a very mixed nature; and searching for the cause, I found one in the abruptly conical termination of the elutriator, at C, where the efflux tube was at first attached. For in that case, the ascending current does not decrease regularly its velocity as the cone expands, but is broken up into a complicated system of eddies, whose general tendency is to ascend in the axis of the instrument, and descend at its sides. So far, therefore, from corresponding to the calculated velocity belonging to the cross section at C, the sediment carried off represents the variable effects of these eddies.

The obvious remedy was to adapt to the wide (upper) end of the elutriator tube a cylindrical portion, as shown in the diagram, above C. When the length of this cylinder is made not less than 125^{mm}, no perceptible eddies reach the efflux tube; and the sediments exhibited a pretty satisfactory uniformity of grain, save in so far as the coarser ones still contained a good deal of fine material.

However, in subjecting the working of the instrument to the test of the balance, I found the results still quite unsatisfactory, and apparently inconsistent, especially as regards the finer sediments.

The cause of these anomalies became apparent upon attempting to work over, the second time, a quantity of sediment originally obtained at the velocity of 1^{mm} per second. It should all, of course, again have passed over at the same velocity; but to my surprise, barely one-half of it did so, while a heavy, coarse sediment collected in the lower portion of the elutriating tube, and even settled into the relay reservoir R; as roughly shown in fig. 2. On returning the portion that had passed over to the elutriating vessel, the same phenomenon recurred; and by repeated "cohobation," I finally succeeded in getting about four-fifths of the whole quantity of sediment settled into the relay reservoir!

On examination I found this coarse sediment to consist of flocculent aggregates of from a few to as many as 30 fine particles of siliceous silt. When violently shaken, they part company and become diffused, singly, through the liquid, which then presents simply a general turbidity; the particles then settling down slowly and singly, at the rate corresponding to their individual size or hydraulic value.

The process of formation of these aggregates may be observed by means of a lens, in all its stages; it being the effect of the downward currents always existing on the sides of the conical vessel, as heretofore mentioned. The aggregation progresses slowly at first; but when once five or six particles have thus coalesced, they begin to descend with increased rapidity, and, growing, avalanche-fashion, as they roll down, finally drop through the narrow lower orifice, despite of the rapid current existing there, into the relay reservoir R.

I have vainly attempted to obviate this trouble in various ways. Even when a central core is introduced in the axis of the conical tube, so as to force up the current close to the sides, return currents *will* form, and with them these miniature avalanches.

It is obvious that this circumstance completely vitiates all determinations heretofore made in conical vessels; whether those of Nöbel's apparatus, or those of Schultze and Fresenius; or even the later ones of Müller, and of Schöne;* in all of which the agitation produced by the current is alone employed for stirring.

The tendency to coalescence diminishes, of course, as the size of the grains increases; but does not altogether cease until their diameter exceeds 0·2^{mm}, or about 16^{mm} hydraulic value. For the elutriation of coarser sediments, hydraulic stirring may be successfully employed. For finer sediments, however, the use of *cylindrical* vessels, and of *rapid agitation by outside power*, seems indispensable.

Fig. 1 of the diagram shows, on a somewhat enlarged scale, the instrument I have devised, with this end in view. The cylindrical elutriating tube T, of 34·8^{mm} inside diameter at its mouth, and 290^{mm} high, has attached to its base a rotary churn P, consisting of a porcelain beaker triply perforated, viz: at the bottom, for connection with the relay reservoir R; and at the sides, for the passage of a horizontal axis A, bearing four grated wings. This axis, of course, passes through stuffing boxes, firmly cemented to the roughened outside of the beaker, and provided with good, thick leather washers, saturated with tallow. These washers, if the axis run true, will bear a million or more of revolutions without material leakage. From five to six hundred revolutions per minute is a proper velocity, which may be imparted by clockwork, or a turbine.

As the whirling agitation caused by the rotation of the dasher would gradually communicate itself to the whole column

---

* I regret having been unable to obtain, for reference, the original papers of the two latter authors; the most thorough, probably, heretofore published on this subject.

of water, and cause irregularities, a (preferably concave) wire screen of 0·8^{mm} aperture is cemented to the lower end of the cylinder. No irregular currents are then observed beyond about 75^{mm} above the screen, whose meshes are yet sufficiently wide to allow any heavy particles or aggregates to sink down freely. Any grains too coarse to pass must, however, be previously sifted out.

Thus arranged, the instrument works quite satisfactorily; and by its aid, soils and clays may readily be separated into sediments of any hydraulic value desired. But in order to insure correct and concordant* results, it is necessary to observe some precautions, to wit:

1. The tube of the instrument must be as nearly cylindrical as possible, and must be placed and maintained in a truly vertical position. A very slight deviation from the vertical at once causes the formation of return currents, and hence of molecular aggregates, on the lower side.

2. Sunshine, or the proximity of any other source of heat, must be carefully excluded. The currents formed when the instrument is exposed to sunshine will completely vitiate the results.

3. The Mariotte's bottle should be frequently cleansed, and the water used be as free from foreign matters as possible. For ordinary purposes, it is scarcely necessary to use distilled water; the quantities used are so large as to render it difficult to maintain an adequate supply; and the errors resulting from the use of any water fit for drinking purposes are too slight to be perceptible, so long as no considerable development of the animal and vegetable germs is allowed. Water containing the slimy fibrils of fungoid and moss prothallia, vorticellæ, etc., will not only cause errors by obstructing the stopcock at low velocities; but these organisms will cause a coalescence of sediments that defies any ordinary churning, and completely vitiates the operation.

4. The amount of sediment discharged at any one time must not exceed that producing a moderate turbidity. Whenever the discharge becomes so copious as to render the moving column opaque, the sediments assume a mixed character; coarse grains being, apparently, upborne by the multitude of light ones whose hydraulic value lies considerably below the velocity used; while the churner also fails to resolve the molecular aggregates which must be perpetually re-forming where contact is so close and frequent.

This difficulty is especially apt to occur when too large a quantity of material has been used for analysis, or when *one* sediment constitutes an unusually large portion of it. In either

---

* **Usually within 5 per cent of the quantities found.**

case, a portion of the substance may be allowed to settle into the relay reservoir, until the part afloat in the churn and tube is partly exhausted; after which, the rest can be gradually brought up and worked off. Or, the sediments shown by the microscope to be much mixed, may be worked over a second time. Either mode, however, involves so grievous a loss of time, as to render it by far preferable to so regulate the amount employed, that even the most copious sediments can be worked off at once. Within certain limits, the smaller the quantity employed, the more concordant are the results. Between ten and fifteen grams is the proper amount for an instrument of the dimensions given above.

I have found that, practically, $0{\cdot}25^{mm}$ per second is about the lowest velocity available within reasonable limits of time; and that by successively doubling the velocities, up to 64^{mm}, a desirable ascending series of sediments is obtained; provided always, that a proper previous preparation had been given to the soil or clay.

Preliminary Preparation.—As regards this point, which is of capital importance, I premise that I find the usual precept of boiling from 30 to 60 minutes almost absurdly inadequate to perform that loosening of the adherence of particles, which is the fundamental condition of success in any process of mechanical separation. In no case have I found less than six hours incessant and lively boiling even approximately sufficient; and even with double that time, so much of the disintegration is often left to be done by the churner of the instrument, as to protract indefinitely the exhaustion of the finer sediments, which are then continually being set free from the coarser portions. Thus, in average cases the sediment of $0{\cdot}25^{mm}$ h. v. may be "run off" in the course of 30 to 35 hours. But in one case, after 12 hours boiling, the 0·25 sediment gave no sign of disappearance after 36 hours, and continued to come off for 54 hours more, with the coarser sediments.

It is therefore a material saving of time, and essentially promotive of accuracy, to effect the mechanical disintegration in the most thorough manner, beforehand. This can rarely be done without long protracted boiling, and the subsequent use of mechanical means (kneading) on the finest sediments. But I cannot see the propriety of using chemical solvents for disintegration, unless the investigation is to extend beyond the physical properties of the substance treated. The miniature Loess puppets, consisting of sand-grains cemented by carbonate of lime; the grains of bog ore, or alumino-siliceous aggregates found in some soils, fulfill, physically, the same office as solid sand-grains of corresponding size; and should appear as such in the analytical statement.

The presence of clay in the instrument would materially interfere with the proper separation of sediments. In consequence of its property of indefinitely fine diffusion in water, clay—i. e., the hydrous silicate of alumina—produces the same effect as would the dissolution of a salt, viz: increases the buoyant effect, and therefore the hydraulic efficacy of water, to such an extent as to enable it to carry off, e. g., sediment pertaining to the velocity of 1^{mm} in pure water, when the actual velocity is but $0{\cdot}25^{mm}$.

In view of these facts, I have adopted the following course of preliminary treatment:

1. Boiling livelily, for 24 to 30 hours, 15 to 20 grams of weighed "fine earth."

This is best done in a thin, long-necked flask of about 1 liter capacity, filled $\frac{4}{5}$ full of distilled water, and laid on a stand at an angle of 40–45°. It is provided with a cork and condensing tube of sufficient length (5–6 feet) to condense all or most of the steam formed when lively ebullition is kept up by means of a gas flame. For the first few hours, the boiling generally proceeds quietly; but as the disintegration progresses, violent bumping sets in, which sometimes endangers the flask, but is of material assistance for the attainment of the object in view. In extreme cases, some of the heavier sediment (generally clean sand) may be removed from the flask; but this is undesirable. It is frequently the case that when the boiled contents are left to settle, the liquid appears perfectly clear within an hour; although so soon as they are largely diluted, the clay becomes diffused as usual, and will not settle in weeks. Probably this is owing to the extraction from the soil of soluble salts, which exert the same influence as does lime or common salt, even in very dilute solutions.

2. The boiled fluid and sediment is transferred to a beaker, and diluted so as to form from 1 to $1\frac{1}{2}$ liters in bulk; and being stirred up, is allowed to settle for such a length of time as (taking into account the height of the column) will allow all sediment of $0{\cdot}25^{mm}$ hydraulic value to subside; the process being repeated with smaller quantities of fresh water, until no sensible turbidity remains after allowing due time for subsidence.

It must be remembered that this time is considerably longer than that for pure water, so long as any considerable amount of clay remains in the liquid, rendering it specifically heavier. And as the precise amount of allowance to be made cannot in general be foreseen, some sediment of, and exceeding, $0{\cdot}25^{mm}$ h. v. will almost inevitably be decanted with the successive clay waters, until the buoyant effect of the clay becomes insensible. The united clay waters (of which there will be from four to eight liters) must therefore be again stirred up, and the proper time allowed for the sediments of $0{\cdot}25^{mm}$, and over, to subside. The dilution being very great, a pretty accurate separation is thus accomplished; the sediments being then ready for the elutriator.

Treatment of the "Clay Water."—I have based on the well-known property of clay, of remaining suspended in pure water for weeks and even months, an obvious method of separation from at least the greater portion of silts finer than $0{\cdot}25^{mm}$ hydraulic value ($< 0{\cdot}25$).

The clay water is placed for subsidence in a cylindrical vessel (in which it may conveniently occupy 200^{mm} in height), and is there allowed to settle for at least 24 hours. This interval of time was at first chosen arbitrarily; but I subsequently found it to be about the average time required by the finest siliceous silt usually present in soils, to sink through 200^{mm} of pure water. So long as any sensible amount of clay is present, the time of course is longer, say from 40 to 60 hours, or even more, if the clay be abundant and the liquid not very dilute. The sharp line of separation between the dark silt-cloud below and the translucent clay water above, is readily observed, and the time of subsidence regulated accordingly. At times, several such lines of division may be seen simultaneously in the column, indicating silt of successive sizes, with a break between. No such appearance is presented when, after weeks of quiet, the clay itself gradually settles. The liquid, which may be almost clear at the surface, then shades off downward very gradually, until, near the bottom of the vessel, it becomes entirely opaque.

After decantation of the clay water, the remaining liquid is poured off temporarily, leaving the sediment as dry as possible. It is then rubbed or kneaded in the decanting vessel itself, with long handled rubber pestle (conveniently cut out of a car spring).

Water is then again poured on (agitating as much as possible, to break up the molecular aggregates) to the proper height, and another 24 hours subsidence allowed. This operation is repeated (6 to 9 times), until either the water remains almost clear after the last subsidence, or the decanted turbid water fails to be precipitated by salt water.

It thus seems possible, by a large number of successive decantations, to separate pretty sharply the clay proper from the fine silts. But the amount of time and care required in the process of complete separation is so great, and the difference of percentage resulting from a neglect of the subsidence beyond 24 hours is in most cases so slight, that in the analyses made thus far, I have throughout adhered to the 24 hours interval;

the "clay" thus obtained being, of course, more or less contaminated with some of the finest silt; which is precipitated with it by salt, provided the relative amount of clay is not too small. Otherwise a slight turbidity may remain for several days in the decanted liquid, which cannot then be cleared by the further addition of salt.

50^{ccm} of a saturated brine (i. e., 1·5 per cent of salt) is ordinarily sufficient to precipitate one liter of clay water; the precipitation is much favored by warming. Half the quantity, or even less, will do the same, but more time is required, and the precipitate is more voluminous.

As it cannot ordinarily be washed with pure water, it must be collected on a weighed filter, washed with weak brine, dried at 100° and weighed. It is then again placed in a funnel and washed with a weak solution of sal ammoniac, until all the chloride of sodium is removed. The filtrate is evaporated, the residue ignited and weighed: its weight, *plus* that of the filter, deducted from the total weight, gives that of the clay itself.

In some cases, especially of clays and subsoils deeply tinged with iron, the clay, *after drying at* 100°, will not readily diffuse in water, and can be washed with pure water until free from salt; it can then of course be weighed directly.

[To be continued.]

ART. XXXII.—*Discovery of a new Planet, and observations on that discovered June 13th;* by JAMES C. WATSON.

ON the 29th of July I discovered a planet of the 12th magnitude and observed the following place:

	Ann Arbor M. T.	α	δ
1873 July 29	$14^{h}\ 1^{m}\ 0^{s}$	$23^{h}\ 8^{m}\ 12 \cdot^{s}35$	$-2^{\circ}\ 23'\ 11''\cdot 0$.

On account of cloudy weather and bright moonlight I did not have another opportunity to observe it until August 16th. I then found what I supposed to be the planet sought, and I observed it as follows:

	Ann Arbor M. T.	α	δ
1873 August 16	$12^{h}\ 38^{m}\ 4^{s}$	23^{h} 2 41·50	$-2^{\circ}\ 37'59''\cdot 2$
16	13 14 24	23 2 40·23	2 38 9·5
16	14 2 4	23 2 38·75	2 38 9·2
16	14 59 27	23 2 37·35	2 38 12·8
17	10 25 3	23 2 2·69	2 39 36·7
17	10 46 20	23 2 1·93	2 39 47·1
23	11 45 7	22 57 28·37	—2 52 51·3

By means of these observations I computed the following circular elements;

Epoch=1873 Aug. 23·5 Washington M. T.

$$u=20^{\circ}\ \ 5'\ \ 50''{\cdot}9$$

$$\left.\begin{array}{l}\Omega=319\ \ 55\ \ \ 37{\cdot}2\\ \ \ i=\ \ \ 6\ \ 45\ \ \ \ \ 5{\cdot}0\end{array}\right\}\text{Apparent Equinox August 23.}$$

$$\log a=\ 0{\cdot}467016 \qquad \mu=\ 707''{\cdot}103$$

These elements represent well the places of the planet to September 2d, and for July 29th they give the following place:

$$\alpha=23^{h}\ 12^{m}\ 41^{s}{\cdot}2 \quad \delta=-\ 2^{\circ}\ 23'\ 42''$$

It is evident, therefore, that the planet of August 16th is different from that of July 29th. I have commenced the search for the latter, and will prosecute it as completely as the weather will permit. The planet of August 16th is at present about a magnitude brighter than that of July 29th.

I add also some observations of the planet discovered by me on June 13th.

	Ann Arbor M. T.	*a*	δ
1873 June 13	$12^{h}\ 43^{m}\ 44^{s}$	$17^{h}\ 16\ \ 59^{s}{\cdot}50$	$-21^{\circ}52'\ 17''{\cdot}4$
13	13 37 44	17 16 57·04	21 51 52·9
14	10 17 9	17 15 56·10	21 42 40·7
15	11 47 20	17 14 41·68	21 31 29·6
18	11 51 51	17 11 16·97	20 59 58·1
July 2	13 5 0	16 57 50·4	18 44 50.
5	13 22 17	16 55 38·43	—18 19 12·7

This planet was of the eleventh magnitude. The following elements have been computed by Mr. Ritter, one of my assistants:

Epoch=1873 June 18·5 Washington M. T.

$$M=\ 79^{\circ}\ \ 38'\ \ 5''.9$$

$$\left.\begin{array}{l}\ \ \mu=152\ \ 38\ \ 14{\cdot}6\\ \Omega=259\ \ 33\ \ \ \ 6.2\\ \ \ \ i=\ \ 21\ \ \ \ 7\ \ 39{\cdot}7\end{array}\right\}\text{Ecliptic and Mean Eq. }1873{\cdot}0$$

$$\varphi=\ 15\ \ 28\ \ 27{\cdot}8$$

$$\log a=0{\cdot}372518 \qquad \mu\ =980''{\cdot}008.$$

Ann Arbor, Sept. 3, 1873.

Art. XXXIII.—*Hayden and Gardner's Survey of the Territories, under the Direction of the Department of the Interior.*[*]

The U. S. Geological and Geographical Survey of the Territories was authorized by the last Congress to make a careful geological and topographical survey of Colorado Territory. Field work was begun about the middle of May. The region selected for this season's operations lies between parallels 38°

---

[*] Communicated by Jas. T. Gardner, Geographer of the Expedition, under date of Middle Park, Sept. 3.

and 40° 20′ north, and between meridians 104° 30′ and 107° west, and contains about 20,000 square miles. It was divided by east and west lines into three districts, each about 58 miles broad by 130 long. The survey of each district was entrusted to a mixed party, of geologists and topographers. The northern district included the Middle Park, the middle district the South Park, and the southern the San Luis Park. Each district presents a complete section of the main upheavals of the Rocky Mts. The whole area surveyed may be regarded as a section, 160 miles broad, of the grandest ranges of the Rocky Mountain system at their point of greatest elevation; and as the most extended region of high peaks to be found in the country. From Mt. Lincoln, which is nearly in the center, we counted 200 peaks of 13,000 feet or over.

Between latitude 38° 30′ and 40° 30′, we find the Rocky Mts. composed of three great parallel meridional ranges; and west of these a grand group, of complex structure, called the Elk Mts., and high plateau-like ridges, sloping westward.

To the most eastern of the three ranges we give the name of Front Range, since it is the grand front which the Rocky Mts. present to the great plains. Standing on a high roll of the prairie back of Denver, one sees the mountains rise abruptly out of the plains and tower to snowy crests that stretch north and south in a magnificent panorama for 120 miles, from Pike's Peak on the south to a group 20 miles north of Long's Peak. Six of the summits—namely, Long's Peak, Mt. Torrey, Gray's Peak, Mt. Rosa, Mt. Evans, and Pike's Peak—attain an elevation of 14,000 to 14,200 feet above the sea. Our artist, Mr. Holmes, has made a very accurate detailed drawing of the panorama, which we expect to publish, with names, heights, etc.

West of the Front Range lie the great parks, separated from each other by comparatively low or broken cross ridges. Parallel with it, and about 40 miles farther west, is a grand line of mountains, forming the western boundary of the South, Middle, and North Parks. We name this the Park Range. Its highest points are near the junction of the cross range that divides South from Middle Park. They are the Mt. Lincoln group, which includes twenty peaks that exceed 13,000 feet in height; and its culminating points, Lincoln and Quandary, rise above 14,000. Twenty miles farther north, the range becomes a very sharply crested wall, with many 13,000-foot peaks, and with its culminating points rising to 13,300 feet. This we call the Blue River group. To its northernmost and highest summit belongs the name of Mt. Powell, from the gallant explorer by whom it was first ascended in 1868. From Mt. Powell northward there are no high peaks until opposite the North Park, where the range rises again into summits of 12,000 feet and over.

West of the southern part of the Park Range is the Arkansas Valley; and beyond this valley is another grand line of heights, heretofore unnamed, and which we call the National Range. It axis is parallel with that of the Park Range, and only about sixteen miles west of it.. It ends abruptly, about 40 miles northwest of Mt. Lincoln, in a very impressive peak, about 13,400 feet high, called the Mount of the Holy Cross. This steep-sided cone with rounded top fronts the east in a dark precipice 3000 feet high, in the center of which is a brilliant white cross 1500 feet long. The form is quite perfect, and plainly visible to the naked eye at 50 miles' distance. We first saw it from Mt. Evans, and then from Gray's Peak, in the Front Range. After tremendous labor,* Mr. Jackson succeeded in obtaining admirable photographic views of the precipice and cross, from a distance not exceeding a mile.

The highest part of the National Range commences about 20 miles south of the Holy Cross, in Grand Mountain, opposite the town of Oro, in the Arkansas Valley. Grand Mt. is about 14,200 feet high, and from here to 50 miles farther south the whole range is elevated to 13,000 feet, while there are ten peaks that rise above 14,000 feet, some of them doubtless reaching 14,400. These culminating points rise at intervals of five to eight miles along the crest of the range. The one next south of Grand Mt. is Mt. Elbert; the next is La Plata Mt.; then come the peaks named by Prof. J. D. Whitney in 1869 Mt. Harvard and Mt. Yale, and so on.

The National Range is one of the grandest on the continent. Through nearly its whole extent it forms the divide between the waters of the Atlantic and Pacific Oceans.

West of this range, and connected with it, is a great group of mountains, lying in the triangle between the Grand River on the north and the Gunnison River on the south, and known as the Elk Mts. Owing to the complexity and variety of their structure, they are of the highest imaginable interest to the geologist. The part that eruptive granite can play in mountain-building is here completely demonstrated. The most elevated peaks of this group form a ridge about 30 miles long, nearly parallel with the National Range, and some 35 miles west of it. At the northern end of this line of elevation, in lat. 39° 15′ N., is Sopris Mt., a long dome-shaped ridge, about 13,000 feet high. Ten miles to the south of it is a sharp cone, overtopping all its neighbors, and rising to about 14,100 feet; this we have named the Capitol. Three miles further south is another great peak, only about 50 feet lower, which we call the

---

* Mr. Jackson, Mr. Coulter the botanist, and one packer, carried 100 lbs. of photographic apparatus for ten hours over rocks and fallen timber and up 4000 feet of steepest débris slope.

White House, from the conspicuous snow-field, about a mile in horizontal breadth and having a slope of half a mile, which covers its eastern front. This snow-mass is by far the largest we have found in the mountains of Colorado, and distinctly marks and characterizes the peak, even as seen from the Front Range, 80 miles away. Yet further south, five and ten miles respectively, are two 14,000-foot peaks, of dark red sandstone, which we call Maroon Mt. and Castle Peak.

West of this group there are no high mountains; within 20 miles the ridges change into plateaus, which fall off to the Colorado River.

We expect to publish accurate panoramic drawings of each of these four ranges; nothing but these and photographs can give an idea of their grand forms and interesting structure.

It seems very remarkable that, in a region where there are so many high peaks, the culminating points should all range between 14,000 and 14,500 feet. So far as I now know, there are 22 summits of this class in our district.

The primary and secondary triangulation, on which all the work is based, has been successfully carried through, in spite of the difficulties that attend the carrying of large instruments to the top of such lofty peaks. The 8-inch theodolite and tripod, weighing about 50 lbs., have sometimes to be carried on the back up ascents of 3,000 to 5,000 feet, over the steepest rocks. By October 1st, the primary triangulation will have been extended over 30,000 square miles.

Art. XXXIV.—*New Observations on the Dinocerata*; by O. C. Marsh.

Many additional remains of the Dinocerata have been obtained by the Yale College expedition during the past summer, and many doubtful points cleared up in regard to the structure of these animals.

1st. The dental formula of this order, so far as now known, is as follows:—incisors $\frac{0}{3}$, canines $\frac{1}{1}$, molars $\frac{6}{6}$, $\times 2=34$.

2d. The premaxillaries are not united in front, and vary much in form in different species.

3d. The lower jaw has no true proboscidean features, but resembles that of the *Hippopotamus*, especially in the great downward extension of the rami below the diastema.

4th. It is extremely probable that both sexes were provided with horns..

5th. It is possible that the osseous protuberances on the skull did not all support true horns.

6th. There were five toes in the manus, with metacarpals moderately elongated.

7th. There were but four toes in the pes, with short metatarsals.

8th. The characters of the order include marked perissodactyl, artiodactyl, and proboscidean features, the last being apparently the least developed.

9th. The geological horizon of all the known animals of this group is Upper Eocene.

A new and well marked species of *Dinoceras* is represented by a nearly perfect skull with the lower jaw entire, and by various other parts of the skeleton. It differs especially from *D. mirabilis* Marsh, the type species, in the greater proportionate width of the skull, the shorter and more massive posterior horn-cores, and the more compressed and prominent nasal cones. The species, moreover, was of greater size. The entire length of the skull was 33·0 inches. The width between outer faces of the occipital condyles was 7·8 inches, and across the zygomatic arches 13·5 inches. The lower jaw measured 11·6 inches between the outer ends of the condyles, and its length from condyle to front of symphysis was 20·8 inches. The canine of the lower jaw was smaller than the last incisor, and slightly separated from it. The three incisors decreased in size back from the symphysis, and all were directed well forward. This species is from the Upper Eocene of Wyoming, and may be called *Dinoceras laticeps*.

Fort Bridger, Sept. 1, 1873.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS AND CHEMISTRY.

1. *On the Measure of Work in the Theory of Energy.* By ROBERT MOON, M.A., Honorary Fellow of Queen's College, Cambridge.—Professor Maxwell gives the following definition and measure of work: "Work is done when resistance is overcome; and the quantity of work done is measured by the product of the resisting force and the distance throughout which that force is overcome." (Theory of Heat, 1871, p. 87.)

(1.) It is to be presumed that when the uniform force F acts throughout the time T in a given direction upon a body which is free to move in that direction, the resistance overcome by the force will be that arising from the *inertia* of the body—in other words, the resistance which the body offers to any change being effected in its state of rest or motion for the time being, and which is always proportional to the force employed in overcoming it. It follows from this, that, under the circumstances referred to, the resistance which is being overcome at each epoch of time, and therefore the work done in equal intervals of time, will be the same throughout the motion. But if the body is at rest to start with, and T is divided into n equal intervals, the work done at the end of the first interval $\frac{T}{n}$, according to the above measure, will be $\frac{1}{2}F^2\frac{T^2}{n^2}$; that done at the end of the second interval will be $\frac{1}{2}F^2\left(\frac{2T}{n}\right)^2$; that at the end of the third interval will be $\frac{1}{2}F^2\left(\frac{3T}{n}\right)^2$, etc.: and therefore the work done in the first interval $\frac{T}{n}$ will be $\frac{1}{2}F^2\frac{T^2}{n^2}$; that *during* the second interval will be $\frac{3}{2}F^2\frac{T^2}{n^2}$; that *during* the third interval will be $\frac{5}{2}F^2\frac{T^2}{n^2}$, etc. It has already been pointed out, however, that the foregoing definition of work implies that the amount of work done in equal intervals of time will be the same. It follows, therefore, that the definition and measure of work above propounded contradict each other in the case we have been considering.

(2.) Suppose a body whose mass is M to be moving in a certain direction with a velocity V_1, and that the force F is applied to the body in the direction of its motion. Professor Maxwell proves that, if during the small time T the body moves through the space s, and has acquired at the end of T the velocity V, we shall have

$$Fs = \tfrac{1}{2}(MV^3 - MV_1^2),$$

an equation, be it remembered, which holds independently of the magnitude of T, provided F be uniform.

If we put $V = V_1 + v$, we shall have

$$\text{work} = Fs = \tfrac{1}{2}M(v^2 + 2vV_1) \quad . \quad . \quad . \quad (1)$$

Now v is the pure product of the force F acting on the body M during the time T; whence it appears that, adopting the measure of work above proposed, the work done by the force F on the body M in the time T involves the variable quantity V_1, which is entirely independent alike of F, of M, and of T.

(3.) The right side of the expression (1) will always be positive so long as V_1 and v have the same sign, i. e., so long as the directions of the force and the initial velocity conspire. But if the force and initial velocity have opposite directions, and T and V_1 are both finite, the right-hand side of (1) will first be negative; as the motion proceeds it will become zero; and it will finally become and continue positive. It results, therefore, from the above measure of work, that the work done in a finite time by a finite force acting upon a body of finite magnitude which is free to move, may be zero.

(4.) The proper work of force is to generate or destroy momentum;[*] and the work done by the force in a given time will be properly measured by the momentum created or destroyed in that time.[†]

The measure thus proposed, in fact, differs from the received measure enunciated by Professor Maxwell less than might at first sight be supposed; for when T is very small, (1) becomes

$$\text{work} = Fs = Mv \,.\, V_1.$$

Thus, while I contend that the work done in a short interval of time under the above circumstances is properly measured by the momentum generated during the time, according to the views upon the subject which are generally received, it is measured by the product of the momentum generated and the initial velocity V_1—a position the reasonableness of which, I apprehend, it will be found difficult to establish.

(5.) If, instead of expressing the work done in terms of the force acting and the time during which it acts, we wish to express it in terms of the force and of the space described under its influence, we have only to replace T in the expression FT by its equivalent in terms of the other variables. This, where the body moves from rest, would give us $\sqrt{2MFs}$ as the measure of the work done by the force F on the body M while moving through the space *s.*—*Phil. Mag.*, Sept., 1873, p. 219.

2. *Sull' Ozono; Noti e Riflessioni, di* GIUSEPPE BELLUCCI, Dottore in Storia Naturale, Professore nel R. Istituto Industriale e Professionale di Terni. Prato, Tipografia Giachetti, Figlio e C. 1869, pp. 456, 8vo.—In this volume, Signor Bellucci, who is now Professor in the University of Perugia, gives a very interesting and valuable *résumé* of the researches upon the subject of ozone, which have occupied the attention of chemists for so many years. The author has drawn his material from the original contributions of the numerous investigators, the sources being carefully indicated by foot-notes. The discussion is divided into five parts, a summary of which will give an idea of the scope and general character of the work.

Part first traces the progress of discovery *in re* ozone from the time of Van Marum, who in 1783 observed the peculiar odor communicated to oxygen by the passage of the electrical dis-

---

[*] No doubt force has another effect—that, namely, of causing a body to describe, or of preventing its describing, space: but of these two effects, viz., the description of space and the generation of momentum in any indefinitely small interval of time, the former will be of a lower order of magnitude than the latter; while, of the small space actually described in the interval, all but an indefinitely small portion will have been described under the influence of the velocity from time to time generated during the interval; the residuum immediately due to the direct action of the force, and in no degree resulting from acquired velocity, being of the *third* order of small quantities at most.

[†] From this it follows that the work done by the force F acting during the time T on a body which is free to move will be measured by FT.

charge, and a year or two later noticed that simultaneously with this effect a diminution of the volume took place, but without having an idea of the significance of these facts, to those of modern chemists, who have so thoroughly cleared up the obscurities which for a long time surrounded this difficult subject.

In part second the author treats of the physical and chemical properties of ozone, and its action upon the animal economy.

In part third are discussed the various modes of producing ozone, and its occurrence in nature.

Part fourth is an exposition of the theoretical views of various chemists relating to the so-called antozone. This is one of the most valuable portions of the book, and it is interesting to see, that from a thorough discussion of the subject, the author concludes that the experiments and theories which were supposed by many to confirm the assumption of an allotropic condition of oxygen antagonistic to ozone are unsound, and that the supposed antozone has in fact no existence. It must be noticed too that the book was published before the more recent researches, especially those of Engler and Nasse, had conclusively proved that the reactions formerly attributed to antozone were really due, in most cases, to the presence of hydrogen peroxide.

In part fifth, he discusses, by comparison, the properties of ozone, of ordinary oxygen, and of oxygen in the nascent or atomic state, with interesting theoretical considerations suggested by the various facts which have been observed.

Although bearing the modest title of "Notes and Reflections," the work is really a full and satisfactory exposition of the theoretical part of the subject, and places under obligation to the author a large class of readers who are interested in ozone and its uses.

Prof. Bellucci has also published more recently a *brochure* upon the subject of the "Hypochlorites as a new Source of Ozone" (Florence, 1873), and another upon "The supposed Emission of Ozone from Plants" (Palermo, 1873), in which, from the fact that his experiments gave negative results, he concludes that the oxygen emitted by plants does not contain an appreciable proportion of ozone. A. W. W.

II. GEOLOGY AND NATURAL HISTORY.

1. *Mountain Making.*—On page 172 the principle that the bottom of a geosynclinal becomes weakened, as subsidence and surface accumulation go forward, through the rise of the isogeotherms, and that "this in an important degree has made possible the catastrophe in which synclinoria have resulted," is attributed to Prof. LeConte. I should have credited to Prof. T. Sterry Hunt the idea of the weakening of the bottom of a geosynclinal in the manner stated. To this idea, Prof. LeConte added the view that through such a weakening, lateral pressure from the earth's contraction (a force not appealed to in Prof. Hunt's hypothesis) was enabled to produce the catastrophe referred to, and this is the important principle adopted from his memoir. J. D. D.

2. *Cretaceous of Long Island.*—In a notice of the United States geological map of Hitchcock and Blake, on page 64 of this volume, the representation of Long Island as Cretaceous is objected to. Prof. Hitchcock writes us that the authors were guided in their decision on this point, not merely by the report of Prof. Mather on the subject, but also, by more recent and satisfactory observations. Prof. Mather, in his New York Geological Report, bases his conclusion on the existence of a bed containing lignite beneath the drift, and on the fact that shells and some bones had been obtained at various times in digging wells and other ways, although he was unable to find any specimens of the shells or bones in the hands of those who reported such discoveries and knew nothing whatever of the species. Three pages of the report are occupied with statements of facts of discoveries having this indefinite geological value. The evidence was so incomplete that the Cretaceous of Long Island does not appear on the geological maps of either Prof. James Hall or Sir William Logan. We understand that there are recent discoveries which will place Prof. Mather's conclusion on a better foundation. J. D. D.

3. *On the Copper Deposits of the Blue Ridge.*—In my last letter I gave some account of the Ore Knob Copper Mine, in Ashe County, North Carolina, where I then was. I have since examined the copper deposits of Polk County, Tennessee, and Carroll County, Virginia. The first of these are the well-known Ducktown mines, which were well described in the report of Messrs. Trippel and Credner to the American Bureau of Mines in 1866. In this, as in the earlier published reports of Messrs. Whitney, Blake, and others, these deposits of Ducktown are indicated as conforming in dip and strike with the enclosing mica-schist, and not as fissure-lodes. Notwithstanding their apparent intercalation, I am, however, disposed to regard them not as comtemporaneous with the strata, but as subsequent deposits in rifts or fissures. This relation of contemporaneous or posterior deposition is evidently the fundamental distinction in mineral deposits; and in the latter case it is but a secondary consideration whether the opening in the strata, in which the endogenous mineral mass has been formed, is transverse or for greater or less distances conformable to the stratification. It is doubtless in some cases difficult to distinguish between the contemporaneous impregnation of a sediment, as in certain foreign copper-slates and some analogous deposits in various crystalline schists, and the penetration by diffusion, which often attends the subsequent deposition of a metallic ore in fissures, since in the cases where these conform to the strata, the local impregnations sometimes give the aspect of a passage from the bedded lode to the adjacent rock. Fine samples of lodes, intercalated for considerable distances with the strata, are seen in the granite veinstones which abound in the gneisses and mica-schists of the Montalban or White Mountain series in some parts of Maine, as described by me in the *American Journal of Science* for March, 1871; and also in the thin parallel veins which, at

Winslow, in that State, carry cassiterite and mispickel in a gangue of fluor, quartz and mica, and are intercalated between the beds of a micaceous limestone with great regularity, and only here and there are seen to traverse the beds, thus revealing their posterior origin. These were described and exhibited by me at the meeting of the Institute of Mining Engineers in February last. In both of these cases, however, the endogenous character and posterior origin of these deposits is evident from their structure and mineral composition, and it is in like manner that, after a careful study of the Ducktown copper deposits, and a comparison of them with others in Virginia and North Carolina, I feel constrained to regard them as having been formed in the midst of the strata, and as apt, in any part of their distribution, to appear as transverse veins. There are, it is true, in their immediate vicinity, impregnations in the mica-schists which simulate closely those of contemporaneous origin, but the great masses of pyritous ores and associated minerals, as disclosed in the deep workings at the East Tennessee Mine at Ducktown, have all the characters of true veinstones. The massive pyrrhotine and chalcopyrite which form the metalliferous portions of the deposit are traversed by large crystals of zoisite, hornblende and pyroxene, the latter sometimes an inch in diameter and six inches in length. The hornblende crystals are often curved, and sometimes partially broken across, and their transverse fissures filled with sulphurets, which are also occasionally interposed between the cleavage planes of the augite crystals. These silicates are sometimes incrusted with chalcopyrite, with galena, with blende, and more rarely with crystallized pyrrhotine; molybdenite is also met with. But for these associations it would be impossible to distinguish specimens of these silicates from those met with in the great Laurentian veinstones so well known to mineralogists, and the resemblance to the latter is still more complete in the great masses of coarsely cleavable white augite rock which form portions of the veinstone, and in others which are an aggregate of long prisms of greenish hornblende imbedded in a gangue of white crystalline calcite. With these are associated varieties of finely fibrous hornblende, greenish, brownish and snow-white in color. The disposition of these is more or less regular, and in some cases, at least, parallel to the plane of the lode. In one instance a layer of prisms of white hornblende, two or three inches in length, is arranged in a columnar manner transverse to the wall, the interstices being filled with chalcopyrite. Layers of vitreous translucent quartz, with enclosed masses of sulphids, are also found, having all the aspects of ordinary quartzose veinstones. A pale cinnamon-colored garnet, sometimes in crystals half an inch in diameter, is also met with imbedded in quartz, or more frequently in chalcopyrite. The latter also sometimes includes large and fine crystals of mispickel. A collection of the various minerals and mineral aggregates from the present workings at the East Tennessee Mine would, I think, convince the student familiar with veinstones that this great deposit, whatever its attitude in regard to the enclosing rocks, is of posterior formation and identical in the mode of its formation with ordinary concretionary veins. Similar evidences, though less completely displayed, are seen at the Isabella and Mary Mines, which are opened on lodes distinct from the East Tennessee Mine.

It is worthy of remark that the garnet here met with is identical in color and in aspect with that found associated with the copper ores of the Ore Knob Mine in Ashe County, North Carolina; and that, passing thence into Carroll County, Virginia, the interstratified copper lodes there found, which are apparently identical with those of Ducktown, are often bounded by layers of vitreous quartz, which sometimes forms large crystals, rounded on the angles and incrusted with metallic sulphids. Similar specimens occur in the clearly transverse lode of Ore Knob. In the Carroll County deposits, fragments of the mica-schist which forms the enclosing rock are found imbedded in the sulphids of the lode, and the contact of the wall-rock with the layer of quartz is perfectly well defined. It should be said that both here and at Ducktown the country rock, like that at Ore Knob, presents the characters of the White Mountain series. Mica-schists, occasionally with garnet, staurolite and kyanite, predominate, and are associated with a blackish or blue-black hornblendic gneiss, and a fine-grained grayish-white gneiss, which at depths where decomposition has not penetrated, resembles the beautiful granitoid gneisses, so much used in Maine and New Hampshire. A stone of this kind is quarried near Hillsville, in Carroll County.

The great ore deposits of Ducktown are certainly very variable in breadth, ranging from 300 feet to not more than twenty. They are, according to Credner and Trippel, occasionally pinched out in their longitudinal extension, and so succeeded by others as to allow of their being described as lenticular masses, arranged *en échélon*. At the same time the length of these is very considerable; one at Ducktown has been worked continuously for black ore for nearly a mile, and another has been opened for a still greater distance in Carroll County, Va.

The curious phenomenon of the black ores of these deposits has often been described, and there seems no reason to question the received explanation that they owe their origin to a reduction, by some as yet unexplained process, of the sulphates formerly generated by oxidation in the upper portion of the lodes, which, as is well known, is changed into a porous mass of hydrous peroxide of iron holding more or less oxides and green carbonate of copper in its lower portions. The analyses by Trippel and others have shown that this black ore is chiefly a sulphid, in which iron sometimes predominates, while more generally it contains a large proportion of copper, and approaches in composition to copper-glance, crystals of which species, according to Mr. August Raht, occur in druses in some varieties of this ore, which, in other cases, approaches more nearly to erubescite or calcopyrite in its composition. Some masses of these ores hold grains of native copper or crystals of red oxide, while copper-vitriol, as a result of oxidation, often impregnates these more or less porous or cellular ores, the drainage-waters from which yield considerable quantities of the salt. The product of cement copper obtained at Ducktown by passing the water from certain of the workings over scrap iron is equal to about 5,000 pounds monthly, and the waters hold, in some cases, as much as one part in 1,000 of copper, though generally more dilute.

The study of these deposits in Ducktown and in Virginia has convinced me that the rich purple, gray and black sulphurets of the Ore Knob Mine, described in my last letter, are of secondary origin, though originating in the alteration of a lode of yellow copper ore of phenomenal richness.

These so-called black ores are found in direct contact with the unchanged sulphids of the Ducktown lodes, and it is by an error that the constant existence of a zone of pyrites free from copper, between the overlying black ores and the productive masses of yellow copper beneath, has been asserted. The fact is that these great pyritous lodes vary in composition in different parts, both laterally and vertically; and it has sometimes happened that a portion comparatively poor in copper has been met with just below the black ores, while elsewhere, as at the Mary Mine in Ducktown, excellent yellow ores are found in that position. The breadth of these deposits is very great; the chief western lode at Ducktown varies from twenty to ninety feet, while the great middle lode, on which the Isabella and Eureka Mines are situated, attains more than 300 feet. All portions of these immense lodes not being equally rich in copper, it has been found advantageous, for the purpose of exploring them and of determining what parts may be mined with the greatest profit, to make use of the annular diamond-drill which has just been employed at Ducktown with remarkable success. The great 300 foot lode, dipping to the southeast at a high angle, has been traversed by two borings nearly at right angles to the plane of the lode, and the inspection of the ores removed shows the existence of two large bands of workable copper ore interposed in the enormous mass of pyrites, which require only to be opened by a shaft to greatly augment the produce of this region. Some details of the mining and smelting of these ores, together with observations on the future importance of these deposits as sources both of copper and sulphur, and on the not less valuable and more accessible lodes of a similar kind in Southwestern Virginia, must be reserved for a third letter.—*Engineering and Mining Journal, N. Y.* T. STERRY HUNT.

Boston, July 25, 1873.

4. *On the Situation and Altitude of Mount Whitney*; by W. A. GOODYEAR, C.E.—On the 27th day of July, 1873, Mr. M. W. Belshaw, of Cerro Gordo, and myself, rode our mules to the highest crest of the peak southwest of Lone Pine, which, for over three years now, has been known by the name of Mount Whitney, and which was ascended and measured as such by Mr. Clarence King, in the summer of 1871. A full account of Mr.

King's ascent of this peak is given in his "Mountaineering in the Sierra Nevada," pp. 264–281.

I know this peak well, and cannot be mistaken as to its identity. As seen from Lone Pine, it appears perhaps the most prominent peak in the whole Sierra; and during the summer of 1870, when, in company with Mr. C. F. Hoffmann and Mr. Alfred Craven, I made a trip for the State Geological Survey through Owen's Valley and the Inyo Mountains, this peak was the object of constant observations by us for a month or more, under the name of Mount Whitney,—which we then supposed it to be. Moreover, since Mr. King's ascent of it in 1871, the half dollar which he left at the summit has been found there, with his name inscribed upon it. There can, therefore, be no mistake as to the identity of this peak with the one ascended and measured by Mr. King in 1871.

I do not mention the fact that Mr. Belshaw and myself reached its summit in the saddle as being one of any new or special interest; for Mr. Sheriff Mulkey, of Inyo County, accomplished the same thing on the 6th day of August, 1872, with his family (i.e., his wife and daughter), and since that time it has also been done by several other parties.

But there is some interest in the fact discovered by Mr. Belshaw and myself, when we reached its summit—that *this peak is not Mount Whitney.*

It is by no means the highest among the grand cluster of peaks which form this culminating portion of the Sierra Nevada; *nor is it the peak which was discovered by Prof. W. H. Brewer and party, in* 1864, *and then originally named by them Mount Whitney.*

For the truth of such a statement as this, after the mountain has become so famous, I shall of course be expected to produce my evidence.

How, then, in the first place, do I know that this so-called Mount Whitney is *not the highest peak* in this vicinity?

First, because on reaching its crest the fact is at once not only apparent, but very striking, even to the unaided eye alone, that a peak which bears N. 67° W. magnetic, distant between five and six miles from the observer, is considerably higher than the one on which he stands. * * *

My second proof of the relative altitude of these two peaks is the following:

I had no spirit-level with me; but I did have a miner's compass, 3¾ inches square, with a clinometer attached. On setting the index of the clinometer at zero, and then sighting along the upper edge of the plate, the line of sight struck far below the summit of the other peak. Then, on reversing the instrument end for end, setting the clinometer again at zero, and sighting along the upper edge of the plate as before, the line of sight, though it struck a little higher than before (thus showing a slight error in the instrument), nevertheless still struck far below the peak. This, if the sighting along the edge of the plate was correctly done, is proof positive that the distant peak is the higher.

But we applied still a third test. While I was busy with my notes, Mr. Belshaw improvised a still more perfect level, by taking a pint cup, four inches in diameter, and filling it *heaping full* of water—i.e., so that the water stood higher than the edge of the cup all around the rim, yet without overflowing. When this was done, it became at once evident, on sighting across the smooth surface of the water, that the other peak was higher than the one on which we stood by an amount which we both of us estimated to be *not less than* 500 *or* 600 *feet.*

As to the proofs that the peak which we climbed *is not the one originally named Mount Whitney by Professor Brewer's party, in* 1864, they are numerous; and among them are the following:

In the first place, Mr. Clarence King, in 1864, on reaching the summit of Mount Tyndall, remarks as follows, in the Geological Survey Report (Geology, vol. 1, p. 386):

> "On setting the level, it was seen at once that there were two peaks equally high in sight, and two still more elevated—all within a distance of seven miles. Of the two highest, one rose close by, hardly a mile away; it is an inaccessible bunch of needles, and we gave it the name of Mount Williamson. The other, which we called Mount Whitney, appeared equally inaccessible from any point on the north or west side; it is between seven and eight miles distant, in a south-southeast direction, and, I should think, fully 350 feet higher than our peak." (Further investigation showed that it was really 600 or 700 feet higher than Mount Tyndall.)"

Now, the peak which we climbed is certainly not 350 feet higher than Mount Tyndall, but very nearly the same altitude. In fact, as closely as we could judge by our water-level at such a distance, Mount Tyndall appeared a *trifle* the higher of the two. Moreover, this peak, instead of being between seven and eight miles distant in a south-southeast direction from Mount Tyndall, is between twelve and thirteen miles distant from it, in a direction about S. 37° E. true course; while the genuine Mount Whitney (i.e., the highest peak) is actually distant from Mount Tyndall only about seven and one-quarter miles in a direction about S. 26° E. true course—thus corresponding exactly with this remark of King's in 1864. It is evident enough that this difference between seven or eight and twelve or thirteen miles air-line distance involves an error which Mr. King would have been by no means likely to make in his estimate of the distance in 1864; while the direction S. 26° E. also corresponds far more nearly to Mr. King's words, "a south-southeast direction," than the course of S. 37° E. does.

Again, after Mr. King's ascent of Mount Tyndall, and the return of the party to Visalia, Mr. King made another excursion into the mountains, leaving Visalia, July 14, 1864, for the purpose of making an attack on Mount Whitney. He followed from Visalia a trail, which appears, so far as his description and my information give the means of identifying it, to have been the present Hockett Trail, to the point where it crosses the main Kern River. From this point Mr. King followed some route among the upper branches of the Kern River, which he has not described with sufficient clearness to enable it to be accurately traced on any map with which I am acquainted in the Geological Survey Office, or elsewhere, to the base of Mount Whitney. In his attempt to scale the summit of the mountain, he did not at the time succeed. But the highest point which he reached, as indicated by his barometric observations, was, "according to the most reliable calculations, 14,740 feet above the sea-level." And "at the point where this observation was taken, he was, as near as he was able to estimate, between 300 and 400 feet lower than the culminating point of the mountain, which, must, therefore, somewhat exceed 15,000 feet in height."

Now, although I do not recollect the exact figures which Mr. King's observations in 1871 gave for the height of the peak which he then measured as Mount Whitney, and to whose summit Mr. Belshaw and I rode the other day in the saddle, I do recollect, with certainty, the fact that these figures were a little less than the altitude of the point which he actually reached in 1864, when he was still, according to his own estimate, "between 300 and 400 feet lower than the culminating point" of Mount Whitney.

Here, then, there was a discrepancy of at least 300 or 400 feet, and probably somewhat more, between Mr. King's barometric results in 1864, and his results in 1871; a discrepancy hitherto utterly unaccounted for, and, if the two peaks were identical, unaccountable, except by supposing the existence of errors of a magnitude which is, to say the least, extremely improbable, in the whole method of computing high altitudes from barometric observations. This strange discrepancy vanishes at once when the fact is recognized that, in 1864, Mr. King was attempting a different and a higher peak than the one he climbed in 1871.

Moreover, the shape of the peak and the surrounding country fully justifies me in making the statement that neither Mr. King, nor any other good mountain climber, would ever have reached a point within three or four hundred feet of the summit of the peak which he measured in 1871, and then have given it up in despair. If he had approached this mountain from anywhere on the north or northwest sides, he could never have reached a point so near the summit; for the precipices in these directions are tremendous, for at least a thousand to fifteen hundred feet below the crest; and on the other hand, if he had approached it anywhere from W.S.W., around by south to southeast, he would have gone directly to the summit with no difficulty whatever; for in all these directions the slopes are comparatively smooth and easy.

The following remarks from the Geological Survey Report (Geology, vol. i, pp. 390 and 391), and for which Mr. King's notes of 1864 also furnished the material, will be sufficient additional proof, I think, of the fact, that the peak which for three or four years has borne that name is not the one originally named Mount Whitney:

"Mount Whitney is a ridge having somewhat the outline of a helmet, the perpendicular face being turned toward the east.

There is snow on the summit, which indicates that there must be a flat surface there. The mountain is the culminating point of an immense pile of granite, which is cut almost to the center by numerous steep and almost vertical cañons, ending in high-walled amphitheaters. Southward of the main peak, there is a range of sharp needles, four of which are over 14,000 feet high. The general aspect of the group is much like that of Mount Tyndall. This mountain has been approached on all sides except from the east, and found to be utterly inaccessible. Mr. King thinks it possible, however, that some route may yet he found by which the summit can be reached."

Now, this description corresponds in every respect, so far as Mr. Belshaw and I could see and judge, with the grand peak to the northwest of us—the original Mount Whitney; and it does not correspond at all with the one we were on, and which by mistake has borne the name so long.

Mount Whitney, having "its perpendicular face turned toward the east," looks from Lone Pine like a pretty sharp conical peak. The other peak shows the "helmet outline" from Lone Pine, and its perpendicular face is turned toward the north and northwest instead of the east; while the true Mount Whitney, as seen from the summit of this peak, assumes again the "helmet outline," with the steepest bluff to the eastward.

Again, the peak we climbed is not cut anywhere near to the center by cañons, either numerous or steep, on the south or southwest sides. Furthermore, there is no vestige of a range of "sharp needles" to the south of it, or of anything that could suggest such an idea; while immediately to the south of the towering peak, northwest from the one we climbed, there is precisely such a range of tremendous and utterly inaccessible crags and turrets, and sharp and lofty pinnacles.

The mountain which we climbed also, instead of being inaccessible "on all sides except from the east," is, as already stated, very easily accessible from anywhere from W.S.W., around by south to southeast.

In the face of all these facts, though it may be possible, yet it certainly seems hardly credible, that Mr. King, familiar as he was, or at least ought to have been, long previous to 1871, with the general appearance of the whole region of country immediately to the north and northwest of Mount Whitney, should, on reaching in 1871 the summit of the peak to whose crest Mr. Belshaw and I lately rode our mules, have failed to recognize at once the fact that he was on a lower and different peak from the one he had attempted in 1864. And yet, on the other hand, if he did recognize this fact, then why, on his return from the trip which he made in the summer of 1871, for the special purpose of climbing and measuring Mount Whitney, did he not make it known and give it publicity?

In any case, the fullness of detail with which Mr. King, in "Mountaineering in the Sierra Nevada" (pp. 277 and 278)—

while standing, in reality, on a peak over five miles distant from the one which he says was under his feet—appears to recognize all the topography of the scenes of his earlier struggles, and of his attempts to reach the summit of Mount Whitney, in 1864, is something interesting.

Certain it is, however, that the peak which for over three years has borne the name of Whitney, has done so only by mistake, and that a new name must be found for it; while the name of Whitney must now go back to the peak to which it was originally given in 1864, and which, is, in reality, the highest and grandest of this culminating cluster of the Sierra Nevada.

Furthermore, it appears that Mount Whitney not only retains its claim to being the highest point of land in the United States of America, but that its claim to over 15,000 feet of absolute altitude above the sea is still indisputable; while, up to the present time, it also retains the prestige of the fact that, in all probability, no human foot has ever trodden its summit.

If Mr. King's descriptions, in 1864, of the appearance and surroundings of this mountain on the north and northwest can be relied upon, it is safe to say that no man will ever ride a horse or mule to the summit of *that* peak, unless it be by a costly as well as a dangerous trail.

Whether the peak is utterly inaccessible or not, is still a question. I am disposed to think that it can be climbed; but it will certainly involve a great deal of hard and, very possibly, some dangerous work for anybody who shall attempt to reach its gigantic crest.

NOTE.—Aug. 6: I have just received from Mr. Belshaw the results of a rough triangulation made by him from Cerro Gordo to the summits of the two peaks in question, since my return.

The figures given by this triangulation, though not to be relied upon as very accurate, are still sufficiently so to show clearly the relative situation of things, and to furnish additional confirmation of the facts as stated in the above paper.

He makes the air-line distance from Cerro Gordo to the peak measured by Mr. King, in 1871, in a course S. 72° W. magnetic, 25 miles, and the altitude of this peak 14,033 feet. The distance to the genuine Mount Whitney he makes 30·18 miles, in a direction S. 80° 5′ W. magnetic, and its altitude 14,930 feet.

Both these altitudes are probably too low; but there can be no question as to which is the higher peak.—*Proc. Cal. Acad. Sci.*, Aug. 4, 1873.

5. *Sixth Annual Report of the U. S. 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 F. V. HAYDEN, U. S. Geologist. 844 pp. 8vo. Washington, 1873. Conducted under the authority of the Secretary of the Interior.—Dr. Hayden's Report for 1872 comes laden with valuable information from the mountains. His explorations are rapidly extending our knowledge of the topography and resources of the mountain territories, and not less enlarging the bounds of science. The region of the headwaters of the Yellowstone has now excellent maps, lakes their right positions and connections, and a park, rendered attractive by the most wonderful fountains the world contains, has been opened to

the public. The volume commences with the special report of Dr. Hayden, containing new facts, both economical and scientific, from the region of the geysers, and the country surrounding, with a reconnoissance of the mining region on Clark's Fork of the Yellowstone, and a partial résumé of previous investigations. New sketches of scenery are contained in the volume, with several new maps, and many geological sections. Dr. Hayden states in his introduction that a large series of maps will soon be got out by Mr. G. R. Bechler, the topographical surveyor of the expedition, only some of the smaller of which appear in this volume.

The Report of Dr. Hayden is followed by those of other members of the expedition.

A. C. Peale describes the geological and mineralogical character of the region visited, giving details with regard to the features and mineral products, and the hot spring regions, the composition and temperature of the waters, composition of the siliceous depositions, the character of the eruptions and their craters, together with various geological facts of value, and a list of the minerals and rocks obtained in the course of the survey.

The Report of Frank H. Bradley, geologist of the Snake River division, announces, among its many interesting facts, the discovery of the Quebec group (the age between that of the Calciferous sandrock and Chazy limestone) in Wyoming Territory —rocks hitherto not found out of Canada excepting by Prof. Bradley near Knoxville, East Tennessee. An abstract of the report of Prof. Bradley, by himself, has been already given on pages 194 to 206 of this volume.

The physical geography and agricultural resources of Minnesota, Dakota and Nebraska, are well described in the following report by Cyrus Thomas.

Part II. is occupied with special Reports on Geology and Paleontology.

Mr. L. Lesquereux has an admirable Report on the Coal or Lignitic formation of the Rocky Mountain territories, and its flora —as already announced in this volume. The subject is discussed with great thoroughness, and over a hundred new species of fossils are described.

H. M. Bannister gives a report of a geological reconnoissance along the Union Pacific Railroad.

Then follows the Paleontological Reports of F. B. Meek, describing the Paleozoic and later formations, and their invertebrate fossils; of E. D. Cope, on the extinct vertebrates (mammals, reptiles, and fishes) of the Wyoming Eocene, with notes on the geology, illustrated by two plates of the *Synoplotherium lanius* Cope, and four of the *Loxolophodon cornutus* Cope; also a paper on primitive art in the Bridger Basin, by J. Leidy, and another on the ancient mounds of Dakota, by C. Thomas.

Part III. consists of special reports on the zoology and botany of the territories: on the mammals and birds of the expedition, by C. H. Merriam; the Coleoptera, by G. H. Horn; Orthoptera, by

C. Thomas; the Odonata, by H. Hagen; New Mallophaga, new parasitic worms found in the brain and other parts of bodies of birds, new insects, and on the insects of the Great Salt Lake, by A. S. Packard, Jr.; Botany, by J. M. Coulter; Cyperaceæ, by S. T. Olney; Graminaceæ, by G. Vasey; Musci, by L. Lesquereux; Lichens, by H. Willey; Fungi, by C. H. Peck.

Part IV. contains the report on astronomy and hypsometry of H. Gannett, giving a great number of heights along different routes over the mountains, besides other information; notes on the climate of Montana, by Granville Stuart, and a résumé of meteorological observations at Fort Ellis, Montana.

Besides working himself, as has been seen, Dr. Hayden has had the coöperation of some of the ablest scientific men of the country. We propose to cite from the volume at another time.

Dr. Hayden has recently been elected a corresponding member of the Academy of Sciences at Liége.

6. *The Geological evidences of the Antiquity of Man, with an outline of Glacial and Post-tertiary Geology, and remarks on the origin of species with special reference to Man's first appearance on the earth;* by Sir CHARLES LYELL, 4th edition, 572 pp. 8vo. 1873. London and Philadelphia (John Murray, London; J. B. Lippincott & Co., Philadelphia).—This 4th edition of Lyell's well-known work on the Antiquity of Man brings the subject down to the present year. The author's wide range of observation, and his extreme care in sifting facts, and gathering in all that is pertinent, make his works a reliable and to a large extent an original source of information for all who wish knowledge on the subject, whether they agree with him in some of his conclusions or not. The volume is printed in the best style, and has a number of good illustrations.

7. *Geological Survey of Wisconsin.*—The government of Wisconsin has authorized a geological survey of the State, and it has been going forward through this summer. The geological corps under appointment consists of—Chief, I. A. LAPHAM, LL.D., Milwaukee; Asst's, ROLAND D. IRVING, A.M., E.M., Madison, T. C. CHAMBERLIN, A.M., Whitewater, MOSES STRONG, A.M., Mineral Point; Chemist, W. W. DANIELLS, M.S., Madison.

8. *Pareira Brava*, the root of which, once famous in medicine, is still important, has long been generally supposed to be *Cissampelos Pareira.* In the Pharmaceutical Journal, August, 1873, Mr. Hanbury convincingly makes it clear that the source of the root is *Chondodendron* (or more correctly *Chondrodendron*) *tomentosum* of Ruiz and Pavon. With this accords the Portuguese name, *Parreira*, signifying "a vine that grows against a wall or over an arbor," and *Pareira Brava* is equivalent to Wild Vine. The foliage of the true plant is not unlike that of the vine, and the fruit resembles a bunch of grapes. A wrong and perfectly inert root has of late years come into the market—not however a *Cissampelos;* but the true root now being known, it would advantageously replace the worthless kind found in the drug trade.

A. G.

9. Elias Durand died at his residence in Philadelphia, on the 14th of August, in this year, so fatal to American botanists. He was one of the oldest, having been born at Mayence, France, on the 25th of January, 1794, and was therefore in the 80th year of his age. He used to tell how he was baptized into botany upon the field of the battle of Leipsic: while serving as *aide-Pharmacien*, the medicine wagon under his charge was brought to a halt almost under fire on the edge of a bog, where he first saw and collected *Menyanthes trifoliata*, and so began his herbarium and the botanical study, which he kept up with order and delight until the failure, first of eye-sight and then of his mental powers, a year or so ago. He had amassed a large and very valuable North American herbarium, which, about five years ago (after consulting the writer of this notice), he presented to the museum of the *Jardin des Plantes* at Paris, desirous, like a true son of France, to do something by which his favorite science might be advanced, and his name honorably remembered, in his native land. No sooner was this, the work of a long life-time, safely deposited in its appropriate final resting place, than Mr. Durand began to devote the remainder of his energies to the formation of a supplementary herbarium, which, when he could do no more, was lately sent on to Paris.

Mr. Durand's principal botanical writings are his *Plantæ Hermannianæ*, and *Plantæ Pratteniannæ*, accounts of interesting Californian collections which were published first in the Journal of the Academy of Natural Sciences, and then, more fully and with plates, in the Pacific Railroad Exploration Reports; also a sketch of the Botany of the Basin of the Great Salt Lake of Utah, and enumeration of the plants collected by Dr. E. K. Kane in his first and second expeditions to the Polar regions, also contributed to the Journal of the Academy of Natural Sciences.

Mr. Durand came to the United States in the year 1806, was for some years chief clerk and afterward a partner in Mr. Ducotel's druggist establishment in Baltimore, but in 1825 he established himself as an apothecary and druggist in Philadelphia, where his store, at the corner of Sixth and Chestnut streets, soon became renowned, and its proprietor took rank at the head of his profession. He pursued it as a learned profession, secured the unlimited confidence and regard of the distinguished medical men of the city, as well as of the public; and, as age drew on, retired with a handsome competency to the more exclusive pursuit of his favorite science. He has been an active correspondent, friend, and helper of all the principal botanists of the country, from Zaccheus Collins and Nuttall down to those who have but lately entered upon the field. With Torrey, whom he has so soon followed, and with his associate, the writer of this notice, his relations were continual and intimate. The frequent mention of his name on the pages of their works bears honorable but very inadequate testimony to his botanical services and usefulness. All those who, like the survivor, were honored by his friendship, will hold in affectionate remembrance the charming personal qualities, the unselfish zeal, the genial kindness, and the true benevolence of the good old man who has now gone to his rest. A. G.

August 18th.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Meeting of the American Association for the Advancement of Science, at Portland, Maine, commencing Wednesday, August* 20, 1873.—The meeting of the Association at Portland was very largely attended, and, with few exceptions, excellent in its scientific papers. Professor Joseph Lovering of Cambridge was President. The members had a generous reception from the citizens of Portland, and enjoyed much the excursions which had been projected for the week. The Association adjourned on Tuesday, August 26, to meet at Hartford, Conn., on the second Wednesday of August, 1874. The officers elected for the next meeting are Dr. J. L. LECONTE of Philadelphia, Prof. C. S. LYMAN of New Haven, Dr. A. C. HAMLIN of Bangor, General Secretary, and Mr. F. W. PUTNAM of Salem, Mass., Permanent Secretary.

The following are the titles of the papers accepted for reading at the sessions.

On the Possibility of a Liquid Solar Envelope; C. A. Young.

Rotation of the Planets as a Result of the Nebular Theory; B. Peirce.

Relation of Internal Fluidity to the Precession of the Equinoxes; J. G. Barnard.

On the Equilibrium and Dynamic Theories of the Tides; J. G. Barnard.

Meridianal Arcs Measured in the Progress of the Coast Survey; J. E. Hilgard.

On the Longitudes of Greenwich, Paris, and Harvard Observatories, determined by the U. S. Coast Survey; J. E. Hilgard.

On Solar Disturbances of the Magnetic Needle; J. E. Hilgard.

On Methods of Determining the Ratio of Volume and Weight of Water; id.

A New Curve; T. Hill.

Three Equations Partially Discussed; T. Hill.

An Attachment to the Whirling Table for projecting Lissejous' Curves; A. E. Dolbear.

On the Convertibility of Sound into Electricity; A. E. Dolbear.

A New Method of Measuring the Velocity of Light; A. E. Dolbear.

On the Periodic Error of the Right Ascensions of the Nautical Almanac, and its Effect on the Longitudes which depend on them; W. A. Rogers.

The Coefficient of Safety in Navigation. An attempt to ascertain within what limits a ship can be located at sea by astronomical observations; W. A. Rogers.

Musical Flow of Water; H. F. Walling.

Dissipation of Energy; H. F. Walling.

Remarks on a projected Gigantic Telescope; P. H. Van der Weyde.

Microscope with a new style of Micrometer, and Remarks on the Method of enlarging the Field; id.

Investigation into the True Cause of a peculiar form of Mirage; id.

On the Telescopic Study of the Solar Photosphere; S. P. Langley.

Angular Aperture of Immersion Objectives for the Microscope; R. H. Ward.

The Cohesion of Liquids; G. J. Wardell.

The Telescope and the means of improving it, and also the Utilization of Solar Heat; G. W. Holley.

Dissociation of Water by Heat as a cause of steam-boiler explosions; L. Bradley.

The Chemistry of Copper Matte; T. S. Hunt.

On the Silt Analysis of Soils and Clays; E. W. Hilgard.

Analysis of Mississippi Soils and Sub-soils; E. W. Hilgard.

On the Distribution of Soil Ingredients in the Sediments obtained by silt analysis; R. H. Loughridge.

On the Influence of Strength of Acid and Time of Action on the Results of Chemical Soil Analysis; R. H. Loughridge.

The Atmospheric Electricity of the Earth, of the Sun, and of the Comets; and the Physical Constitution of the Sun and of the Comets; J. Ennis.

New Theory of Geyser Action; E. Andrews.

Cold Water Condensers; J. B. Walker.

On Heating Iron by Hammering; F. W. Clark.

Plate Lime-glass, and the Manufacture of Glass; L. Feuchtwanger.

An Automatic Filtering Apparatus. Presentation of the Apparatus at work, described in May number of Am. Jour. Sci.; H. W. Wiley.

Automatic Registering and Printing Thermometer; G. W. Hough.

Automatic Registering and Printing Evaporator and Rain Guage; id.

Tornadoes of Illinois; M. L. Comstock.

On the Storms of Western Illinois; M. L. Comstock.

Peculiar Formations of Wind in Local Thunder Storms; H. A. Cutting.

The Arctic Regions; W. W. Wheildon.

On the Unification of Doses and the Introduction of the Metric System into Medicine; H. W. Wiley.

Method of Harmonizing Apothecaries' and the Metric System of Weights; E. B. Elliott.

Metric and Radial System of Measures of Length; E. B. Elliott.

2—*Statistics.*

Unreliability of Life Statistics as usually compiled; T. S. Lambert.

On the Credit of the U. S. Government, as indicated by the daily market quotations of prices of its Securities; E. B. Elliott.

Periodicity of Rates of Interest in the New York Market; E. B. Elliott.

International Coinage—its progress; E. B. Elliott.

Irregularities in the returns of the population of the U. S. Census of 1870, at earlier ages, with methods and results of correction and adjustment; E. B. Elliott.

Life Table, Table of Mean Future Duration of Life, and Table of Life Annuity, on the Basis of the U. S. Census of 1870, with Method of Construction; id.

3—*Geology, Natural History, etc.*

Lateral Position of the Vent in Amphioxus, and in certain Batrachian Larvæ; B. G. Wilder.—Present aspect of the question of Intermembral Homologies; id. Variation in the condition of the Sense Organs in Fœtal Pigs of the same litter; id.—Lateral Asymmetry in the Brains of a Double Human Monster; id.—The Papillary Representation of two Arms in a Double Human Monster; id.—Variations in the Cerebral Fissures of Domestic Dogs, and its bearing upon Scientific Phrenology; id.—The Pectoral Muscles of Mammalia; id.—Variation in the Pectoral Muscles of Domestic Dogs; id.– The Cerebral Fissures of Mammalia and the limits of their homologies; id. —The Habits and Parasites of Epeira riparia; id.—The nets of Epeira, Nephila, and Methros; id. — Composition of the Carpus in Dogs; id. — The need of a Uniform Position for Anatomical Figures; with a recommendation that the Head be always turned toward the left; id.

Some remarks on the Zoological and Physical Explorations of the New England Coast by the U. S. Fish Commission; A. E. Verrill.

Animal Organology; T. C. Hilgard.

Relations of Dentalium; E. S. Morse.

Genitalia of the Brachiopoda; E. S. Morse.

Embryology of the Brachiopoda; E. S. Morse.

Further Remarks on the Embryology and Morphology of Limulus; A. S. Packard, jr.

Note on Bufo Americanus; T. Hill.

On the Genus Mycropterus (Grystes) and its Species; T. Gill.

Hints for the Promotion of Economic Entomology in the U. S.; J. L. LeConte.

On the Origin of Species; G. C. Swallow.

On means of distinguishing between Vegetable and Animal Life; T. S. Lambert.

Remarks on the Origin of Insects and on the Antennal Characters in the Butterflies and Moths; A. R. Grote.

Notes on Liparis, Cyclopterus and their allies; F. W. Putnam.

On the Question, "Do Snakes Swallow their Young?" G. B. Goode.

Concerning Hyalonema; S. Lockwood.

The Museum of Natural History in Central Park, New York; A. S. Bickmore.

Suggestions for Facilitation of Museum Administration; T. Gill.

The Identity of the Locust of the Prophet Joel (ii, 55) with the Œdipoda migratoria of Europe; C. Thomas.

On recent additions to the Fish Fauna of Massachusetts; T. Gill.

On Hermaphroditism in Rhus cotinus and R. glabra; T. Meehan.

Some Botanical Contrasts of Portland with New York city; J. Hyatt.

On the effects of certain poisons on Mollusks; W. N. Rice.

On a Remarkable Group of Wasp's Nests found in a hollow stump; P. R. Uhler.

On Movement in the Stigmatic Lobes of Catalpa; T. Meehan.

Calvert's supposed relics of man in the Miocene of the Dardanelles; G. Washburn.

On the Marble Deposits of Pottsford, Vermont; J. S. Newberry.

On the Age and Structure of the Cincinnati Anticlinal; J. S. Newberry.

On Circles of Deposition in American Sedimentary Strata; J. S. Newberry.

On some Paleozoic Fishes from the rocks of Ohio; J. S. Newberry.

On the Geological Relations of the Niagara and Lower Helderburg Group of Rocks in the United States and Canada; James Hall.

Breaks in American Paleozoic Rocks; T. S. Hunt.

The Geology of Southern New Brunswick; T. S. Hunt.

The Metamorphoses of Rocks; T. S. Hunt.

The Geology and Economic Mineralogy of the Southern Appalachians; id.

On Staurolite Crystals and Green Mountain Gneisses of Silurian age; J. D. Dana.

The Slates of the Taconic Mountains of the age of the Hudson River or Cincinnati Group; J. D. Dana.

On some extinct species of horned perissodactyls; E. D. Cope.

The Devonian Limestone in Ohio; N. H. Winchell.

Geology of the Northwest part of Maine; C. H. Hitchcock and J. H. Huntington.

Note on the Cretaceous Strata of Long Island; C. H. Hitchcock.

Geological History of Lake Winnipiseogee; C. H. Hitchcock.

Geology of Portland and vicinity; C. H. Hitchcock.

Means of determining the Stratigraphical Order of Seams of Coal in Ohio, Kentucky, etc.; E. B. Andrews.

Geological Relations of the Iron Ore Deposits of Nova Scotia; J. W. Dawson.

Specimen of Sigillaria showing marks of Fructification; J. W. Dawson.

Zones of Parallel Lines of Elevation in the Earth's Crust; A. Ross.

The Quartzite of Williamstown and vicinity and the Structure of the Graylock Range; S. Tenney.

Exhibition of Marl Fossils from New Jersey, near the coast; L. Feuchtwanger.

Artificial Shell Heaps of Fresh-water Mollusks; C. A. White.

The largest Tooth of the Fossil Elephant yet described; E. O. Hovey.

On some Spontaneous Fractures, Movements, and Expansions of Rock observed in Munson, Mass.; W. H. Miles.

On an Ancient Burial Ground in Swanton, Vermont; G. H. Perkins.

Exhibition of Colored Diamonds and other gems, with brief remarks on their formations; A. C. Hamlin.

On the Origin of Mountain Chains; C. Whittlesey.

On the cause of the Transient Fluctuation of Level on Lake Superior; id.

On the Descent of the Rivers of the Valley of the Missisippi; C. Whittlesey.

Natural Features of the U. S. National Park in the Rocky Mountains; J. Curtis.

Architecture of the American Aborigines; L. H. Morgan.

2. *Popular Lectures on Scientific Subjects;* by H. Helmholtz, with an Introduction by Prof. Tyndall. 388 pp. 12mo. New York, 1873 (D. Appleton & Co.). The lectures of Helmholtz, the leading physicist of Germany, here presented in an English form through translations by different authors (among them Tyndall), are on—The relation of Natural Science to science in general; Goethe's scientific researches; the physiological causes of harmony in music; ice and glaciers; the interaction of the natural forces;

the recent progress of the theory of vision; the conservation of force; and the aim and progress of physical science. They are all of the widest general interest, and are treated in a simple and popular manner. The volume has several wood-cut illustrations.

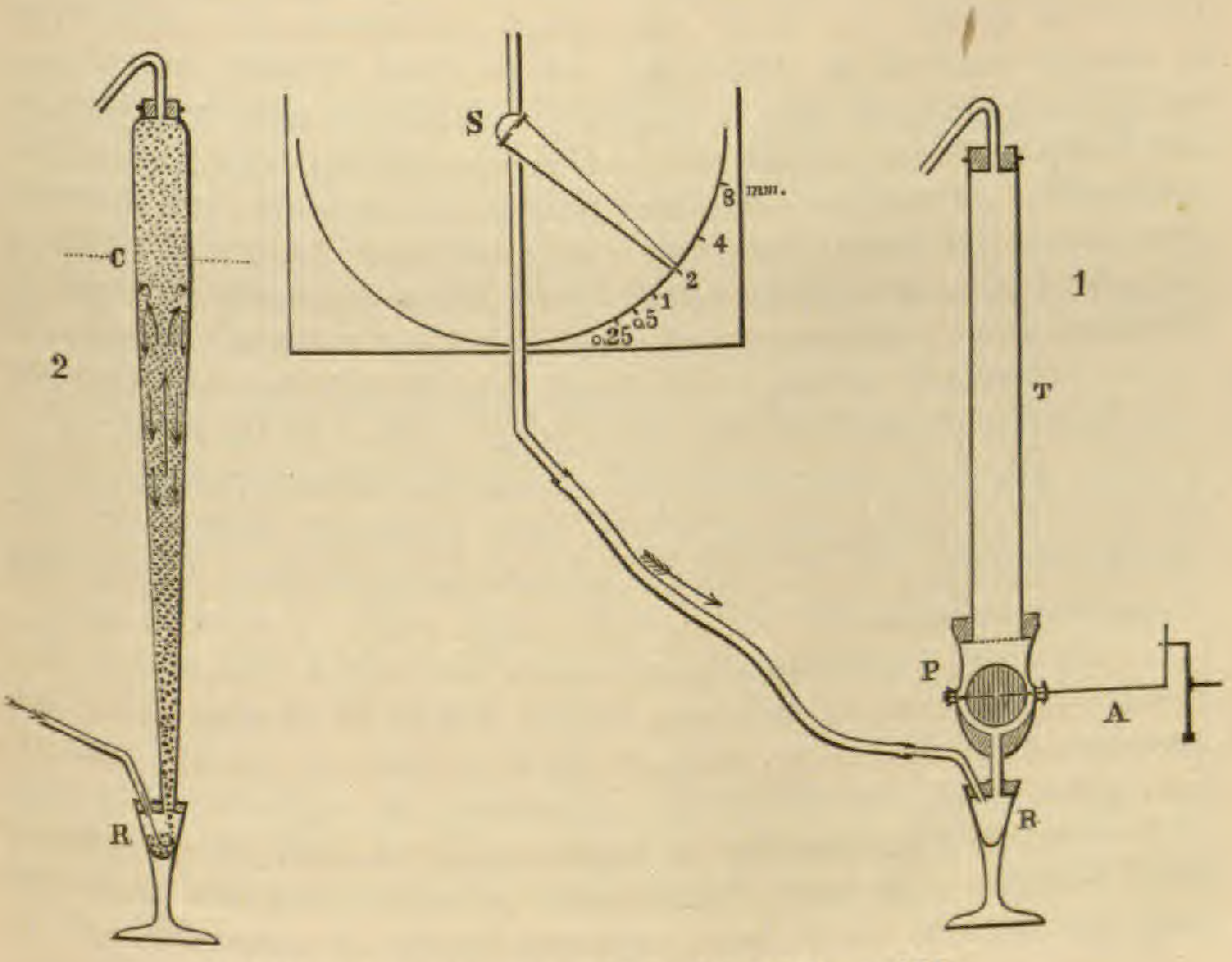
3. *Minerals Springs of North America, how to reach and how to use them;* by J. J. MOORMAN, M.D., Physician to the White Sulphur Springs, Virginia. 394 pp. 12mo. 1873 (Lippincott & Co.). A popular work, containing notices of many of the mineral springs of the continent, intended for the tourist and invalid. 182 pages out of the whole are devoted to Virginia Springs. Some analyses are given, and also the "thermalization"— in ordinary and much more correct language, temperatures—of various warm and hot springs of the United States. We leave it for medical men to pronounce on its medical opinions.

4. *Foods;* by EDWARD SMITH, M.D. 485 pp. 12mo. New York, 1873. (D. Appleton and Co.)—This work is one of Appleton's "Scientific Series," of which Tyndall's Form of Water and Bagehot's Physics and Politics have already been noticed.

Dr. Smith is widely known as a physiologist who has in his own person carried out a large number of experiments on the influence of food and drinks upon respiration, nutrition and digestion. He handles his subject, therefore, with the power of an original investigator. His book is replete with facts and experimental results, and will be read with interest by a large class of non-scientific readers as well as specialists. The American reader must be pardoned for smiling at some of his statements respecting familiar facts in this country: as for example, that the "juices" of the sugar maple "are very abundant in spring and summer," that the tree "resembles the sycamore tree," and that the "other flavors besides those due to sugar," he thinks, would "occasion it not to be preferred to the purified cane sugar where that could be obtained at about the same cost;" while this is the very reason why the maple sugar commands in our cities double the price of refined cane sugar. But we will leave our usually accurate author to settle this little difference with "Young America," who will be as a unit against his statement. Not less will the American whisky drinker be surprised to hear that the "peach whisky" is named first of those kinds "accounted the best." His chapter on "Alcohols," which follows that on Tea, Coffee, etc., as Liquid Foods, is the one of all others on which opinion will be most sharply divided, as he frankly says, both on "the question of their right to be called foods, and upon moral grounds, they are driving civilized nations into two hostile camps." But however men may differ, the experimental results recited by Dr. Smith on his own person and others, bring the subject within the range of scientific research.

Dr. Smith's statements as to the nearly valueless character of the Liebig beef extract as nutriment, have excited much discussion, but he sustains them by arguments founded on analyses and observation. The book is full of valuable hints for the physician. It is to be followed by another on Diets.

FILTERING APPARATUS, Art. XXV, p. 214.



HYDRAULIC ELUTRIATORS, Art. XXXI. p. 288.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXXV.—*The Queen's Chamber in the Great Pyramid;* by Prof. H. L. SMITH. With Plate II.

THE so-called "Queen's Chamber" in the Great Pyramid of Jizeeh has not hitherto received as much attention as has been bestowed upon the other portions of that most remarkable structure; and yet, as we shall presently show, it is of prime importance in deciding upon the truth or falsity of certain hypotheses which have been proposed as to the objects of causation of this wonderful building. For the present, without expressing any opinion ourselves, we shall present certain facts, leaving our readers to make their own inferences. We may, however, premise that the most commonly received hypothesis is, that the great pyramid, and all the other pyramids in Egypt, are gigantic tombs, built for the safe preservation of an enclosed sarcophagus and the kingly body once placed therein.

So far as all the other pyramids are concerned, we will consider this hypothesis admitted, but there are a few who believe that the great pyramid was built for the preservation of certain grand metrological standards, and for the purpose of conveying to man in these latter days some remarkable astronomical truths and high mathematical (geometrical) relations; and they call upon us to admit, either that this knowledge was given by inspiration, or that a high degree of civilization existed, and a knowledge of geometry, arithmetic and astronomy, not merely up to, but in some respects surpassing, that of the present day, was possessed by man, 4000 years ago. Either horn of this dilemma is sharp enough; and it is, as bearing upon the necessity of accepting one of them, that we present, as briefly as possible, the result of our investigations in the "Queen's Chamber." For the benefit of those who may not at once recall the structure of the great pyramid, we refer to fig. 2, plate II, which is a sectional view, in the plane of the meridian, looking eastward.

1, is the entrance passage, inclined at an angle of about 26° 27′; this passage, at a distance of some 300 feet, enters into the subterranean chamber 11, which is an unfinished room, situated about 106 feet vertically below the base of the pyramid, and it is cut in the limestone rock upon which the pyramid is built. The entrance passage is rectangular, about 41 inches in breadth and 47 inches in height, lined with polished limestone of a much finer quality than that constituting the mass of the pyramid; and the joints are exquisitely fine. About 30 feet within the passage, at 2, in fig. 2, there is on either side a *thin*, *fine*, *exquisitely-ruled line*, cut by a master hand, exactly vertical by severest tests. Whatever else these lines may symbolize, we find them to be so situated that, to an observer placed midway between them, in the axis of the passage, the walls at the entrance would be tangents to the diurnal path of a pole star (α Draconis), at a distance of 3° 42′ from the pole; within limits of the thickness of the casement. At 3, the ascending passage commences, at an inclination of 26° 18′ very nearly. Originally, this ascending passage was closed by a triangular stone, inserted in the roof of the descending passage at 3, and effectually concealing it. This stone was accidentally dislodged, during the progress of the forced entrance made into the pyramid by the Khaliph Al Mamoon, some 3000 years after the erection of the pyramid, and by its fall revealed the ascending passage, still closed, however, by a granite block about 8 feet long, which, apparently, had been caused to slide down the passage, previous to the insertion of the triangular stone; it still remains in place, and the ascent is now made by passing around it, in what is known as Al Mamoon's hole. A careful examination of the floor directly under the ascending passage shows the insertion of a different, much harder stone, with joints diagonal to the passage, all the others being at right angles; perhaps intended to indicate to any one really searching for it, that just above was the place to look for the upper passage.

Ascending for about 128½ feet, the grand gallery is entered at 4. This gallery has a length of 157 feet, nearly, and a height of 28 feet; the walls have seven overlappings, and a stone bench, or ramp, along either side; the distance between the ramps being 3 feet 6 inches, and above them 6 feet 10 inches. Originally the floor of the gallery was continuous, but a portion removed near the commencement of the ascent shows the horizontal passage into the Queen's Chamber, 9. This neat room is lined with white limestone, exquisitely polished; though now covered with dirt, and saline incrustations in some places nearly or quite one inch in thickness; the joints of the stone are cemented, and of microscopic fineness, often within the thickness of a hair. Unlike the other chambers of the pyramid, this has a gable-roof; and the floor is rough; the floor is 205 inches by 227 inches, the height to the apex of the roof is 244·2 inches, and under the eaves 182 inches, nearly. A very nicely constructed niche, about 15 feet high, and some 40 inches deep, is cut into the eastern wall; it is eccentrically placed, its axis being 25 inches south of the central line of the east wall. The workmanship of this niche is very excellent. This is the room and niche to which we now invite attention, and hitherto there has been scarcely an attempt at an explanation; none whatever upon the tombic hypothesis.

Passing up the grand gallery, we enter the little ante-chamber 6, a very curiously constructed room, partially lined with polished granite; from this we enter the so-called "King's Chamber," 8, upon the floor of which stands the coffer, or sarcophagus, as some suppose, 7. This noble room, probably the finest ever built, is lined with polished granite, in five courses all of the same height, 47 inches, except the lower course, which by a rise of 5 inches of the polished granite floor, inside the room, is only 42 inches in height; the object of this appears to be quite clear, but it is no part of our present purpose to discuss the features of this room. The chamber is approximately 34 feet 4 inches long, 17 feet 2 inches in breadth, and 19 feet 2 inches in height. Nine beams of polished granite cross the room from north to south, forming the ceiling, (one of these stones would weigh about 60 tons.) The stone coffer is rectangular, of polished granite, but now shamefully broken and abused; it is entirely plain, and indeed, no hieroglyphs are anywhere found in the great pyramid. For a discussion of the significance of the coffer, and the dimension of the King's Chamber, we must refer to the works of Prof. Piazzi Smyth, John Taylor, Mr. St. Vincent Day, William Petrie and others. Above the King's Chamber are five small chambers, entered by a forced passage; probably constructed to relieve the enormous pressure of the superincumbent mass above the ceiling of the King's Chamber. In these "chambers of construction" were found some rough quarry marks, (not incised,) expressing the names of kings of the fourth dynasty, Shofo and Nu-Shofo. The date of erection of the great pyramid is astronomically determined by computing the time when α Draconis was the pole star, with a distance of 3° 42′ from the pole; and it is especially as bearing on this question, that our own investigations in the Queen's Chamber become valuable. Upon this supposition, the pyramid was built, in round numbers, 2170 years B. C. The base of the pyramid is a square covering some thirteen acres, and the sides of this square are very exactly, two in the plane of the meridian, and two in that of the prime vertical.

The standard of length, which appears to have been adopted in the pyramid, is 25,025 British inches, which happens to be the one-ten millionth of the polar radius of the earth, and, so far, a much more convenient unit than the French meter, which is the same proportional part of a particular quadrant. The height of the pyramid, as determined by the most careful discussion of all the measures hitherto made, is given by Prof. Piazzi Smyth at 5813 pyramid inches, =5819 British inches; and the length of base as 9131·05 pyr. inches, = 9140 British inches, nearly. These measures we adopt.

Supposing now the triangle XNS, fig. 2, to be so constructed that 2CX : 4NS :: 1· : 3·14159, &c., i. e., the circle struck with the height of the pyramid as radius, to have a perimeter equal to the perimeter of the square base of the pyramid, then, upon this supposition, the angles XNS, and XSN, can be computed, and they are found to be 51° 51′ 14″ ·3. And again, peculiar to a triangle with the proportions we have supposed, are three other angles, viz:

26° 18′ 10″ *	Upper culmination of pole star.
30	Latitude.
33 41 50	Lower culmination.

And also, derived from above, 41° 59′ 48″ ·7, angle of arris. With these angles demanded, we enter the Queen's Chamber; let us see what we shall find there.

We remark that Prof. Piazzi Smyth had no conception of the amazing importance of the Queen's Chamber when he made his measurements; and, as he had no theory with regard to it, whatever we deduce from these measurements comes, so far, unbiassed; at the same time, there are certain portions which we could have wished he had more carefully measured; but when he states that other portions *have been* measured with care, we feel bound to adhere very closely to his figures.

Having an idea from the roughness of the floor, that at some time a lining might have existed, he searched for evidence of it along the vertical walls; he assures us that he "had to follow the walls upward from their very bottom, to the level of the first overlappings of the niche in the eastern wall, and to the

---

* See "Life and Work at the Great Pyramid," by Prof. C. Piazzi Smyth, vol. iii, p. 41, et seq.

top of the northern doorway, before any horizontal cuttings were met with"; this is the height of the line K′L, fig. 1, and was measured by him as 66·7 Br. inches, or 66·634 py. inches nearly; does this mean anything?

We turn to a table of natural tangents, and lo! ·6668 natural tangent, 33° 41′ 50″. Farther up, Prof. Smyth measured the height of the line KS′, fig. 1, as 127 inches, mean of two measures, one being 127·2 inches; he says, however, that having no ladder to stand upon, the "measurements of the upper portions are rude in the extreme;"* but from table of tangents we have 1·2732 equal to natural tangent, 51° 51′ 14″. Taking, however, 127· given as the actual measure, makes but a difference of some 4′ in the angle, a difference which, considering that the floor just under the niche, and also the back of the niche itself, up to this height, has been more or less broken, and removed, in the search for treasure, or hidden passage, is, we think, quite as near as could be expected. Passing now two stages higher of the niche, we find two measures of this, one 184·8 Br. in., the other 186·4 Br. in. We feel quite justified, then, in this difference of 1·6 in., in adopting 185·218 Br. in., or 185·033 pyr. in., as the true height, especially as this particular number is again tested hereafter by an entirely different process, and proved correct. The line N′B, fig. 1, marks this height, and BK is equal to 57·713 pyr. in., but ·57713 is the natural tangent of 29° 59′ 24″. The true latitude of the pyramid is, according to the laborious measurements of Prof. Smyth, 29° 58′ 51″, and by M. Nouet, in the celebrated national French work, 29° 59′ 6″.

The pyramid, then, is not in lat. 30° N. exactly; but the ancient builders, in their endeavor to make it so, have pushed it to the extreme N.E. boundary of the hill, and have used the chippings of the stones, an immense mass, to build out the hill on this side, and to strengthen it. We have now three of the angles required, with sufficient exactness, and the others follow from them; but we have, as yet, scarcely made a beginning. We consider now the geometrical construction of the room, assuming as data, for east wall,

Height,	185·033 pyr. in., as above.
Breadth,	205·00 " "
Height of gable,	244·2 " "

205 in. and 244 Br. in., are given by Prof. Smyth as the most probable approximations.† Our numbers are evidently not quite exact, as the construction will show, yet they are very close. We begin then with a rectangle, fig. 1, N′BDH; N′B, equal to 205 in., and BD, 185·033 in. (all hereafter pyr. measure, i. e., 25 py. in. =25·025 Br. in.); bisect N′B in O, and HD in A, join

---

* "Life and Work, &c.," vol. ii, p. 66.

† Ibid.

AO and prolong it to E, making AE equal to 244·2 in. Join EB and EN′; the angles EBO and EN′O are each equal to 30° [I].*

Join ED; it will cut N′B in C, and OC will equal 25 inches. Join HO; produce it to meet EB in F, and from F drop a perpendicular upon OB; it will meet OB in C; prolong FC, to meet HD in B′ it is the axis of the niche. Our equations [II] and [III] give results which differ not quite ·2 in. from 25 inches, but, as this number has been adopted by Prof. Smyth, and as a very slight variation in our assumed elements would give it exactly, we assume OC=25· in. Set off DL equal to 66·68 in., and DK equal to 127·32 inches, as indicated above; draw K′L and S′K parallel to each other and to HD. Join EL; the triangle EBL is isoceles; the angles at the base are each 30°; the same is true of the triangle EN′K′ [IV]. The triangle EK′L is equilateral; the angles at E, K′, and L being each 60°, ∴ EK′ = K′L = EL = 205 in.

Join N′L and BK′; they bisect each other in the point M, in the line EA; and the angles MN′O, MBO, MK′N, and MLN, are each equal to 30° [V]; ∴ K′B,= LN′,= 2BL,= 2N′K′, and BL,= MB,= BE,= EM,= EN′= N′M,= N′K′,= K′M. With M as a center, and radius = ME, describe the arc N′EB; N′M will represent the polar axis, and E the zenith, at the latitude of the pyramid. Draw S″MX′ parallel to S′K; it will represent the horizon. Through the intersection S, of EL, and N′B, draw MSF′; it will bisect EB in F′, and since the angle F′MX′ is equal to 60°, MF′ will represent the equator at the latitude of the pyramid; also MF′ will equal OB [VI].

From the point F′, drop the perpendicular F′H″ upon HD; it will bisect OB in C″, and pass through the point P, where MB and EL bisect each other [VII]. K′B cuts S′K, in I and IK = 100 inches [VIII], (and I is one inch from the corner of the niche, X.) Join ID, and prolong it to meet AE in γ; join γH; then will HγD represent a meridional section of the great pyramid, and the angles γHD and γDH will each be equal to 51° 51′ 14″ [IX].

Join Lγ, and prolong it to meet HN′ produced, in γ′; join γ′M; the angle γ′MS″ will equal 33° 42′ nearly [X], upper culmination of a pole star, which at this distance from the pole in 2170 B. C. was found by Sir John Herschel to have been α Draconis.

Through J, intersection of K′L, and axis of niche, draw DJ, meeting HN′ in δ; join δM; the angle δMS″ will equal 26° 18′ nearly [XI], direction of lower culmination of α Draconis.

Set off CO′, equal to 12·5 inches join K′O′, intersecting EA in V. Join HV, and DV; the angles HVA; and AVD will each be equal to 33° 42′ nearly [XII].

---

* "The numbers in brackets refer to the equations at the end of this article.

Produce HV, it will meet H″C″ produced in C′, in the arc EC′B [XIII]; join MC′; the angle C′MF′ will represent 4° 20′ north declination [XIV].

But the declination north, of η Tauri, the lucida of the Pleiades is computed by the well-known astronomer Brunnöw, to have been, in the year 2170 B.C., 4° 13′ 46″.

His computation shows further, that its right ascension at this time was 0° 57′ 26″, or that it was nearly in the equinoctial point; and moreover, that at this time, when η Tauri and the equinoctial point were on the meridian *above*, at C′ and E′, α Draconis was within 20^m of culmination at δ, *below* the pole; and hence the reason why the entrance passage was made to point to the lower rather than the upper culmination, the date of the pyramid erection being commencement of the grand Pleiades year.

We will now proceed to construct the niche, having already the axis and the point O′. We assume also that the line C″H″ marks out one side of the niche, though upon calculation it differs from it ·12 inches, with our assumed data for height and breadth of the east wall. We set off A′H′, equal to 61·4 inches, as we find upon trial that 61·3, measured by Piazzi Smyth, is somewhat too small, yet this number, with slight change of breadth of the room, would do as well. The line S″D will cut the corner of the niche very nearly in N″ [XV].

Join N″K; it will cut C″H″ in D′, corner of the niche; by the computation D′G = 31·86 inches [XVI], but as the line C″D″ does not quite agree with the side of the niche (with our present data), we take 31·84 inches as the true height. From G, draw GX parallel to γG′; it will meet KS′ in X, a corner of the niche.

If the point G was in the line C″H″, we would have 52·5 in. for the breadth of this part of the niche; this would be perhaps too great a strain on Piazzi Smyth's measure, 52·3 Br. inches. If, however, we suppose the corner of the niche, G, to be ·1 in. nearer the axis, this would give his measure exactly; thus, for the half breadth; CB−(C″B+·1) or 77·5 in. −51·35 in. =26·15 inches. We next compute XX″, remembering, however, that the line GX″ is ·1 inch toward the axis; it is found to be 47·63 [XVII]; adding to this ·1 inch and also 51·25 in., the value of KX, is found to be 98·98 in., or practically 99 inches ∴ IX = one inch. The corner of the niche X is therefore 3·5 inches from the middle of the room, which gives us 21·5 inches for the half breadth of the niche at this place.

The height of the fourth compartment is determined by the line T, T′, drawn parallel to N′B, through the point P, and is found to be 28·13 inches, and at the same time the height of the upper compartment is determined to be 29·58 inches (XVIII). The breadth of the fourth compartment, 32·2 inches, is determined by joining the points O and H′. The line OH′ cuts T T′ in W′, a corner of the niche, bisecting the angle at W′ (XIX). The breadth of the top compartment is already determined as 25 pyramid inches, or the "sacred cubit."

We now place these determinations alongside the measurements of Prof. Piazzi Smyth for comparison.

	Heights.		Breadths.	
	C. P. S. Br. in.	H. L. S. Pyr. in.	C. P. S. Br. in.	H. L. S. Pyr. in.
1st Compartment,	66·7	66·68	61·3	61·4
2d "	31·6	31·84	52.3	52·3
3d "	28·7	28·8	43·3*	43·
4th "	29·4	28·13	34·3*	32·2
5th "	29·4	29·58	25·3*	25·

The agreement is quite within the errors of measurement; but as these computed values depend on the assumed values of height and breadth of the east wall, they are subject to slight correction when these are better known. With these computed values we will determine the angles made by drawing the diagonals of the niche, O″R, W′W, IG′, and ZH′, and we obtain

The angle at O″ (XX), 26° 21′ upper culmination.
The angle at W′ (XXI), 33° 30′ lower culmination.
The angle at X (XXII), 38° 8′ 46″ exactly,

being the half angle at the summit of the pyramid, and giving, for the angle at the base, 51° 51′ 14″. And lastly, the angle at Z (XXIII), 30°, latitude of the pyramid.

The discovery of these angles, which are also substantially given by using Prof. Smyth's numbers, was first made by me, and announced to Prof. Smyth before any one had suspected this design of the niche. It is most fortunate that the measures of Prof. Smyth, recorded in vol. ii of his "Life and Work at the Great Pyramid," were all made, so far as the Queen's Chamber is concerned, independent of any theory.

We have not by any means finished with this peculiar chamber. If we suppose now a diagonal drawn from E (toward the spectator), and touching the west wall at the height of the line LK′, we obtain once more the angle 51° 51′ very nearly (XXIV), and we may also notice, that the length of the room is a mean proportional between the height of the niche and the breadth of the room. The ratio of height to breadth of the east wall is nearly 9 : 10, and the diagonal HB gives therefore HBD, the arris angle, 42° nearly ∴ BHD=48° [XXV].

We have alluded to the π theory of the great pyramid; let us see what the Queen's Chamber gives us here, observing

---

* Estimated—not measured by Prof. Smyth, but determined by considering the offsets all equal, i. e., 4·5 inches.

simply that divisions of 5^s and 10^s characterize the pyramid ratios—

$185{\cdot}033 \times 10 \times \pi = 5812{\cdot}978$ pyr. inches.

But 5813 in. is the most recent and accurate determination of the height of the great pyramid adopted by Prof. Smyth after diligent comparison; it is equal to 5819 Br. inches nearly.

At a height of about 40 inches above the floor, in the first compartment of the niche, is a bank or shelf $L'L''$, and while the main portion of the niche is 40 in. deep, this is about 100 in. in depth; the line δJD gives its height approximately; it was not measured carefully by Prof. Smyth.

Taking the height at 39·71 inches, we have, for the height of the niche above this shelf, 145·32 inches.

Now $145{\cdot}32 \times 10 \times \pi = 4565{\cdot}5$,

but this is half the base length of the pyramid, according to the most accurate determinations, viz: 9131 pyr. in. or 9140 Br. in.

We have then, in these two portions of the niche,

185·03 : 145·3 : : height of pyramid : half base of do.

If now we extend the line $L'L''$ to meet γH and γD, and take this for the base of the pyramid, the line $K'L$ will represent the level of the King's Chamber, given by Prof. Smyth as 1688 inches above the base; and by computation 1691·6 inches above the base, on the hypothesis that the area of a section of the pyramid at this height is half the area of the base as first announced by us, the vertex of the pyramid being represented by γ. The computed quantity for the height of the base of the pyramid above the Nile level, is 1769 in., giving us the *rough* floor as representing the level of the Nile at the date of erection; this height was estimated by Mr. Perring at 1767 in.

It may be noted further that $\gamma A = 130{\cdot}5$ inches, and $130{\cdot}5 \times 10 \times 7 = 9135$, which is the length nearly for one side of base of the pyramid.

It is much to be regretted that *absolutely correct* measurements are not at hand to test how closely the ancient builders could work to what seems to have been the design, at least in part. Upon the whole, the results show that they were more accurate, and capable of doing better work, than many modern scientific men. Let us see then what modern men *have* done, measuring the same things, and it is lamentable to notice discrepancies like these for the Queen's Chamber.

	C. Piazzi Smyth.	H. Vyse.	E. Lane.	M. Jomard.
	Br. in.	Br. in.	Br. in.	Br. in.
Length,	226·7	225	228	228.13
Breadth,	205·8	204	204	205·72
Height to roof,	182·4	177	162	162·01

	C. Piazzi Smyth.	H. Vyse.	E. Lane.	M. Jomard.
	Br. in.	Br. in.	Br. in.	Br. in.
Height to angle of roof,	244·4	243	246	258·41
" of niche,	185·8	183	----	----
Width of lower part,	61·3	61	----	----
" of top,	25·3?	23·5?	. --	----
Distance of axis from center of wall,	25·3?	26·?	----	----

In view of these discrepancies, shall we demand superhuman accuracy on the part of the pyramid builders?

Notwithstanding the remarkable proportions, and evident geometrical relations, from a rectangle of the height of the niche, yet, in practice, the builders appear to have made the walls of the north and south sides of the chamber almost 2·5 inches lower than the niche. Was this careless workmanship, or was it designed? Let us see. We adopt 182·62 in. as the true height of the north and south walls, which is very near Prof. Smyth's mean—

$182{\cdot}62 \text{ in.} \times 100 \div 3{\cdot}14159 = 5813 \text{ in.} =$ height of the pyramid,

and calling the 182·62 so many cubits—

$182{\cdot}62 \text{ in.} \times 25 = 4565{\cdot}5 \text{ in.} =$ half base length of the pyramid:

and again, $$\frac{182{\cdot}62 \times 10}{185{\cdot}033} = 9{\cdot}869587728 + = \pi^2.$$

Moreover, $182{\cdot}62 \times 2 = 365{\cdot}24 =$ days in a year. If we take now 5813 in. and 9131 in., representing height and base of the pyramid, we get the following proportions:

Arc equal to radius = 3438′ : 9131′ : : 10° : 26° 34′.
" " " " 3438′ : 5813′×2 : : 10° : 33° 48′.

The following are the results of the very accurate measurements of Prof. Smyth for the internal dimensions of the coffer:

Mean length,	77·93 inches.
" breadth,	26·73 "
" depth,	34·34 "

The last number is, almost, the right sine of 90°, or 3437·75, or the arc equal to radius. If now we multiply 3437·75 by the natural sine of 51° 51′ 14″ i. e., ·7864, we get 27·03 for breadth of coffer, which is quite within some of the individual measures. We cannot expect any similar result for the length, if the cubical dimensions were designed to be a given quantity. Finally, we have, breadth of coffer : depth of do. : : height of pyr. : half base of do.

5813 : 4565 : : 34·34 : 26·9.

We have thus the π ratio in the coffer, and exactly, if we might substitute for Prof. Smyth's numbers 34·3775 and 27.

Thus, $$\frac{27 \times 4}{34{\cdot}3775} = 3{\cdot}14159.$$

Are these all coincidences? And was the niche built as a mere freak of ignorant, and debased idolaters?

Since the preceding was written, Prof. Smyth calls our attention to the pavement of the ante-chamber, which is not of one material, but partly limestone, partly granite, with accurate joints. He has not yet stated his own results to us, but doubtless he has already the following, and probably more.

The pavement is a rectangle, and lengthwise, is situated exactly north and south; AD being the length of the northern, shorter, and limestone portion; DB that of the southern, longer, and granite portion; AA′ the breadth, and AB the whole length; we find

$$\frac{DB}{AD} = \pi, \quad \frac{2AD}{AA'} = \pi, \quad \therefore AA' \times DB = 2AD^2.$$

Theory.	Measured by C. Piazzi Smith.	Diff.
$AA' = (1+\pi) \times 10 = 41{\cdot}4159$ in.	41·45 in.	–·034 in.
$AD = (\pi+\pi^2) \times 5 = 65{\cdot}0559$ "	64·5 "	–·56 "
$DB = (\pi^2+\pi^3) \times 5 = 204{\cdot}379$ "	203·6 "	–·62 "

AD and DB were determined by Prof. Smyth by measureing from the edge of the great step (now much worn) to the successive joints of the pavement, and cannot be as correct as the measurement of AA′, which is the distance between the polished granite walls, comparatively in good condition.

Equations.

I. OB : R :: EO : tan. EBO. 102·5 : 1 :: 59·17 ·57727; nat. tang. 30° nearly.

II. AE : AD :: EO : OC. 244·2 : 102·5 :: 59·17 : 24·83; diff. ·17.

III. BO : OE :: BC : CF. AO : HA=BO :: CF : CO. ∴ AO : EO :: BC : CO, 185·033 : 5917 :: 77·5 : 24·8.

IV. Sin. 30° : EO :: R : BE, ·5 : 59·17 :: 1 : 118·34 = BE = BL; angle EBL=90°+30°=120°. ∴ BEL=30°=BLE.

V. K′L : BL :: R : tan. BK′L. 205 : 118·353 :: 1 : ·5773; nat. tang. 30°.

VI. MO=EO, OS is common, and ang. O=90° ∴ ES=MS and ESM=120°, OSM=60°=SM′X′. EOB and BF′M are similar, and EB=BM; ∴ F′M=BO and EO=BF′.

VII. R : F′M :: sin. 30° : MX′, 1 : 102·5 :: ·5 : 51·25=$\frac{1}{4}$ N′B=$\frac{1}{2}$ BO. BM and EL bisect each other in P. In the triangle EBM, F′H, parallel to the base, bisects BE; ∴ it will bisect BM, i. e., will pass through P.

VIII. LB : K′L :: BK : IK, 118·353 : 205 :: 57·713 : 99·98; diff. ·02.

IX. IK=100=Rad. DK=127·32=IA. IK : R :: IA : tang. IDA, 100 : 1 :: 127·32 : 1·2732; nat. tang. 51° 51′ 14″.

X. In the triangle γAD, R : AD :: tang. γDA : γA, 1 : 102·5 :: 1·2732 : 130·5. γN = γA − DL = 130·5 − 66·68 = 63·82 = ½ KD. $\gamma' K'$ = 2 γN = 127·64, $S''K'$ = MN = (MA − AN) = (AE − EM − AN) = (244·2 − 118·353 − 66·68) = 59·167 = EO. $\gamma' K' - S''K' = \gamma' S''$ = 127·64 − 59·167 = 68·473. MS'' : R :: $\gamma' S''$: tan. $\gamma' MS''$, 102·5 : 1 :: 68·47 : 66·8; nat. tang. 33° 45′; diff. 3′.

XI. AM = AE − EM = 125·85, $B'D : B'J$ :: DH : Hδ, 77·5 : 66·68 :: 205 : 176·3. $S''\delta = H\delta - S''H$ (= AM) = 176-3 − 125·85 = 50·45. $S''M$: R :: $S''\delta$: tang. $\delta MS''$, 102·5 : R :: 50·45 : ·492+; nat. tang. 26° 13′; diff. 5′.

XII. $K'VN''$ and VOO' are similar, and V' divides ON in the ratio $KN'' : OO'$; ON = AO − AN = 185·03 − 66·68 = 118·35. OO' = 37·5. $K'N''$ = 102·5. 140 : 102·5 :: 118·35 : 86·6 = NV. AV = NV + AN = 153·28 (= ¾ HD). AV : R :: AH : tang. HVA. 153·28 : 1 :: 102·5 : ·668; nat. tang. 33° 45′.

XIII. Join HC'. The arc $C'B$ = 34° 20′ (XIV) ∴ Chord $C'B$ = 2R. Sin. 34° 20′ ÷ 2 = 69·86, $C'C'' = \sqrt{C'B^2 - BC''^2}$ = 47·4+ ∴ $C'H''$ = 232·43. $C'H''$: R :: HH'' : tang. $HC'H''$. 232·43 : 1 :: 153·75 : ·661 nearly; tang. 33° 28′. This so nearly equals the angle HVA, that we consider HVC' a straight line.

XIV. MC' : R :: MX'' : cos. $C'MX''$, 118·35 : 1 :: 51·25 : ·433; nat. cos. 64° 20′. 64° 20′ − 60° = 4° 20.

XV. $S''H$ = EA − EM = 125·85, DH : HS'' :: $A'D : A'N''$, 205 : 125·85 :: 108·2 : 66·42; diff. ·26.

XVI. $N'L$: KL :: $N''G : GD'$, 108·2 : 60·64 :: 56·85 : 31.86; diff. ·02.

XVII. Tan. $GXX'' : GX''$ :: R : XX'', 1·2732 : 60·64 :: 1 : 47·63; but, as the line GX'' is ·12 in. nearer center of room than $C'H''$, $X''K$ = 51·37 : adding XX'' gives XK = 99 in. ∴ IX = one inch, and from center of room to X = 3·5 in. OC − 3·5 = 21·5 = half breadth.

XVIII. IK : KB :: PT : TB, 100 : 57·713 :: 51·25 : 29·58 = BT; KB − BT = KT = 28·13.

XIX. AO : AH' :: $OV' : V'W'$, 185·03 : 55·7 :: 29·58 : 8·9. OC − $V'W' = W'U$, 25 − 8·9 = 16·1 = half breadth. $H'O$ bisects angle at W', nearly; this angle as shown in (XXI) is 33° 30′. AO : R :: AH' : tang. AOH', 185·03 : 1 :: 55.7 : ·301; nat. tang. 16° 45′.

XX. Dropping a perpendicular from O'' upon SK, we have a right-angled triangle, of which the vertical side = 57·713, the horizontal = 28·6. $\frac{57{\cdot}71}{28{\cdot}6}$ = 2·018; nat. tang. 63° 39 = angle at base ∴ ang. at O'' = 26° 21 = lower culmination nearly.

XXI. In like manner $\frac{56{\cdot}93}{37{\cdot}6}$ = 1·51 = nat. tang. 56° 30′ = ang. at W ∴ ang. at W' = 33° 30 = upper culmination.

XXII. $\frac{60{\cdot}64}{47{\cdot}65}$ = 1·273 = nat. tang. 51° 51′ 14″ = ang. at G, ∴ ang. at X = ½ summit ang. = 38° 8′ 46″.

XXIII. $\frac{98 \cdot 52}{56 \cdot 85} = 1 \cdot 732 =$ nat. tang. $60 =$ ang. at $H' \therefore$ ang. at $Z =$ $30° =$ latitude.

XXIV. 177·52 : 1 : : 226·4 : 1·275 ; nat. tang. 51° 55′. 185·03 : 205 : : 205 : 227·1 ; diff. ·7.

XXV. 185·03 : 205 : : 1 : 1·1078 ; nat. tang. 47° 55′ ; diff. 5′.

ART. XXXVI.—*On the Silt Analysis of Soils and Clays*; by EUG. W. HILGARD, State Geologist of Mississippi.

[Continued from page 296.]

Properties of Pure Clay.—The "clay" so obtained is quite a different substance from what usually comes under our observation as such; since its percentage seems rarely to reach 75 in the purest natural clays, 40 to 47 in the heaviest of clay soils, and 10 to 20 in ordinary loams. Thin crusts of it are occasionally found in river bottoms, where clay water has, after an overflow, gradually evaporated in undisturbed pools. When freshly precipitated by salt it is gelatinous, resembling a mixed precipitate of ferric oxide and alumina. On drying, it contracts almost as extravagantly as the latter, crimping up the filter, to which it tenaciously clings, and from which it can be separated only by moistening on the outside, when it may mostly, with care, be peeled off.

After drying, it constitutes a hard, often horny mass, difficult to break, and at times somewhat resonant. Since the ferric oxide with which the soil or clay may have been colored is mainly accumulated in this portion, it usually possesses a correspondingly dark brown or chocolate tint. When a large amount of iron is present, water acts rather slowly on the dried mass, which gradually swells, like glue, the fragments retaining their shape. Not so when the substance is comparatively free from iron. It then swells up instantly on contact with water; even the horny scales adhering to the upper portion of the filter quickly lose their shape, bulge like a piece of lime in process of slaking, and tumble down into the middle of the filter.

There is a marked difference, however, in the behavior with water of clays equally free from ferric oxide; some exhibiting the phenomena just described in a much more energetic manner than others. On the whole, those freest from iron appear to imbibe the water, and crumble, most readily. Inasmuch as this property possesses highly important bearings, both on the agricultural and ceramic qualities of clays, I propose to investigate it more minutely hereafter.

The pure clay, when dry, adheres to the tongue so tenaciously as to render its separation painful. When moistened and worked into the plastic condition, it is exceedingly tenacious and "sticky," adhering to everything it touches.

Under a magnifying power of 350 diameters, no definite particles can be discovered in the opalescent clay water remaining after several weeks' subsidence. The precipitate formed by saline solutions then appears as an indefinite cloud (mostly of a yellowish tint), for which one vainly seeks a better focus. In stronger clay water one can discern a great number of indefinite, punctiform bodies, very uniformly diffused throughout the liquid, and apparently opaque; the precipitate then formed by brine also shows a faintly dotted structure of its clouds.

Doubtless the fine silt obtained in the 24 hours' subsidence, the diameter of whose quartz particles varies from 0·001 to 0·02 of a millimeter, is not entirely free from adherent clay, as is indicated by its deeper tint, compared with that of the coarser sediments. The extent to which this contamination exists, the possible means of further separation, and the distribution of the important soil ingredients among the several sediments, I reserve for future discussion.

Separation of the Coarser Sediments.—The mixed sediments remaining after the separation of the clay, and silts of less than $0{\cdot}25^{mm}$ hydraulic value ($< 0{\cdot}25$), by decantation, are transferred to the elutriator, after separating by means of a sieve, such as, being of more than $0{\cdot}8^{mm}$ diameter, would fail to pass through the wire screen, and thus interfere with the operation. The water should previously have been let on, so far as to stand above the screen; otherwise some sediment may be forced back into the rubber connecting tube.

The Fine Sediments.—The operation is best begun by running up the column rapidly nearly to the cork, allowing a few seconds' subsidence, and then setting the index to the proper velocity of $0{\cdot}25^{mm}$ per second at the beginning. At first the sediment passes off rapidly and the column remains obviously and evenly turbid, from the point where the agitation caused by the churner ceases, to the top. But this obvious turbidity generally exhausts itself in the course of a few hours, and it then requires some attention to determine the progress of the operation. I have never known the $0{\cdot}25^{mm}$ sediment to become exhausted in less than 15 hours, and in one case it has required 90. The more rigorously the process of preliminary disintegration, above described, has been carried out, the shorter the time required for running off the fine sediments, which otherwise tax the operator's patience severely. In matter of fact, they never do give out entirely; doubtless for the reason that the stirrer continues to disintegrate compound articles which had resisted the boiling process. Besides, downward currents on the sides of the vessel *will* form, despite all precautions; so that the interior surface of the cylinder becomes coated with pendant flakes of coalesced sediment. These must from time to time be removed by means of a feather, so as to again bring them under the influence of the stirrer; but it is, of course, almost mathematically impossible that under these circumstances, any of the sediments subject to coalescence should ever become completely exhausted. Practically, the degree of accuracy attainable at best, renders it unnecessary to continue the operation beyond the point when only a fraction of a milligram of sediment comes over with each liter of water. It is admissible, and even desirable, to run off rapidly the upper $\frac{1}{3}$ of the column at intervals of 15 to 20 minutes; whereby not only time is gained, but also the sediment in the reservoir is stirred and brought under the influence of the churner, for more complete disintegration.

It is noticeable that recent sediments—river alluvium, etc.—are much more easily worked than more ancient ones; as might be expected.

Up to 4^{mm} hydraulic value, the use of the rotary stirrer is indispensable, on account of the tendency to the formation of compound particles. Beyond, this tendency measurably disappears, so that for the

Coarse Sediments of 8 to 64^{mm}, hydraulic stirring may be employed, and an elutriating tube of smaller diameter may advantageously be substituted, in order to diminish the otherwise somewhat extravagant expenditure of water. The entire amount required for one analysis is from 25 to 30 gallons; provided a thorough previous disintegration has been secured. The average times required are as follows:

Sediment	$0{\cdot}25^{mm}$	30 to 40^{h}
"	$0{\cdot}5^{mm}$	15 to 25^{h}
"	$1{\cdot}0^{mm}$	5 to 10^{h}
"	2 to 64^{mm}	6 to 10^{h}
Total,		56 to 85^{h}

With proper arrangements, much of this can be done automatically, at night; completing an analysis (except the clay and finest silt determinations) in the course of three or four days.

As the soils are most conveniently weighed "dried at 100°,"* I have always weighed the sediments in the same condition. Great care is necessary to obtain the correct weight of the (extremely hygroscopic) clay; the same is true, more or less, of the $<0{\cdot}25$ sediment, which, moreover, is so diffusible in water that it cannot readily be collected on a filter. I find it best, after letting it subside into as small a compass as possible, to

---

* A somewhat clayey soil will continue to lose weight at 100°, for 5–6 days. But after the first 6 hours the loss becomes insignificant for the purpose in question.

evaporate the last 25–50 c.c.m. in the platinum dish in which it is to be weighed.

From the other sediments, the water may be decanted so closely as to render their determination easy.

The loss in the analysis of clays and subsoils containing but little organic or other soluble matter, is usually from 1·5 to 2·0 per cent, resulting partially, no doubt, from the loss of the fine silt which comes off more or less throughout the process, and is decanted with the voluminous liquid. When the turbidity is marked, it indicates imperfect preliminary disintegration; it may be removed, and the silt collected, by adding a weighed quantity of alum (about 25 milligrams per liter is sufficient), precipitating with carbonate of ammonia, and deducting from the weight of the (flocculent) precipitate the calculated amount of alumina.

The analysis of soils rich in vegetable matter involves some modifications in the preliminary treatment and final weighings. which I shall not now discuss. Ignition of the soil previous to elutriation, as proposed by some, is obviously inadmissible, as it would render impossible the separation of the clay from the finer sediments.

As I have heretofore stated,† I consider that, ordinarily, the investigation of the *subsoils* is better calculated to furnish reliable indications of the agricultural peculiarities of extended regions, than that of the surface soils, which are much more liable to local "freaks and accidents," and usually differ from the corresponding subsoils in about the same general points. For practical purposes, therefore, the difficulties incident to the treatment of soils rich in humus, may in most cases be avoided.

Character of the Sediments.—As regards the size of the particles constituting the successive sediments, the most convenient, because almost universally present, material for reference is quartz sand. I give below a table of measurements, concerning which I remark that the values given refer to the largest and most nearly round quartz grains to be found in each sediment, and to scale divisions of $\frac{1}{180}$ millimeter each.

As a matter of course, all sizes between that given and the one next below are to be found in each sediment. A few grains of the finer sediments are also invariably present, owing both to the progressive disintegration of conglomerated particles by the stirrer, and to the inevitable formation of the avalanche-like aggregates of the finer sediments.

While the measurement of the quartz grains, which are rarely wanting in a soil or clay, affords sufficient landmarks to the scientific observer, it seems desirable to attach to them, besides, generally intelligible designations, which shall approximately, at least, indicate the nature of the sediment. This I have attempted in the table, which is in this respect, of course,

---

† This Journal, Dec., 1872; Proc. Am. Assoc. Adv. Sci., 1872, p. 71.

open to criticism; since it is not easy to indicate in popular language, distinctions not popularly made.

Table of Diameters and Hydraulic Values of Sediments.

No.	Designation of materials.	Diameter of Quartz grains.	Velocity pr. sec., or Hydraulic value.
1.	Coarse Grits,	1—3 mm	?
2.	Fine "	0·5—1 "	?
3.	Coarse Sand,	80—90 ($\frac{1}{180}$) "	64 mm
4.	Medium "	50—55 "	32 "
5.	Fine "	25—30 "	16 "
6.	Finest "	20—22 "	8 "
7.	Dust "	12—14 "	4 "
8.	Coarsest Silt,	8—9 "	2 "
9.	Coarse "	6—7 "	1 "
10.	Medium "	4—5 "	0·5 "
11.	Fine "	2·5—3·0 "	0·25 "
12.	Finest "	0·1—2·0 "	$<$0·25 "
13.	Clay "	?	$<$0·0023 "

I remark that the absolute diameter of the elutriator tube exerts a sensible influence on the character of the sediments, in consequence of the comparatively greater friction against the sides in a tube of small diameter. Strictly speaking, none of the sediments actually correspond to the velocity calculated from the cross section of the tube and the water delivered in a given time, but to higher ones, whose maximum is in the axis of the tube, and which gradually decrease toward the sides, according to a law which may be demonstrated to the eye by slightly diminishing the velocity while a sediment is being copiously discharged, so that the turbid column remains stationary, while clear water is running off. The surface then assumes a paraboloid form, which is sensibly more convex in a tube of small diameter than in a wide one; the results obtained in the latter being, of course, nearest the truth.

Still, the accompanying samples of sediments from Mississippi soils and subsoils show at once, even to the naked eye, that the assorting process has been quite successful, and that the prominent characteristics of soils in these respects may thus be determined and exhibited to the eye, with a very satisfactory degree of accuracy.

I reserve for future communications the detailed discussion of the services which this method of analysis is capable of rendering to the theory and practice of both agriculture and the ceramic art. But I feel confident that the comparativeneglec t of the subject of soil analysis during the past decennium, was the result of hasty judgment, and that, by properly combining the examination of the physical and chemical properties of soils and clays, we shall be able to fulfill, in a great measure, the high expectations entertained in the early days of agricultural chemistry.

The important bearing of the phenomena of "molecular coalescence" upon the formation of natural sediments, is too obvious to require discussion. It explains at once why we so rarely find a deposit composed of particles of uniform hydraulic value, however favorable to such a result may have been, apparently, the circumstances attending its formation. And it warns us to be careful in our estimate of the nature and velocity of depositing currents, as deduced from the character of the sediments.

In previous papers on the Quaternary formations of the lower Mississippi Valley, I have called attention to the somewhat singular composition of the material characterizing the Bluff or Loess group, which fails to show any marks of assorting or stratification of materials, even in profiles of 70 feet; although it consists of all grades of silt and sand from $\frac{1}{1000}^{\mathrm{mm}}$ upward. The uniform intermingling of these ingredients ceases to be surprising, when we consider that, under the influence of the slow eddying motion of shallow and uniformily slow-flowing water, the finest particles may assume the hydraulic value of very coarse ones, and be deposited with them. We thus, *a posteriori*, arrive at the same conclusion concerning the circumstances under which this deposit was formed, as had been previously deduced from geological data alone.

As might be expected, the temperature of water exerts a strong influence on the coalescence of particles. It is sensibly less in hot water, so long as the water is either strongly agitated, or perfectly quiescent. But the circulating motion set up in hot water exposed to cooling influences very soon effects coalescence, and consequent clearing of a turbid fluid. The habitual stirring-up of precipitates by chemists, to favor subsidence, need but be mentioned in this connection; as also the fact that troublesome powdery precipitates, such as oxalate of lime or molybdo-phosphate of ammonia, become flocculent when allowed to deposit on a sloping surface.

The presence of dissolved mineral matter greatly favors the coalescence of particles, and especially the precipitation of clay. Foremost among the active substances are lime and common salt; the action of the latter being exemplified on the large scale, at the mouths of rivers, where the fine mud, whose molecular properties with pure water would have kept it in suspension for many days, is suddenly thrown down in the shape of mud shoals, in consequence of the admixture of sea water.*

---

* This action of salt in clearing water has lately, it seems, been claimed as a new discovery by Mr. D. Robertson, in a communication to the British Geolog. Society. But the clearing of muddy water by salt, as well as by alum, has been a popular recipe for ages; and the action at the mouths of rivers is pointedly referred to by Mr. Sidell, in Rep. Phys. and Hydr. of Miss. River, App. A, p. xi.

The "settling" effect of alum, however, appears to be mainly due to the precipitation of alumina by the carbonates of lime and magnesia, present in almost all sediments.

The remarkable action of *lime*, in preventing diffusion and diminishing the plasticity of clay, will form the subject of a future communication.

NOTE.—The subjoined comparative analyses of one and the same material, after boiling 6^h and 30^h, respectively, exhibit the effect of thorough preliminary preparation, and the gross errors which may result from its neglect. It will be seen that while agreeing as closely as could be expected as regards the coarse materials, the diffrrences in the percentages of the fine ones are so great as to render the first one absolutely nugatory, and calculated to lead to an utterly false estimate of the soil's qualities.

No. 173. Under-subsoil of Cretaceous prairie, Monroe Co., Miss. (See Miss. Rep. 1860, p. 262).

Time of boiling.	6 h.	30 h.
$>$ 64^{mm} h. v. (bog ore)	2·10	2·07
8–64 " " (siliceous sand)	0·62	0·55
8 " "	0·20	0·21
4 " "	1·26	1·21
2 " "	5·18	2·92
1 " "	6·30	7·36
0·5 "	13·19	8·81
0·25 "	27·93	7·85
$<$0·25 "	27·02	35·22
Clay,	14·82	33·16
	98·42	99·36

ART. XXXVII.—*On Rocks of the Helderberg era, in the valley of the Connecticut—the kinds including Staurolitic slate, Hornblendic rocks, Gneiss, Mica schist, etc., besides Fossiliferous Limestone;* by JAMES D. DANA.

IN my memoir on the rocks of Berkshire, I have shown, on stratigraphical grounds, that the metamorphic rocks, gneiss, mica schist, mica slate, chloritic mica slate, chlorite slate and others occur, underlying and overlying quartzite, in *one of the later Lower Silurian formations*; and also that staurolite crystals abound in a mica schist of the same age.

In the following pages, it is further demonstrated that not only the same kinds of metamorphic rocks, but even hornblende rock and schist and syenitic gneiss are extensively developed in *a formation of Helderberg age*, and probably the Upper Helderberg or Lower Devonian. Moreover, crystals of staurolite are here also abundant; so that this mineral species, which some American geologists have thought as good as a fossil for distinguishing pre-Silurian rocks of a specific age, has the chronometric virtues only of a species of immensely wide range.

That I may not be supposed to misrepresent the views of "some American geologists," I here cite a paragraph from the observations of Professor James Hall on metamorphic rocks, to be found in the third volume of his N. Y. Paleontology (1859), p. 93.

"The imperfect study of these metamorphic rocks which I was able to make, while engaged in other duties, during the years 1843, 1844 and 1845, enabled me to recognize among these deposits a certain order which appeared to me to be marked by the presence of characteristic minerals which had been segregated from the surrounding mass. These observations, combined with subsequent considerations of the subject, convinced me that much might be done in the recognition of metamorphic masses by the contained minerals; and that a proper study of these would reveal some means of identification of beds at distant points, analogous to the mode of distinguishing successive formations by their contained fossils. I have subsequently, on many occasions, advocated this view, in discussion before the American Association for the Advancement of Science, and I am convinced that something of this kind will yet grow out of the farther investigation of the metamorphic rocks and their contained minerals."

To which is added in a note—

"Every observing student of one or two years' experience in the collection of minerals in the New England States, well knows that he may trace a mica schist of peculiar but varying character from Connecticut through Central Massachusetts, and thence into Vermont and New Hampshire, by the presence of staurotide and some other associated minerals, which mark with the same unerring certainty the geological relations of this rock, as the presence of *Pentamerus oblongus*, *P. galeatus*, *Spirifer Niagarensis* or *S. macropleura*, and their respectively associated fossils, do the relations of the several rocks in which they occur."

If Professor Hall intended, in the last paragraph, to imply only that the staurolite crystals afford aid in tracing a given continuous formation over Central New England from south to north, he is right. But the paragraph from the text shows that he means more,—that he holds that this mineral may be used for the "identification of beds at distant points, analogous to the mode of distinguishing successive formations by their contained fossils;" and this general principle has been since applied by more than one investigator of crystalline rocks.

It has, further, been put forth, by a geologist who agrees in the above with Professor Hall, that "the old idea of the conversion of great masses of Paleozoic, Mesozoic and Cenozoic rocks into series of crystalline schists, which so long found favor in Europe and in America, is now proved to be an hypothesis based on very slender grounds."

From the time these ideas were first published, I have had a strong desire to learn whether facts sustained them. My stratigraphical observations over Western New England, in which the Taconic rocks were also studied, were begun some years since with special reference to the discovery of the truth on this subject; and through the whole this object was prominent. The examination of the Bernardston region, the results of which are here given, was undertaken partly for the same purpose. Both have led to the conclusion that—

Lithological evidence of geological age among metamorphic rocks *of distant regions* is in general[*] worse than worthless. It is easy to use, and presses itself on the mind most insinuatingly when a conclusion is eagerly wanted; and on this account it should be treated with extreme distrust. I have further found that—

The Earth did not finish up its metamorphic work in pre-Silurian time, or even by the epoch closing the Primordial, as it did not its mountain-making. And this should be so, if, as Mallet has demonstrated, the motion attending the uplifting and folding of rocks, or mountain-making, is, like other motion, transformable into heat.

It is now twenty-two years since the first announcement, by Professor Edward Hitchcock, of the unexpected discovery of a bed of limestone containing well preserved stems of Crinoids in the very center of New England,[†] and twelve years since the detailed report on the locality by C. H. Hitchcock, in the Geological Report of Vermont.[‡] Mr. Hitchcock observes that Professor Hall had examined the Crinoidal remains (some of the stems of which are three-fourths of an inch to an inch in diameter) and had inferred from them that the beds were probably of *Upper Heiderberg* age. The conclusion, as stated by Prof. E. Hitchcock, locates a Devonian sea in central Massachusetts; and the distribution of the underlying roofing slate was regarded by him as indicating the extension of this sea northward over Eastern Vermont.

The locality of Crinoidal limestone is about three-fourths of a mile north of the "New England House" in Bernardston—a village a few miles west of the Connecticut River in Northern Massachusetts. On the accompanying map of part of the town of Bernardston[§] the position is marked by the letter *l*.

---

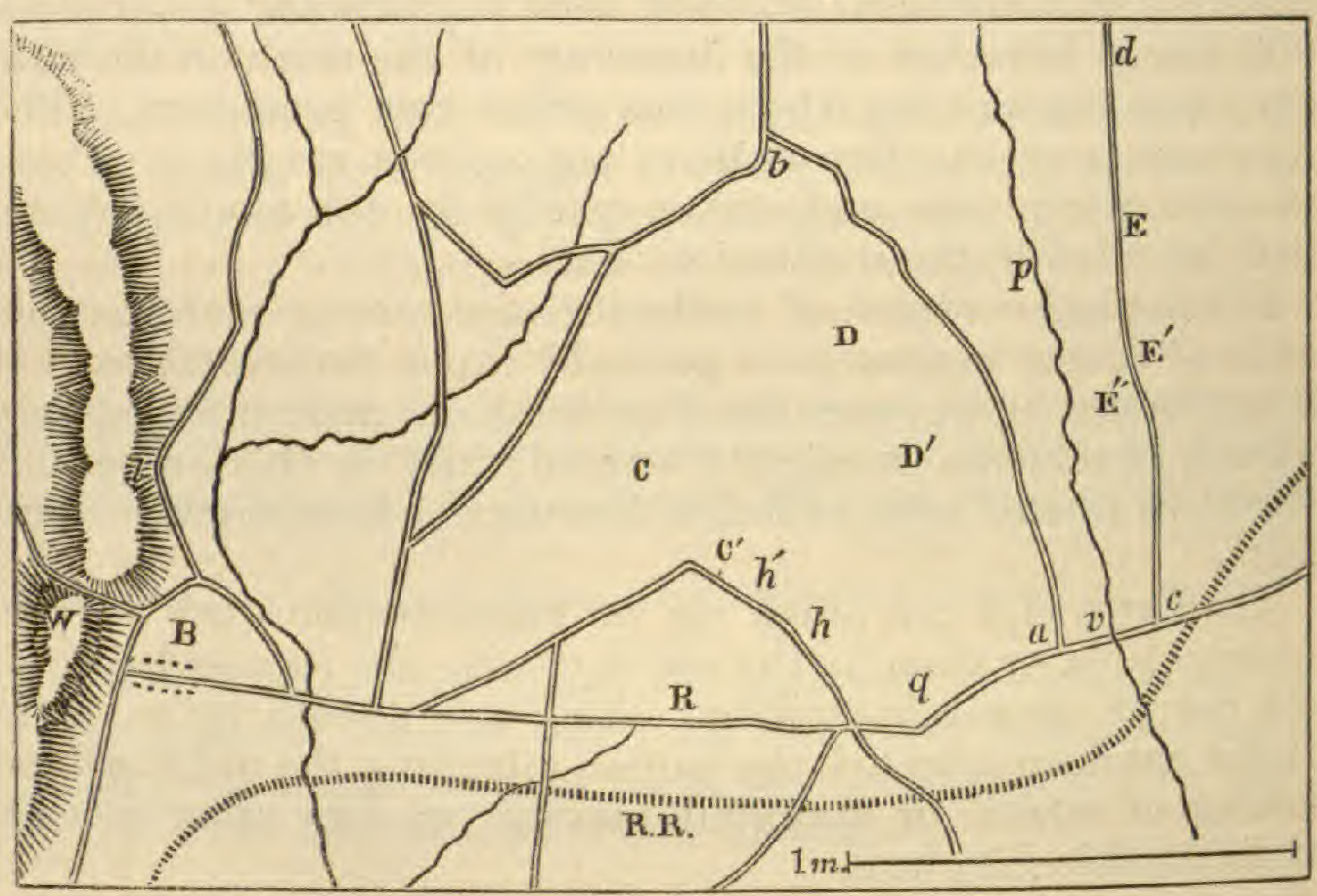
[*] The exceptions here in view are certain of the earlier Archæan (Azoic) rocks, as hypersthenite and other coarsely crystallized labradorite rocks, the very coarse reddish and dark gray syenites, zircon-syenite, and chrysolitic rocks. At the same time, it is far from certain that these rocks are exclusively Archæan.

[†] Report Amer. Assoc. for the year 1851, p. 299.

[‡] Rep. Geol. Vermont, 2 vols. 4to., 1861, p. 447.

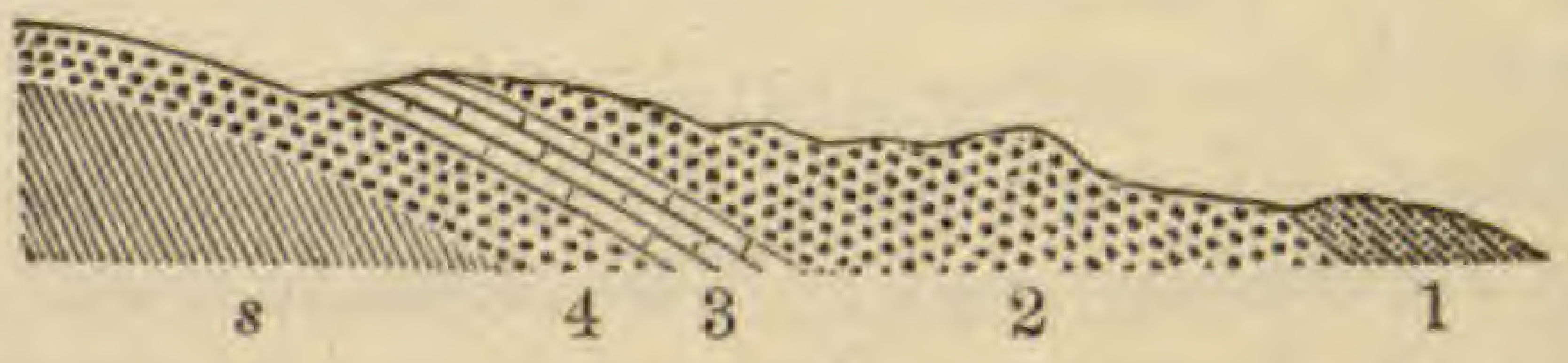
[§] This map is here inserted that geologists may have no difficulty in finding the places referred to, and so verifying the facts. Bernardston is on the Connecticut River railroad; and its depot is the last stopping place for trains going north, before entering Vermont. South Vernon is about seven miles by road northeast of the village of Bernardston, but hardly six in a direct line.

Directly west of the village (B) rises the ridge called West Mountain (W); the locality is on the eastern slope of a low part of this ridge, north of the higher portion.*



The rock of West Mountain and of its continuation to the north is clay-slate, it being part of the great slate formation of Eastern Vermont, quarried in several places for roofing slate. The Helderberg beds overlie the slate.

Hitchcock's section in the Vermont Report gives the order of succession. Another is here annexed. There is, first, as



the upper member (though near the foot of the slope), a grayish-black mica slate (1); below this (higher up the slope), a thick bed of quartzite (2); next, the Crinoidal limestone (3), the bed at least 30 feet thick; and, finally, underlying this (though at a still higher elevation), another stratum of quartzite (4), which, in some places, passes locally into a black siliceous slate. The strike of the beds, along a line from the foot of the slope up to the limestone, is about N. 45°–50° E.,† with the dip 30° to 35°; the dip of the limestone at the quarry is 25° to 30°; and, higher on the hill, that of the lower quartzite is 10° to 15°,

---

* The locality is on the land of Mr. Williams. After passing his house (white), take the path leading up the hill back of the northern end of the barn. The first rock encountered is the slate of the Helderberg series; then quartzite; finally, after ascending about 150 feet, the limestone. The Crinoidal remains are found on the weathered surfaces of blocks quarried out from the more western openings.

† Compass course, as elsewhere. The variation of the compass is 10° to the westward.

but generally not distinct. Following the outcrops of the upper stratum of quartzite (No. 2) to the southward, the strike changes to N. 65°–70° E., making the dip S. 20°–25° E. in direction, with the amount unchanged.

The clay-slate of West Mountain (or that of western Vermont), is made in the section (at *s*) an earlier *unconformable* formation.* At the nearest outcrop of this slate to the Helderberg beds—about 300 yards distant—the strike of the slate is N. 14° E., and the dip 60° to the eastward (that is, S. 76° E.). A few rods south, the same slate has the strike N. 20°–30° E., and dip 55° to the eastward; and higher up West Mountain, half a mile to the south, the strike is N. 50° E., and dip 80° to the eastward; the slate varying much in strike. Thus, while the Helderberg beds have a small dip everywhere, and the smallest as they approach the clay-slate toward the top of the ridge, the slate is very high in dip. Moreover, this difference characterizes the formations in other parts of the town of Bernardston; and hence, although no section of the two together was found exhibiting to the eye their relative position, the facts left little doubt of their unconformability.

Again, the Helderberg slate is a widely different rock from the older clay-slate, it being strictly a *mica slate*. Under a lens, the scaly glistening texture is apparent; moreover, there are distributed through all of it numerous small prisms of brown mica, usually lying on their sides or oblique to the plane of bedding, which show their foliation and luster on a cross fracture of the slate, or by an oblique view of the surface of a slab. These prisms are from a line to half a line in breadth and length. The prismatic edges are rounded, so that the prisms have really a narrow elliptical base. They have the aspect of phyllite (chloritoid) in some clay slates; but the folia are easily separable and flexible. There are also minute red dodecahedral garnets in the slate. On account of the mica crystals and garnets, the slabs freshly broken out are covered with small pimples and pits.† The clay-slate, on the contrary, is without the prisms of mica, and is far finer in texture; what unevennesses it has are not due either to mica or garnets. The Helderberg slate carries this feature through the region, and far beyond it; and the clay-slate is as persistent in its different characteristics.

The Helderberg garnetiferous mica slate is in all cases lami-

---

* Hitchcock, in the Report of the American Association, makes both slates alike in character and conformable. In the Vermont Report, the section represents the lower slate as conformable, but the text leaves it in doubt.

† An examination of the slate for water has been made by Mr. George W. Hawes, assistant in the Sheffield Scientific School; and in it he obtained 2·41 to 2·94 per cent. In a blowpipe trial of one of the little prisms of mica, only traces of water were found. The amount of water seems hardly sufficient to warrant calling the slate a hydromica slate: and, moreover, it does not feel at all greasy.

nated parallel with the bedding. Whether this is so or not with the roofing slate of the region is not positively known; the probability is against it.

The limestone is crystalline, some of it coarsely so, and much of it impure. It contains in places disseminated pyrites, and large portions have consequently rotted away, and left beds of limonite. The purer kinds, on the surface of fresh fractures, are generally coarsely crystalline, and have nothing clearly indicating the presence of fossils; while a weathered surface of the same block may be covered with prominent crinoidal stems.

The sight of a locality of Crinoids in the heart of metamorphic New England is calculated to impress the mind strongly with the belief that it is a key that will open the mysteries of New England geology. The Geological Report of Vermont states that a quartzite formation occurs in the next town to the north, Vernon, the southeast town of Vermont, and the Massachusetts Report, that it is also largely developed just across the Connecticut River, in the town of Northfield; and this suggested the true way of bringing the key into use.

After a first visit to the village of South Vernon—six miles northeast of Bernardston—with this object in view, I visited the region again in 1871, by appointment with Prof. C. H. Hitchcock, then, as now, State geologist of New Hampshire. The quartzite of South Vernon was found to be overlaid by an extensive hornblendic formation; mostly a coarse or fine grayish-green hornblende rock, or rather, in view of its color, actinolite rock, but part grayish-black Some beds are speckled with feldspar, and others are a handsome syenitic gneiss. The quartzite and the other rocks have an eastward dip of 30° to 35°, and the strike is N. 15° E. to N. 40° E.; but much of the hornblende rock is massive and jointed, and obscure in its bedding.

Besides these rocks, there is, at a cut on the railroad, a few rods south of the depot, quartzite associated with a mica schist varying from fine to very coarse scaly in its different beds, and part of it gneissoid. Again, along a north and south road a mile west of South Vernon, a slate rock was found, part of which contained crystals of staurolite; and near it there was an outcrop of quartzite giving positive evidence of the conformability of the two. The strike of the beds at this place is N. 35°–40° E., and the dip 40° to the eastward.

We thus passed over a considerable variety of rocks conformable to the quartzite—namely, coarse and fine mica schist, gray hornblende rock, both a pure and a feldspathic kind, syenitic gneiss containing the hornblende partly in oblong pointed crystals, and staurolitic slate; but we failed to find any limestone, and did not obtain good evidence that the quartzite was the same in age with the Bernardston quartzite. Prof. Hitchcock observed that the staurolitic slate, quartzite and hornblende rocks were just those of his Coös group in New Hampshire, a formation that covers a narrow band east of the Connecticut River from Massachusetts to Northern New Hampshire. We crossed the river together, and saw these rocks in Northfield, Mass., and Hinsdale, New Hampshire. It was evident that the South Vernon rocks were Coös, whether the Bernardston were so or not.

The characteristics of the Coös group, as given in Prof. Hitchcock's Annual Report for 1869, are, "the presence of quartzite, staurolitic rocks, mica schists, hornblende schists, perhaps gneiss, protogine and other rocks, lying west of the White Mountain series and east of the Connecticut River, along the whole of western New Hampshire," besides argillaceous slates, whetstone, mica schists, grits, etc., of Coös Co., etc. The occurrence of beds of limestone at intervals is mentioned in the Report of 1870.[*]

The facts observed in the region at that visit made it evident that the relation as to age of the Bernardston and South Vernon quartzites was a subject of great interest, especially in connection with New Hampshire geology. Prof. Hitchcock appreciated it, and expressed his intention of soon having the South Vernon region—for the investigation of which he had a kind of prior right—carefully studied.

The year 1872 passed without anything being accomplished, owing, as he informed me, to the demands on his time made by portions of the New Hampshire Geological Survey. A day's excursion was planned in the course of the summer; and, finding that he could not join me, I took a rapid turn over the country alone, in order to gratify a reasonable curiosity. Crossing from South Vernon westward, to the road next west, nearly a mile, the hornblende rock of the first ridge was left for a whitish or grayish gneiss, which, while mostly poor in its bedding, showed in some places the strike N. 15° E. and a dip of 30° to 55°, not essentially different from the same in the overlying hornblende rock. The gneiss became to the westward hornblendic in many of its layers, and also graduated into hornblende schist and hornblende rock; next beyond, appeared the staurolitic clay slate, with the same eastward dip. The hornblende rock stratum and that of gneiss were each several hundred feet in thickness.

---

[*] In Prof. Hitchcock's Report for 1870, four sections across the Coös group are given. In the description of that through Lyme there is the entry 2200 feet of quartzite and limestone; that through Orford, 100 feet of limestone; that through Lisbon, 50 to 100 feet of limestone. It is stated that "mineralogically the schists of the Coös group are distinguished by the presence of cyanite, andalusite or staurolite," which are "silicates of alumina without alkalies." "Garnetiferous clay slates" are mentioned as 4,500 feet thick in one section and 3,078 in another, evidently the same rock essentially that occurs at Bernardston and in Vernon.

The quartzite, which overlies the hornblende rock, constitutes a ridge just west of the road to Bernardston, commencing a short distance south of the village of South Vernon; one outcrop of it and of the conformable underlying hornblende rock was met with two and a half miles east of Bernardston, between the two railroad crossings. About two miles east of Bernardston, I took a road leading northward to "Purple's slate quarry" (*p*, on the map), and found the slate identical in every respect with that of the Bernardston Crinoid locality—the same in texture and in its imbedded crystals of mica and garnets. Its strike was northeast, and the dip 20° to the southeast. Thus a mica slate identical with that of Bernardston, and the hornblende rock and quartzite characteristic of South Vernon, were found within two and a half miles of the old Bernardston locality, and all had approximately the same dip. The probability of an identity of age was strong; but still doubt remained.

Another year having passed, and the important question still remaining unsettled,—as shown by Prof. Hitchcock's geological report issued in July last, apparently preliminary to his final report—I thought myself released from further obligation to leave the field alone, and in August went to Bernardston for a final settlement of the question; and in an hour's excursion it was done. In September, I was over the ground again to point out the decisive localities to Prof. Hitchcock.*

The facts are simply these:—

The Bernardston Helderberg locality (*l* on the map) is situated, it will be remembered, on the *western* sloping border of the plain on which the village stands. On the ridge forming the opposite or *eastern* border, just north of the road to South Vernon (R), and only 1¾ miles from the Crinoid locality (1½ miles from the village), there is visible from the road a hill with a quartzite summit (*q*). The beds dip 15° to 25° to the southward and southeastward. In the fields to the northwest, still nearer Bernardston, just east of a road but little traveled (at *h*, *h*′), there are ledges of *hornblende rock* precisely similar to that of South Vernon, a gray compact jointed rock, generally obscure in bedding, in some beds speckled with feldspar, and thence graduating into a syenitic gneiss. The dip of the rock was 15° in the direction S. 30° E. Between an upper and a lower stratum of the hornblende rock, constituting ledges a short distance apart, there was an outcrop of mica slate, identical in all respects with that of the Bernardston Crinoid locality, the small imbedded prisms of mica and dodecahedrous of red garnet making it easily recognized; and it dipped with the hornblende rock. Moreover, the lower stratum of hornblende rock

---

* Between these two visits, I learned that Prof. Hitchcock had contemplated examining the region this autumn.

contained intercalated portions of the same slate; further, the proportion of slate in this ledge increased much to the eastward. Part of it contained the mica crystals very thickly disseminated so as to crowdedly spangle the surface of a cross-fracture—a variety closely like part of the rock at the railroad cut just south of the South Vernon depot. Thus the fact that the Bernardston garnetiferous mica slate and the South Vernon hornblende rock were of one and the same formation was made certain, for here, besides occurring in alternating beds, they graduate into one another. The position and dip of these ledges indicated that they were all inferior in stratigraphical position to the quartzite of the hill above mentioned.

Decending the quartzite hill on the north side and continuing in that direction, the rock changed first to the same mica slate, the slate outcropping at one place from beneath the quartzite. The prisms of mica in some of the slate were an eighth of an inch in breadth and length; and, on a worn surface of it, they appeared as dull black, squarish spots. The garnets in all cases were minute and not very numerous.

Such facts, observed right on the eastern border of the Bernardston plain, establish the identity of the western and eastern groups of rocks, although limestone was not found in the latter. They prove that *hornblende rock*, *syenitic gneiss* and hornblende schist are rocks of the Helderberg series, as much as the Bernardston garnetiferous mica slate. The surface between these eastern and western outcrops is covered partly by the Triassico-Jurassic red sandstone formation, and for the rest of the way by alluvium and stratified drift.

East of this region (marked CC′ on the map) there are two ridges (D D′ and E E′), one to two hundred feet high, separated by a valley (*v p*), and in this valley lies the road (*a b*), and also, adjoining the brook, Purple's slate quarry (*p*), mentioned on the preceding page. The road *c d* is on the ridge E E′.

West of the ridge D D′ and of the valley there bounding it, there is an outcrop of the mica slate with the mica crystals an eighth of an inch across. On the east side of this valley, and at the west foot of D D′, stands in the field a small ledge of grayish white *gneiss*. Part of it seemed to be in place, and had a small southward dip; yet it is not too large a mass to be a transported boulder. Rounded masses of the same gneiss were found scattered over the slopes and summit of ridge D D′, but no other outcrop was met with.

In the meadow at the eastern foot of ridge D D′, lies the slate of Purple's quarry, having the dip and strike already stated; and it is beyond question the Bernardston slate, whatever be true of the gneiss of ridge D D′.

In the top of the ridge (E E′), bounding this valley on the east, near E′ and E″, there is true quartzite, having a dip of 20°

to 28°, with the strike S. 20°–30° E. But, at both E′ and E″, the *quartzite directly overlies and graduates into gneiss.* It is itself in places micaceous, and then becomes true gneiss. A little north of E″, the gneiss is well-characterized; and it is an old-looking kind, that might be thought pre-Silurian by a believer in the lithological test. The outcrops on the ridge were numerous, and the intimate connection of the unlike rocks too plain for the strongest doubter to question it.

This adds to the *Helderberg* series, gneiss in extensive strata, another of the rocks observed at South Vernon. From the relative position of the quartzite and underlying gneiss in the ridge E E′, and the slate in the valley over a hundred feet below, the mica slate must be an inferior bed in the series, unless there is a fault.

While at Purple's quarry, Prof. Hitchcock remarked to me that the slate was precisely the rock that in the Coös group contains staurolites; and a moment afterward I found in some slabs of it a few cross-crystals of the mineral, representing among them both of the known kinds of twins.

This adds *staurolitic slate* to the *Helderberg* series of Central New England.

We are now prepared for our conclusions.

1. This Helderberg series in Central New England comprises a large part of the common kinds of metamorphic rocks, gneiss of several varieties, undistinguishable lithologically from the oldest; hornblende rock and schist; syenitic gneiss; coarse mica schist and mica slate; staurolitic slate.

2. A large part of the rocks that have been distinguished as of the "Montalban" or "White Mountain series" in New Hampshire, and regarded of pre-Silurian age, are here included, and are hence nothing but altered Helderberg sediments. It is hence far from true that "the crystalline rocks of the Green Mountain and White Mountain series" and "the whole of our crystalline schists of Eastern North America are not only pre-Silurian, but pre-Cambrian in age."*

3. The passage of quartzite into gneiss is exhibited in different ways. The presence of mica in the quartzite is one of the steps But, at the locality marked *q* on the map, part of the quartzite is very finely banded with white and gray, and the

---

* Hunt's Address before the American Association in 1871, pp. 8, 36. The rocks referred to the "White Mountain series" are stated, in the Address, to include "well defined mica schists interstratified with micaceous gneisses" and every variety "down to a fine-grained schist which passes into argillite;" "beds of micaceous quartzite," "dark-colored gneisses and schists, in which hornblende takes the place of mica," which "pass occasionally into beds of dark hornblende rock, sometimes holding garnets;" "beds of crystalline limestone in the schists," which are intimately associated with the highly micaceous schists containing staurolite, andalusite, cyanite and garnet."

white portions are feldspathic, as is proved by their fusibility before the blowpipe, while the light gray are quartz, and some short darker lines are micaceous. Thus this region, like that of Berkshire, demonstrates that gneiss and quartzite are rocks of the most intimate relations, as intimate as mud and sand along seashore flats. Part of the feldspathic layers widen at intervals into forms an inch or more thick at the middle; but they are generally nearly even.

4. Hornblende rocks of the purest kind, and of great extent, are here so intercalated with quartzite and mica slate, and so often graduate into one or the other, that all must have been alike a result of the metamorphism of sedimentary beds. It is not possible that these hornblende rocks, constituting part of a Devonian or Upper Silurian formation, should have come from the metamorphism of beds of a pre-Silurian, chemically-deposited, meerschaum-like hydrous silicate.*

5. The Bernardston, South Vernon and Northfield beds being of Helderberg age, the Coös group, which is but the northern continuation of the same series, is, if correctly traced out, also Helderberg. Hence, in the era of the Lower Devonian, the Connecticut Valley, from the latitude of Bernardston northward, was an arm of the sea, extending down from the great Devonian Gulf of St. Lawrence. Crinoids require the best of ocean water, and thus they had it in central New England.

6. The Bernardston beds have been supposed to be Lower Devonian or Upper Helderberg on the ground of Hall's opinion, and also on that of Billings's, recently obtained. But both of these paleontologists speak of it only as the most probable conclusion from the fossils thus far found: they may belong to the Lower Helderberg or later part of the Upper Silurian. According to Prof. Hitchcock, a slate containing imbedded crystals of mica, just like that of Bernardston, occurs near Lake Memphremagog, where there are fossil corals of unquestionable Lower Devonian types; and, as the same slate follows the Coös series through to that region, the lithological resemblance suggests identity of age, though not proving it without a further stratigraphical study of the region between.

7. At Littleton, also, fifty miles south-southeast of Lake Memphremagog (S. 24° E.), there is a limestone, half metamorphosed, containing Helderberg corals—one of the important discoveries of Prof. Hitchcock, to whom I am indebted for guidance over the region. The limestone is associated with quartzite and clay slate, and also with a series of chloritic rocks partly feldspathic, including chlorite slate and a kind of protogine in which a pseudophite-like mineral is disseminated in small grains; and it appeared to me that all were conformable.

---

* Hunt's Address, page 12.

If this conformability is sustained by further observations, we shall have here the additional lithological fact that—

Chlorite rocks, including protogine, may constitute metamorphic beds of Helderberg age.

8. The facts which have been presented sustain the statement, made on an early page of this article, that lithological evidence of geological age is to be distrusted. If, when used by one who has made it a special study, it leads to the conclusion that true *Helderberg* rocks in the White Mountain series are of Cambrian or earlier age, it is surely a bad reliance. If it also makes out that Green Mountain rocks are of Huronian age, or of some other pre-Silurian period, when in reality belonging to the later part of the *Lower Silurian*, geologists may well be afraid even of its suggestions, unless it have sure stratigraphical support. "Huronian" areas have been defined in various parts of the country and the world, on the basis of this evidence alone; and in such cases who knows any thing whatever with regard to the real age of their rocks? It is probable that the rocks considered characteristic of the Huronian occur also among true Laurentian terranes; it is certain that they do in formations later than the Lower Silurian.

Finally, what reason is there in chemistry or geology why crystals of andalusite and staurolite should have been made only in pre-Silurian time? Andalusite consists simply of silica and alumina, and staurolite of the same, along with iron. These three ingredients are now and ever have been the most abundant of all the mineral constituents of the globe. With or without the iron, they are the materials of all clay deposits; and clay deposits from the decomposition of granite, gneiss and related rocks have been forming over the globe, and increasing in amount, ever since these rocks began their existence.

They are therefore the very last minerals that should be thought of as pre-Silurian "fossils." Were zirconium or any other of the rare metals a constituent in the species, there would be some reason for suspecting their restriction to the more ancient formations; since later sediments would contain only traces of them. But silica, alumina and iron belong to all time. These remarks apply equally to chlorite, in which these three ingredients occur, with only a little magnesia beside, and water.

9. The epoch of disturbance, in which these Helderberg rocks of the Connecticut Valley were upturned and crystallized, was probably that closing the Devonian, when, as Dawson and others have shown, extensive upturning, plication and crystallization of Devonian and older rocks took place over New Brunswick and Nova Scotia. It was the most prominent epoch of mountain-making on this eastern border of the continent,

after the Lower Silurian. Facts are against any earlier epoch; and the only other probable suggestion is that the time was after the Carboniferous age, when the Alleghanies were made. Hence, the various Helderberg rocks of the Connecticut Valley have their actual date as crystalline or metamorphic rocks either from the close of the Devonian, or that of the Carboniferous era.

The conclusions which have been presented are based on a foundation of facts—certainly as far as the region of Bernardston, Vernon, Northfield and Hinsdale is concerned, where my own observations were made; and, judging from the descriptions of Prof. Hitchcock, they appear to be sustained as regards the Coös range to the north.

I now pass to what is at present hypothetical, since I can appeal only to the observations of others, and they are not sufficient in detail for positive conclusions. I propose to examine the region personally, another season.

2. *The Connecticut Valley in Massachusetts.*

The region of the Connecticut Valley, south of Vermont and New Hampshire, commencing in the northern towns of Bernardston and Northfield, is covered to a breadth of ten to twenty miles with the Triassico-Jurassic Red Sandstone formation; so that the opportunities for observing the continuation of the more northern formations southward are thus much restricted. Still there are pertinent facts on record.

In the geological map of Massachusetts connected with Hitchcock's Report, the hornblendic rocks of South Vernon and Northfield are made to extend southward in two lines, one south of South Vernon, passing by Leverett, Amherst and Granby, the other south of Northfield, through Shutesbury, Belchertown, Palmer, Monson and Wilbraham, each line quite crossing the State to Connecticut. Gneiss, mica schist and clay slate occur with the hornblendic rocks, as at the north. Quartzite is spoken of as occurring with the hornblendic rock of Northfield, Palmer, Monson and Granby.

The varieties of rocks described by Hitchcock are similar to those of the Vernon and Northfield region, excepting that no staurolitic slate is mentioned.

There is hence a probability, that these lines of hornblendic rocks are but a continuation southward of the Coös formation: and, if either is so, then the wide Helderberg sea of the Connecticut Valley extended southward across the State of Massachusetts.

3. *The Connecticut Valley in Connecticut.*

In Connecticut the Connecticut Valley terminates at New Haven Bay—not at Saybrook. The river leaves the great central valley of New England at Middletown, it there passing out of the area of the Triassico-Jurassic Red Sandstone (which continues through to New Haven) by cutting through the metamorphic rocks of Eastern Connecticut.

Percival, in his Report on the Geology of Connecticut, states that, adjoining the Red Sandstone region on the east, there extends, southward from Massachusetts, a range of hornblendic and chloritic rocks associated with gneiss, and in some places with imperfect quartzite. He remarks that he has traced this chloritic and hornblendic range into Massachusetts as far as Wilbraham, one of the localities of hornblendic rock mentioned by Hitchcock, showing that it is identical with the eastern of the ranges in Massachusetts. He followed it in Connecticut through Somers, Ellington and Glastenbury to North Chatham, in the latitude of Middletown, where it disappears beneath the Red Sandstone formation.

The chloritic rocks include a chloritic gneiss, related to protogine, and also a compact rock which he says resembles greenstone. Percival suggests that this chlorite formation is continued on the west of the Red Sandstone formation abreast of New Haven, stating that part of the eastern chloritic rocks are more like those near New Haven (in the towns of Orange and Woodbridge) than any others in the State. In fact, part of the rock of the latter region much resembles greenstone or diorite, and was called "primitive greenstone" in the first published account of New Haven geology, by Prof. Silliman, in 1811.*

If Percival is right in his suggestion, then all these Connecticut chloritic rocks adjoining the Connecticut Valley are as much Helderberg rocks as the hornblendic and associated rocks of Massachusetts from Monson to Northfield, or those of the Coös group of New Hampshire. Even diabase, a labradorite rock which, under the name of diorite often given it, is of intensely Huronian look to the Huronian-seeker, is one of the New Haven Helderberg rocks like the rest. Much limestone occurs in the formation west of New Haven.

Thus the observations of Hitchcock and Percival, in connection with those made farther north, lead toward the view that in the Helderberg era the Connecticut Valley, through its whole length from north to south, was a wide crinoidal and coral-growing sea separating eastern from western New England. These are suggestions—but suggestions with probability enough in their favor to give profound interest to further investigations throughout the valley.

---

* Bruce's Mineralogical Journal, vol. i, p. 145.

ART. XXXVIII.—*Letter of* DR. B. A. GOULD, *Director of the Cordoba Observatory, to the Editors, dated Cordoba, Aug.* 5, 1873.

MY last letter to you was written in the beginning of Sept., 1872, at which time I gave you some account of the progress of the Uranometry, and of the preparations which were then going on for the commencement of the long deferred work of the zone observations.

Since that date I have been so overwhelmed with labors of various sorts, that I have scarcely been able to secure the needful hours for physical repose, while various superadded cares,—almost inseparable, I suppose, from an undertaking of such magnitude,—have scarcely left me the quiet for ordinary affairs of routine, and have rendered letter-writing altogether out of the question. Yet I have greatly desired to send you some brief account of the progress of the work, and now avail myself of the earliest good opportunity.

Work at the Cordoba Observatory.

The observations for the Uranometry were essentially completed early in the present year, nothing remaining to be done except the examination of discordances and the scrutiny of doubtful cases. The observations for these purposes have been carried on by Mr. Thome, in such intervals as the absorbing duties of the zone-observations permitted, and nothing now remains to be accomplished except the reductions of the star-places to the mean equinox of 1875·0, the actual preparation of the charts, and the careful delineation of the Milky Way. These represent a large amount of labor, although small in comparison with the work of observation and identification already accomplished.

Mr. Davis nearly completed the drawings of the Milky Way, upon his first series of maps, before he left us in March last; and I hope that before long the remainder may be disposed of. The preliminary tests of the observations show all the accordance that could reasonably be expected between the results obtained by the different observers; and one of the earliest processes yet to be undertaken will be the thorough and systematic comparison of the results of the four observers, and the determination for each one of his probable error for a single estimate. I am confidently hoping that a few weeks will enable us to begin the preparation of the Uranometry for publication. The rule has been to determine the magnitude of all stars down to the 7·3 magnitude, partly in order to make sure of omitting none as bright as the 7·0, and partly for other reasons. The magnitudes thus determined for stars not to be included in the Uranometry will be available for the catalogue, which I hope to construct from the zone-observations.

On the 9th of September, the observations of the zones were commenced in earnest, after a considerable amount of preliminary practice and a good deal of trouble in bringing the various apparatus into order. Whenever the weather permits we take three zones nightly, the length varying according to circumstances, but averaging somewhat less than 100 minutes. Each zone is preceded and followed by the observation of four stars, well adapted for the determination of the instrumental corrections, and by the measurement of the nadir in both cöordinates; so that the entire series of observations occupies at least eight hours.

During the intervals between the zones I give rest to my eyes—the assistant who has read the microscope for the first zone taking the observations for instrumental determinations; and being himself relieved at the microscopes by a colleague, who also officiates during the second zone, while the former enjoys a period of rest. Thus the routine gives alternately to each recorder at the microscopes one night with one zone, one with two zones, and one of repose. This arrangement, which is the most convenient, was interrupted in April, by the reduction of our force to two assistants. The weather, which had for four or five months been indescribably bad, so much so indeed that from the solstice to the March equinox there had been but 5 nights free from clouds, had just become settled and favorable; during an entire month there were but two cloudy nights, and until the middle of May we enjoyed magnificent opportunities for observing. During all this time, Messrs. Thome and Bachmann continued the work without interruption or diminution, so that we observed one-half as many stars during this period of six weeks as during the whole six months preceding. This unremitting alternation they continued without the respite of a single night, provided the sky was clear, until within a few days, when the new assistant, Mr. Latzina, had acquired sufficient dexterity to relieve them in a measure by permitting the resumption of the old routine.

Thus, notwithstanding the very unfavorable weather, which has essentially delayed the completion of these series of observations, that will now require the greater part of another year, I have the satisfaction of informing you, that we have secured no less than 379 zones, containing about 50,000 stars, of which less than one-fifth are duplicates. For the width of the zones I took two degrees as far as 46° Decl., and thence gradually increased it southward, until the last belt comprises the five degrees from 75° to 80°. In the Milky Way this width is halved, and in the magnificent galactic region near η Argus and the Cross, it became necessary to subdivide yet again. Thus my original estimate of the amount of work to be done fell short of the truth, and my present means of judging lead me to expect somewhat more than 500 zones between the parallels of 23° and 80° South Declination. These should contain about 65,000 stars, so that you will see how large a share of the work of observation has already been accomplished. I am now considering the advisableness of repeating the observation of the 10 degrees farthest north, and am inclined to believe that I shall decide to do this, in so far as it can be accomplished, without delaying the conclusion of the undertaking,—for which the greater part of another year will be needed to fill up the various regions which have been and are "being lost." Naturally, in the intensity of all this labor, no time has been available for the reduction of these observations, nor indeed has comparatively more than a small part been even read off from the chronograph-sheets.

The Southern Circumpolar list of 54 stars, which as I once wrote you was prepared during the first year and has been worked up in the same manner as the analogous lists for the Northern Circumpolars, which I prepared for the Coast Survey some fifteen years since, and has been adopted by the American Ephemeris, affords us an ample series of well-determined stars for determining the azimuth at any desired time, and obviates the necessity of too long an interval for the observation of determining stars between the zones.

The intervals between the transits of the fundamental stars are turned to account for the determination of the positions of other stars, and in this way the materials for a small catalogue of carefully determined star-places are gradually accumulating. Among these are many of the stars used for comparison with the comet observed in January and February, 1872, but I find that I had unfortunately over-estimated the optical power of the meridian circle, which had at that time not been mounted. Thus there are several of the comparison stars which prove too faint for determination with the circle,—in which instrument I have been obliged to sacrifice the illumination of the threads upon a dark field, for the sake of obtaining a better illumination of the field itself. The continued cloudiness of the early months of this year cost me the determination of some of these comparison-stars, so that I have not even yet taken up the reduction of the observations.

In this catalogue I am endeavoring to include as many as possible of those of Lacaille's stars which have not been well observed since his time, and those stars whose places are not accordant in the different catalogues.

Mr. Davis left us early in March, as I have already mentioned, and as he desired to return home by the way of Chile, I availed myself of the opportunity to obtain data for determining the longitude of some places through which his route would pass.

His observations were made with much precision, and afford admirable determinations of the longitude of the cities of Rio Cuarto and Mendoza. Similar observations made at San Luis prove to be affected by errors of record, which preclude satisfactory results; but any future observations capable of giving results of sufficient approximation to indicate the errors which exist, will make these data available also. I had hoped to have obtained before this time the means of determining the longitudes of several other provincial capitals and prominent points, but the number and character of the impediments which are continually presenting themselves would be almost incredible to those not familiar with these regions. Still I hope before many months to carry out this plan.

The longitudes thus far determined are:—In connection with Sr. Moneta, Chief of the National Engineers, by transit observations and exchange of signals on several nights—

Rosario,	E.	$0^h\ 14^m\ 14^s\cdot 48 \pm 0^s\cdot 02$	(latitude, $32^\circ\ 56'\ 41''\cdot 7$)
Buenos Aires,	E.	$0\ \ 23\ \ 18\cdot 88 \pm 0\cdot 03$	" $34\ \ 36\ \ 21\cdot 4$

By solar observations made by Mr. Davis with reflecting circle—

Rio Cuarto,	W.	$0^m\ 36^s\cdot 4$	(lat. $33^\circ\ 7'\ 19''$).
Mendoza,	W.	$0^h\ 18^m\ 30^s\cdot 6$	(lat. $32^\circ\ 53'\ 6''$).

The photographic work went on with all the success that we had any right to expect with the broken lens. Dr. Sellack succeeded in obtaining impressions of some twenty Southern clusters, among them one of the *η Argus* cluster with 57 stars, and one of the magnificent cluster near χ Carina with 122 stars. But the fracture seems to have been fatal in one respect, for none of the stars on these plates give a trail, so that the zero of position is not determined with the sharpness desirable. Finally, I decided to bespeak another object-glass of Mr. Fitz on my own account, and in October sent him the order. The National Government, with the liberality which it has never failed to manifest on every fitting occasion, soon afterward authorized the purchase of the lens for the Observatory, and gave to Dr. Sellack an appointment from the beginning of the year, as professor in the scientific faculty now organizing in this University, with instructions to continue the photographic work at the Observatory for the present. The new lens has now arrived in perfect order. Mr. Fitz gives very encouraging accounts of its performance, and a very few days ought to see the work resumed anew under better auspices for success. Before long I hope to be able to give you good accounts of the results obtained.

Cordoba Meteorological Bureau.

The meteorological bureau, of which I wrote, was established by the National Congress soon afterward, and is already organized. A liberal sum was placed at my disposition for the purchase of meteorological instruments, to be distributed to such competent persons, in different parts of the country, as may be willing to undertake the necessary observations. Although I lost no time in ordering some instruments, as preliminary specimens, from various countries, only a few have as yet arrived; and these are already distributed. Meanwhile I am doing my best to secure the co-operation of educated men in various parts of the country, that their observations may commence as soon as the requisite instruments are at their disposal. And in the interval I am endeavoring to obtain whatever meteorological observations may have been heretofore made, within the Argentine territory, in the hope of publishing the results as a sort of basis for the study of the climatic and atmospheric relations of the country. I have had the gratification of finding that two gentlemen have carried on uninterrupted series of observations for some dozen years past, the one in Buenos Aires, the other in Bahia Blanca, near the Patagonian frontier. Others have likewise made series of observations of greater or less extent, in other places, all which I hope soon to have collected. Unfortunately, the difficulty of obtaining and transporting mercurial barometers has led almost all the observers to make use of aneroids which have been inadequately or not at all compared, and even now the transportation of a barometer is a matter of serious difficulty; since the interior traffic is chiefly carried on by troops of mules, and even where the roads permit of carriage in wagons, the peril to a fragile instrument is not much less. One gentleman recently informed me that he had had six Fortin barometers successfully forwarded him, and with every precaution which his ingenuity could suggest,—but none had ever reached him in safety. The post-office has recently introduced a lighter class of vehicles for easier and quicker transmission of the mails; and as the government is providing for the construction of roads between all the principal towns, I hope for better success in the distribution of the instruments,—since every existing facility is afforded with the utmost cordiality and liberality by the administrative officers.

Thus far the new meteorological office has secured the co-operation of about fifteen correspondents, of whom ten are already provided with the necessary instruments, and I have small doubt of finding as many more willing to undertake the gratuitous and arduous labor of three daily observations,—a matter requiring far more effort and care in this country than at home. It has seemed the far wiser policy to aim first simply at securing a few elementary data, than by asking for many and varied observations to imperil the accuracy and systematic character of the whole, and incur danger of deterring observers from an undertaking which might appear to them too laborious. Hence the programmes issued ask only for the readings of the barometer, thermometers with wet and dry bulbs, direction and estimated force of wind and amount and form of the clouds, and quantity of rain. These taken at 7 A. M. and 2 and 9 P. M., are quite enough for persons not devoted to scientific pursuits. I have prepared a little pamphlet giving the necessary instructions and precautions, and blank forms, modeled essentially upon those of the Smithsonian institution, for the registry of the observations,—both of which have been already freely distributed. Some of the officers of the national army had commenced regular observations at frontier stations, when the present insurrectionary movement of Lopez Jordan, the assassin of Gen. Urquiza, in Entre Rios, interrupted the undertaking by requiring a concentration of the national troops in that unfortunate province, now for the second time in three years devastated by the semi-savage hordes, whom the hope of plunder, and the excitement of a mode of life more attractive to the gaucho than the pastoral pursuits of peace, have served to gather round this chief.

Earthquake of October, 1871.

You may remember hearing of the calamity to the Argentine city of Oran, which was destroyed by an earthquake on the 25th October, 1871. This was the most northerly town in the republic, situated about $4^h\ 14^m$ W. from Greenwich, and 23° 10′ S. lat., and contained about 4500 inhabitants, of whom perhaps a thirtieth part perished in the ruins. The houses in these regions are usually built, as you know, with but one story: the better class consisting of single rooms arranged round one or more open court-yards; the poorer, of a single apartment like an Irish cabin; and all constructed principally of adobe or sun-dried bricks,—so that the loss of life on such occasions is far less than would be the case were the building material harder, or the structures more elevated. This unfortunate town, having just been rebuilt from its ruins, has now suffered the same fate for the second time.

On the 7th July, I received from Major Host, a Prussian engineer officer with whom I had just concluded arrangements for determining the longitude of the city of Salta (latitude 24° 15′, longitude about $4^h\ 23^m$ from Greenwich), a telegraphic message informing me that on the day preceding, at $3^h\ 54^m$ P. M., Salta had been visited by a violent earthquake, which lasted for 28 seconds, and consisted of about five severe shocks at intervals of 5 or 6 seconds,—the motion being from N.E. to S.W., followed by a series of slight vibrations which continued until about 10 P. M.

Later accounts brought information that the city of Jujuy, north of Salta, had suffered much injury, the church tower having been thrown down, the principal public buildings much injured, and many private houses destroyed; and we have now the tidings of the new destruction of Oran. Meantime, through the courtesy of Mr. Voglino, Superintendent of the Transandine telegraph, and the kindness of correspondents, I have learned of several shocks in the cities of San Juan, Santiago and Valparaiso on that evening and the following night, which for a time impressed me with the suspicion that the earthquake which destroyed Oran and shook the cities of Salta and Jujuy must have been the same which was felt on the Pacific Coast ten hours later. This belief appears to be generally entertained, and statements to this effect have been made in the principal journals. Nevertheless, the intrinsic improbability of such a phenomenon seemed so great, that I have made very careful inquiries, through those regions of this republic and of Chile which suffered on those dates, and have convinced myself that the first impression was incorrect.

The shocks which destroyed Oran at about 3½ P. M., July 6, are stated to have been felt at Jujuy and Salta, at from 6 to 8 minutes before 4, and at Tucuman (approx. lat. 26° 50′, long. $4^h\ 15^m$) at about $4^h\ 35'$ to $4^h\ 40^m$. But it must be remembered that in all these places most of the people are unaccustomed to any exact determination of time, and that even the few who carry good watches have no correct standard of local time. The lines of telegraph which the National Government has been rapidly extending in various directions throughout the country, and which are now provided with the correct Cordoba and Buenos Aires time, are beginning to remedy the deficiency, but this is comparatively a slow process. Therefore it is unsafe to found any careful estimate of the velocity of the wave from the data given. The managers of the National Telegraph and of the Transandine line uniformly afford every possible facility for scientific investigations, and Mr. David, the Chief of the Cordoba office, has gathered from the various offices to the northward, as has Mr. Voglino from those to the westward, all the data which could be obtained. It is now clear to me that there were two distinct shocks at an interval of some ten or more hours; one on the borders of Brazil and Bolivia on the afternoon of the 6th, and the other on the Pacific Coast at a little after 2 A. M. of the 7th. Both shocks appear to have been felt in Rioja, San Juan and Mendoza, along the eastern slope of the Andes; but the data relative to the precise time of the shocks are so vague, that I do not venture to draw any inferences as to the rapidity with which the wave traveled. In Valparaiso there were eleven distinct shocks, so severe as to break all the telegraph wires between that city and Santiago.

Meteoric Iron of Grau Chaco.

The government of the Argentine province of Santiago del Estero has offered a liberal premium for the discovery of the mass of meteoric iron so often cited as existing within that province in the uninhabited region known as the Grau Chaco. This mass of iron, cited in almost all the books, was described in 1788 by two engineers, Celis and Cervino, who had been sent by the viceroy of Buenos Aires to examine into the truth of the reports given by the Indians on the subject. They reported that near the middle of a great plain called *Otumpa*, about sixty leagues tó the eastward of the city of *Santiago del Estero*, they found the mass of iron in question, in form approximately a parallelopiped, of dimensions not much less than 9½ feet by 6, and 4½ thick, and whose weight they estimated at about 90,000 lbs. During the War of Independence, while the port of Buenos Aires was closed by the Spanish blockade, an expedition was sent to the Grau Chaco to obtain iron from this source for the manufacture of fire-arms.

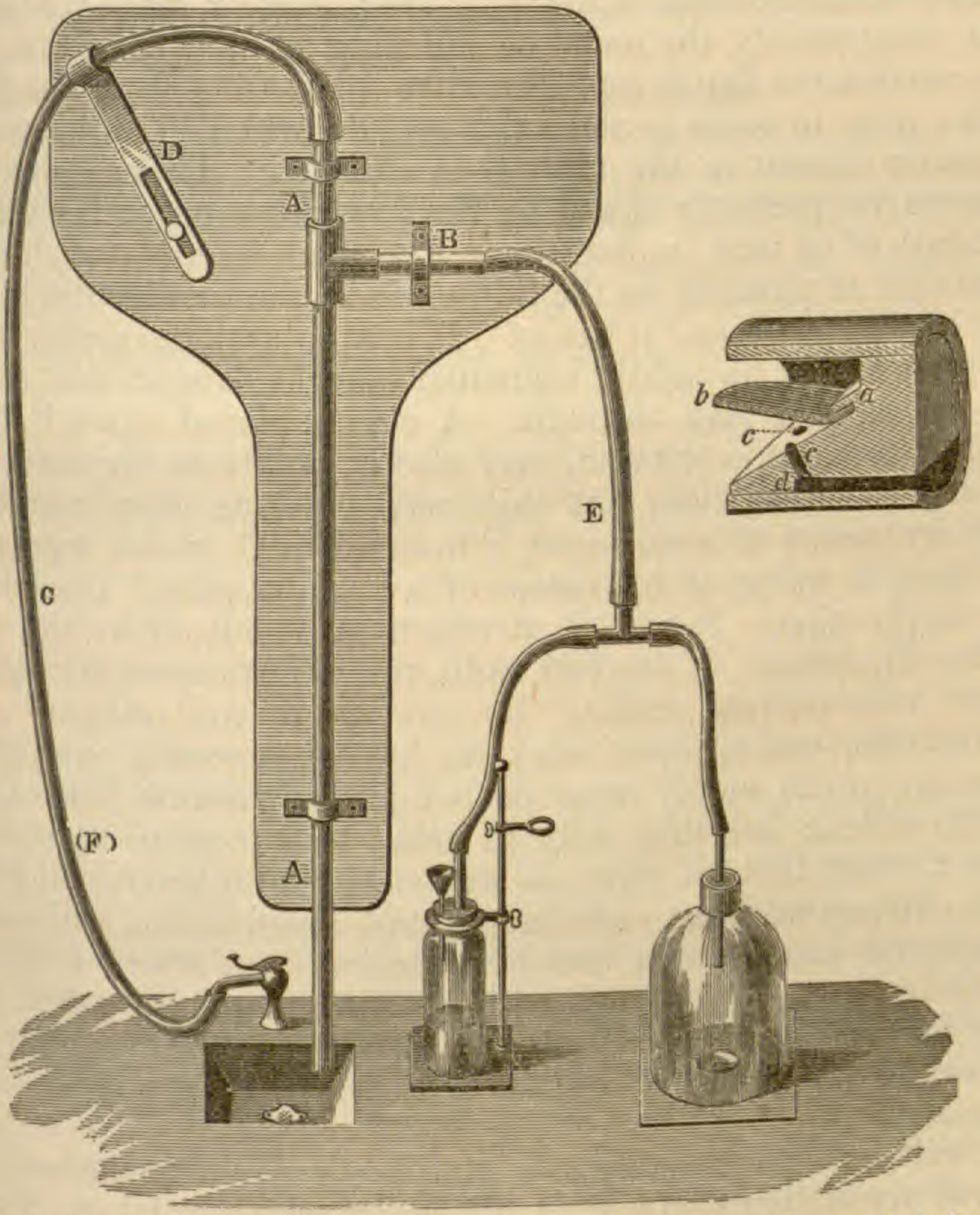
The expedition was successful, and returned with a considerable quantity: a piece weighing about 1,500 lbs. was given to Sir Woodbine Parish, the English Consul, who described it in his well known work on the La Plata, and sent it to the British Museum. The English chemists found it to contain about ten per cent of nickel. A brace of pistols manufactured from the same material was sent to the President of the United States. Similar but smaller pieces of iron are said by the Indians to exist in abundance in the same region, and it is to be hoped that under the stimulus of the large pecuniary reward now offered, the long lost site may be discovered anew.

ART. XXXIX.—*On a Modification of the Jagn Vacuum or Filter Pump*; by Prof. A. E. FOOTE.

THE introduction of the Sprengel vacuum pump—so widely known since Bunsen applied it to rapid filtration—has been greatly limited by the fact that most laboratories do not command the needful head of water. Jagn's pulsating pump, described in Liebig's Annalen, November, 1872, is capable of producing a very good vacuum with a water fall of three to five feet. In adopting this pump for laboratory use, I found, in common with many other persons, that the form given by the inventor has grave defects. Of these, the most troublesome lies in the caoutchouc valve, which after a time becomes stiff and acts imperfectly or not at all. The valve devised by Thorpe, described in the Phil. Mag., October, 1872, and noticed in this

Journal, March, 1873, has in my hands proved difficult of construction, works badly unless perfect, and quickly wears out.

My device is exceedingly simple and easily constructed. It can be made of common materials by any plumber, or gas fitter. It has been in use in this laboratory for some months, and we easily produce by it a vacuum of twenty-five inches of mercury. The following is a description of the apparatus as modified by myself.


1.

2.

A A is a tube about four feet long, and from three-eighths to one inch in diameter. To the side of this an arm B is affixed, by means of a T coupling. B is from four to eight inches in length, and may have a manometer tube attached. C is the caoutchouc vibrating tube which conducts the supply of water to A. The upper part of A over which C is thrust, is cut off at an angle of 40°. The vibrations are regulated by a moveable arm D. To B is attached a rubber tube E, which leads to the vacuum bell jar or bottle. Within B and near its connection with A, is fixed by cement, the valve represented in fig. 2.

The valve is constructed as follows: A cylindrical metal plug about one inch long, and of such diameter as to slip easily within the tube B, is cut away at one end (as shown in fig. 2, where it is represented in section, with a portion of tube B), leaving a tongue of metal *a*. This tongue of metal is driven down upon a flap of sheet caoutchouc, about 1 millimeter in thickness, *b*, which is thus held upon the bevel of the plug and covers the two channels, *c c*, one of which is seen in section. These channels communicate with the passage *d*, made by filing away tangentially the metal of the plug as shown in the cut. The caoutchouc flap is represented as lifted away from the face of the plug in order to show the orifices which it closes when the water current in the tube B is checked. These holes, in order to be perfectly closed by the flap, must be at least one-sixteenth of an inch in diameter. The sheet caoutchouc should be as thin as possible, as the thinner it is the smaller the holes may be, and the better it works. It is absolutely necessary that the plug should be tightly cemented into the tube so that not a trace of air can leak through. A clamp placed upon E, and used to retain the vacuum, may also be made to regulate the rapidity of exhaustion, but this may be done more conveniently by means of a stop-cock F inserted in C, which regulates the flow of water, or by means of a "globe valve" placed in the supply pipe. The angle at which A is cut off at the top is also important. If not just right, the vibrations of the caoutchouc tube are not perfect. By the use of the ordinary gas fittings (stop-cocks, pipes, etc.), we have connected one pump to several quite widely removed bell-jars or vacuum bottles.

I have been led thus fully to detail this piece of apparatus from a belief that, as soon as known, its simplicity, compactness, efficient working, and cheapness of construction, will cause its general introduction into laboratories even where a fall of thirty feet can be obtained without difficulty. Its value, not only for rapid and difficult filtrations but also for evaporations where the application of heat is objectionable, cannot be overestimated.

I will here make note of a simple arrangement devised by one of my students, Mr. F. D. Whitney, which quickens filtration sufficiently for many purposes.

To the top of the shelving behind the sink fasten a tube vertically. Join one end of this to the water-supply pipe, the other to the bulb of a thistle tube, by means of a glass tube inserted through a rubber cork; through another hole in the rubber cork is carried a tube which connects with a vacuum bottle. The vacuum produced is of course proportional to the column of water supported in the thistle tube and its connections.

For the platinum cone used in filtering, I take an old worn piece of platinum foil, one that has been used in blowpipe work, make it perfectly smooth and cut it to the center on one side, bend it till it nearly fits the bottom of the funnel and then press it in place by means of a turned wooden cone. The more *small* holes in the foil the better.

I will add that these valves, as shown in fig. 2, as well as the entire apparatus, fig. 1, are made in the college workshops here, and will be furnished at cost, on application to Professor Anthony.

Chemical Laboratory of the Iowa State Agricultural College,
Ames, Iowa, Sept. 8th, 1873.

ART. XL.—*Chemical Papers from the Massachusetts Institute of Technology.*—No. III. *On the Synthesis of Hydrocarbons by the treatment of Cast Iron with Acids* ; by F. H. WILLIAMS.

SINCE the day when the close relations between mineral and organic chemistry were first recognized up to the present time, the artificial production of carbon compounds from inorganic sources has occupied in a remarkable degree the attention of chemists, and the discoveries of Woehler, Kolbe, Berthelot and others, in this direction have been received with the greatest interest; it is therefore singular that the simplest possible means of preparing artificially hydrocarbons has received so little accurate study.

No synthesis in chemistry can be neater than that which joins the carbon combined in cast iron with the hydrogen evolved during the solution of the compound in an acid, and if no one has hitherto isolated and examined the products of this reaction, the reason of this neglect may perhaps lie in the erroneous assumption, that the hydrocarbons must consist in such large part of marsh gas or similar gases, as to make it impossible to separate them from the hydrogen evolved.

Dr. Schafhæutl* has given us the most precise accounts which we possess, of attempts to isolate the hydrocarbons produced during the solution of pig iron in an acid, but he does not appear to have obtained any notable quantities of substances pure enough to be recognized.

I publish here some attempts in the same direction, notwithstanding their incompleteness, in the hope that the results may be found sufficiently definite to awaken interest. They seem to point to the possibility of obtaining by the above mentioned method a great variety of hydrocarbons, belonging to the satu-

---

* Erdmann, Jour. der Chemie, 1859, 76, 271.

rated and non-saturated series; and these experiments, which restricted time obliges me to terminate for the present, afford the hope that some at least of those bodies may be obtained in a state of purity by operating with larger quantities. The material for the investigation was white spiegel eisen containing a very high percentage of carbon.

Of the volatile products, only those which could be separated from the hydrogen by condensation in a freezing mixture or by combination with bromine were examined, and those which could not be separated from the hydrogen by these means were lost. The compounds of carbon remaining in the liquid after the solution of the iron were collected.

The following apparatus, after several trials, was found the most convenient for the treatment of the iron with an acid, and the collection of the hydrocarbons, which could be condensed in a freezing mixture or combined with bromine.

A six liter retort was supported in a water-bath and connected with the lower end of a Liebig's condenser one meter long. To the higher end of the condenser was attached a chloride of calcium tube; from this a small glass tube carried the gas to the first of three tubes immersed in a mixture of snow and salt. From the last of these tubes the gas was conveyed to the hood, where it was passed through bromine and was allowed to escape.

The Liebig's condenser was cooled by water. It was used to condense any vapor of water which might come over, and was inclined in such a way as to cause the water to run back into the retort.

The arrangement of freezing tubes was as follows: In the bottom of an old oil cask, which was supported six or eight inches above the desk, were bored three holes. Into each was inserted, from the inside of the cask, a rubber stopper having a single perforation. Three glass tubes, somewhat less than a meter long and about thirty millimeters in diameter, were drawn out in such a way as to leave a small-sized tube three or four inches in length on one end of each; this end was pushed through the hole in the rubber stopper until the shoulder of the tube rested on the rubber; the upper ends of the tubes were stayed to the side of the cask with large copper wire. To the small lower ends of the tubes projecting through the bottom of the cask, were attached small rubber tubes closed by spring-clips.

The upper end of each tube was closed by a stopper having two perforations. Through one of these passed a small glass tube, bringing the gas nearly to the lower end of the larger tube; through the other a small tube, which took the gas to the next condensing tube, was passed just through the stopper. In this way the gas was required to go to the whole length of the tube in the freezing mixture. Nearly all the hydrocarbons were condensed in the first of the tubes, some in the second and almost none in the third.

The cask was kept filled with a mixture of snow and salt, which gave a temperature of 15° C. nearly constant day and night during the experiments. The retort was charged with three kilograms spiegel iron, in pieces about the size of a walnut, and three liters of carboy muriatic acid 21·5 Baumé, and was quickly connected with the condenser. The disengagement of hydrogen was regulated by heat applied through the water-bath to the retort, and was kept as nearly constant as possible. About sixteen hours after, six or seven c.c. of liquid hydrocarbons were drawn off from the freezing tubes. The liquid had a very unpleasant odor and burned with a very smoky flame.

About eighteen hours after charging the retort, it was disconnected from the rest of the apparatus and the black liquid in it poured on a filter, care being taken not to allow any of the iron to go out. Two liters of fresh acid were added and the retort put back in its place. The black residue on the filter and the filtrate from it will be referred to again.

The next day the liquid was poured out of the retort; two liters of fresh acid and one kilogramme of iron were put in. The retort was charged with two or three liters of acid daily, and iron was added on alternate days for ten days; care was taken to keep the condensing tubes well cooled, and as soon as the bromine was saturated it was replaced by a fresh quantity.

The amount of iron dissolved in the first experiment was 7430 grams. 49 grams or ·66 per cent. of liquid hydrocarbons and 325·5 grams of bromides were obtained.

The whole of the hydrocarbons, together with a small quantity of muriatic acid drawn from the freezing tubes, were treated with water, with dilute caustic soda, and then again with water, until they gave no reaction with litmus. The hydrocarbons were separated from these and weighed. A small quantity of chloride of calcuim was added to absorb the water completely. They were allowed to stand some time in a stoppered bottle, when the most concordant analyses gave the following results:

I. Hydrocarbons,	·1764 grms.	II. Hydrocarbons	·3213 grms.
CO_2	·4838 "	CO_2	·8822 "
H_2O	·2172 "	H_2O	·3728 "
III. Hydrocarbons	·3625 "	IV. Hydrocarbons	·3555 "
Ag Cl	·1677 "	Ag Cl	·1761 "

	I.	II.	III.	IV.
Carbon	74·79	74·89	....	....
Hydrogen	13·67	12·89	....	....
Chlorine	....	....	11·44	12·25

A portion of the hydrocarbons was distilled in a small flask fitted with a thermometer. The vapor began to go over at 93° C., the temperature rose steadily to 135°, where it paused slightly, thence to 155°, which seemed to be the limit. The larger portion of the liquid distilled over at 135° C. There was no decomposition or disengagement of chlorhydric acid. The few drops left in the flask had a slight acid reaction.

The bromides, after being treated several times with dilute caustic soda, was washed with water until they gave no reaction with litmus paper; they were then weighed.

They were allowed to stand over night with a small quantity of solid caustic potash; in the morning they were poured into a flask and heated until the caustic potash melted. Under this treatment the liquid changed from a dirty milky to a dark, not very clear, vinegar color.

The bromides were distilled from a flask through a Liebig's condenser cooled by water. A thermometer inserted through the cork of the flask gave the following readings. The temperature rose from 20° slowly but steadily to 120° C, more slowly from 120° to 130°, still more slowly 130° to 140°, a barely perceptible motion 140° to 145°, stopped some time at 146°, motion of the mercury could hardly be seen from 146° to 148·5°, stopped some time at 148·5°, motion could not be appreciated from 148·5° to 149·5°, stopped at 149·5° a short time, rose slowly 149·5° to 151°, rapidly 151° to 158°, slowly 158° to 163°, rapidly 163° to 169°, slowly 169° to 176°, less slowly 176° to 179°, when the lamp was taken away, as bromhydric acid was given off. About four-fifths of the liquid had distilled over.

In another experiment using the same acid with German spiegel eisen, kindly furnished by the Bay State Iron Works, 2778 grams of iron were dissolved, and 15 grams or ·54 per cent of liquid hydrocarbons were obtained; also 68·6 grams bromides.

In this experiment all residues from the retort, consisting of graphite, silica, &c., were collected on a large filter; these residues were placed with the filter and about a liter of water in a flask and distilled. There came over and was condensed with the steam a clear, yellow, oily liquid, which was collected from the surface of the water and weighed 4·37 grams or ·15 per cent of the iron dissolved; nearly all of this came over with the first half liter of distillate.

In a third experiment, using the same iron as in the second, but instead of muriatic, dilute sulphuric acid, one part to four of water, 1691 grams of iron were dissolved; 1·8 grams, or ·11 per cent, of hydrocarbons were condensed in the freezing tubes; the bromides weighed 94·7 grams.

The muriatic acid probably favored the condensation of the hydrocarbons in the first two experiments; also at times during this experiment, owing to difficulties in procuring the freezing mixture at the proper time, the condensing tubes were not as well cooled as they should have been; this would allow more of the hydrocarbons to go on to the bromine.

Just previous to the last experiment a new retort was procured and the condenser and freezing tubes were cleaned.

The heat used under the retort in the experiments with muriatic acid was very slight at first. Some time after the retort was charged and the rapidity of the current of gas slackened the temperature was raised. When sulphuric acid was used, a considerably lower temperature was sufficient to generate the gas rapidly enough.

The gas, when lighted at the end of the apparatus, always burned with a small light-giving zone indicating the presence of hydrocarbons which were not collected.

Once during the first experiment, when the retort was emptied, the liquid was poured into a stoppered bottle, the excess of chloride of iron allowed to crystallize out over night; the solution was then filtered, and four or five c.c. of nitric acid were added to about a half liter of the filtrate. The mixture was boiled, and ammonia water nearly to alkaline reaction added; the precipitate of hydrate of iron was filtered off, washed, heated with sulphuric acid and ether in a stoppered bottle, and shaken at intervals for two or three days. The ether layer was distilled, and a portion of the distillate allowed to evaporate spontaneously on a platinum dish left no residue; the lower layer was now added and distilled; no oily layer was found on the water in the receiver.

The residue in the flask was filtered, very dilute ammonia added until quite a precipitate of hydrate of iron was obtained, the solution still giving an acid reaction; the precipitate was filtered off, dried at 100° C., a portion heated in a closed tube. Steam and chloride of ammonium were given off: a small quantity of a black substance also condensed on the walls of the tube; no organic compound appeared to have been precipitated with the oxide of iron.

The chloride of calcium in the drying tube, through which the gas had passed more than three weeks, was dissolved in water and distilled; there was collected from the surface of the distillate an oily liquid, resembling in odor and appearance that obtained from the residue in the retort.

The result thus far obtained may be briefly summed up as follows: There may be obtained by the solution of cast iron in an acid, besides gaseous bodies, which escape with the hydrogen, volatile hydrocarbons, boiling between 93° and 155° centigrade, probably belonging partly to the saturated and partly to the non-saturated series; of this latter series, very considerable quantities may be condensed by combination with bromine after having passed through a freezing mixture. It is particularly interesting to observe that when chlorhydric acid is used, the chlorides of hydrocarbons are obtained.

Under the conditions of these experiments the quantity of hydrocarbons, which are not volatile with the vapor of water, is too small to allow them to be collected.

No formation of an organic acid could be observed.

No. IV. *On the Estimation of Arsenic as Pyroarseniate of Magnesia;* by L. F. Wood.

Fresenius'[*] determination of the solubility of arseniate of magnesia and ammonium in different saline solutions, and Puller's[†] very thorough investigation of the conditions under which arsenic acid should be precipitated with magnesic mixture, and of the properties of the precipitate, show us the sources of error to which this method of analysis is liable and also the means of avoiding them.

Puller recommends using a slight excess of magnesia mixture, and assumes that the quantity of hydrate which is precipitated with the arseniate compensates for the solubility of the latter in the solution in which the precipitation is made; and he allows one milligram of arseniate of magnesia and ammonium to every 16 c.c. of washwater, to compensate for the solubility of the precipitate in dilute ammonia water.

Puller confirms Wittstein's observations, that when the hydrated arseniate of magnesia and ammonium is heated very gradually, and with extreme care to transform it into pyroarseniate, the results are exact, and gives this method the preference.

Rose's method of estimating arsenic acid is then reliable under the conditions described by the above authors; but the necessity of allowing for the solubility of the precipitate, and the liability to error from hasty ignition, are grave inconveniences. The following experiments were made in order to find a method of precipitation and ignition free from the above objections, and if the results are confirmed by more extended experiments, the process described in Finkener's edition of Rose can be successfully used with some modifications.

The precipitant used was a solution of pure chloride of magnesium in alcohol of strength about 85 per cent. The solution contained about 100 grams $MgCl_2$ per liter.

---

[*] Zeit. für Anal. Chemie, 1864, p. 206. [†] Zeit. für Anal. Chemie, 1871, p. 41.

In each analysis 0·3000 gram arsenious acid was used and dissolved in a solution containing 2 grams of carbonate of sodium, and oxidized to arsenic acid in the usual way with chlorine gas. The solution was then made acid with chlorhydric acid, about 2 grams of solid chloride of ammonium added, and then ammonia water in considerable excess. The alcoholic solution of $MgCl_2$ was now added as long as the formation of a precipitate continued, and then an additional quantity of about 1½ c.c. was added, and the mixture allowed to stand over night. A quantity of alcohol (85 per cent) equal in bulk to one-half the liquid was then added, and the precipitate was filtered upon a weighed filter and washed with a mixture composed of about 2 parts alcohol, 1 part strong ammonia water and 3 parts water.

In each case, when taking the weight of the filter, it was nearly balanced on the opposite scale-pan by another filter of the same diameter.

Since loss is unavoidable when the filter is burnt with the arseniate of magnesia adhering to it, and since, on the other hand, the complete drying of a large quantity of precipitate at 100° is very tedious (see Puller, Zeit, 1871, p. 63), only the small quantity which could not be easily detached from the filter was dried to a constant weight at 100°. The bulk of the precipitate was put in a porcelain crucible, three or four drops of strong nitric acid added, and the whole placed in a crucible of larger dimensions and heated at first for about 15 minutes, at a gradually increasing temperature, to drive off the nitric acid and decompose the magnesic and ammonic nitrates. The object of covering the small crucible and placing it within a larger crucible was to avoid spattering and to keep away reducing gases. It also served to protect the wearing of the crucible, as at the end of seven analyses the small crucible did not differ in weight from its first time weighing.

The crucibles were finally heated over the blast lamp for periods of 5 minutes, until the weight became constant. Since the products of decomposition of nitrate of ammonium are oxidizing agents, there is little reason to fear a reduction of arsenic acid in the process, and the following results appear to show that none is lost by volatilization.

In the following analyses, in which 0·3 gram As_2O_3 was taken, the weight of arsenious acid regained was calculated from the weights of pyroarseniate of magnesia in the crucible, and from the weight of hydrated arseniate left upon the filter.

I. Filtrate = 137 c.c. Washwater = 54 c.c.
Weight of $Mg_2As_2O_7$ = 0·4637 grams.
" " $MgNH_4AsO_4$+Aq. = ·0076 "

As_2O_3 equiv. in weight = 0·30005 "

II. Filtrate = 146 c.c. Washwater = 50 c.c.
Wt. of $Mg_2As_2O_7$ = 0·4637 grams.
" $MgNH_4AsO$+Aq. = 0·0076 "
Wt. As_2O_3 calculated = 0·3008 "

III. Filtrate = 106 c.c. Washwater = 58 c.c.
Wt. of $Mg_2As_2O_7$ = 0·4576
" $MgNH_4AsO_4$+Aq. = 0·0134
Wt. As_2O_3 calculated = 0·2992

In the following analysis the solution was allowed to stand four days after the addition of the alcoholic-magnesia solution and the alcohol. The result indicates the precipitation of magnesic hydrate or carbonate.

IV. Weight of $Mg_2As_2O_7$ = 0·4962
" " $MgNH_4AsO_4$+Aq = 0·0083
Wt. As_2O_3 calculated = 0·3212

In order to avoid this error in the following analyses, the first precipitate after filtration was dissolved in chlorhydric acid, and reprecipitated with an excess of ammonia water; and a quantity of alcohol equal to half the bulk of the liquid was added. The results were the same, whether this precipitate was filtered immediately or after the lapse of 24 hours. Probably, if a second precipitation is employed, the alcohol might be added immediately during the first precipitation instead of waiting 24 hours.

Results obtained by two precipitations.

V. 1st filtrate = 109 c.c. 2d filtrate = 68 c.c.
Wash water = 45 c.c.
Wt. of $Mg_2As_2O_7$ = 0·4630
" $MgNH_4AsO_4$+Aq = 0·0068
Wt. As_2O_3 calculated = 0·2992

VI. 1st filtrate = 125 c.c. 2d filtrate = 64 c.c.
Wash water = 40 c.c.
Wt. of $Mg_2As_2O_7$ = 0·4596
" $MgNH_4AsO_4$+Aq = 0·0124
Wt. As_2O_3 calculated = 0·2999

VII. 1st filtrate = 165 c.c. 2d filtrate =
Wash water = 45 c.c.
Wt. of $Mg_2As_2O_7$ = 0·4615
" $MgNH_4AsO_4$+Aq = 0·0099
Wt. of As_2O_3 calculated = 0·2999

Two of the filtrates and one of the washwaters were examined for arsenic acid. One filtrate and washwater were acidified with chlorhydric acid, and saturated with sulphuretted-hydrogen. After allowing to stand 20 hours, no precipitate was formed. The other filtrate above mentioned was treated with a large excess of magnesium mixture and warmed; the precipitate of magnesic hydrate or carbonate which was formed was filtered and redissolved in a very small quantity of chlorhydric acid. On the addition of an excess of ammonic hydrate, no precipitate was obtained. It appears from these experiments that arsenic acid can be completely precipitated by employing an alcoholic solution of chloride of magnesium, and that the precipitate can be ignited without danger from loss by reduction, after the ammonia which it contains has been transformed into the nitrate by the addition of nitric acid.

ART. XLI.—*On Glaciers of the Glacial Era in Virginia*; by R. P. STEVENS. (From a letter to one of the Editors.)

IN a late visit to the Richmond, Va., coal field, my attention was drawn to palpable signs of glacial action, in long and narrow trains of pebbles and small boulders: one train I traced for more than five miles. These trains in the vicinity are called "*ancient river beds.*" Their general direction was north and south.

Other than these signs were seen at the new opening upon the middle vein, on lands of the James River Coal Co., lying north of the James River. I found the northeastern outcrop of the Coal-measures, including the lower vein of coal, had in many places been removed, and, with the debris of associated strata, had been carried over and deposited upon the northerly slope of the hill holding the upper vein of coal, making a true drift deposit, composed of Coal-measure materials mingled with material from gneissoid rocks. I was able to follow the line of removed outcrop up to the northern limit of the coal field. I had previously noticed similar phenomena south of James River. That the Richmond coal field had been struck by a moving glacier was quite as palpable as the northern fields of Pennsylvania. Richmond is in latitude 37° 30′ S.

From Richmond, as far as Covington, I passed over the Chesapeake and Ohio R. R.: consequently no observations for glacial action could be made. At Covington, which is situated on the Jackson branch of the James River, having a short time for examination, I soon found in the railroad cuts the upturned edges of bluish slates shaved off, with drift clays and gravel reposing upon them. Similar observations were made all the way up to Lewis Tunnel, or the passage of the railroad into the valley of the Green River.

The Jackson branch has its source on the east flank of the east front of the Alleghany Mts., in Highland Co., Va. The Green River rises on the west side of the same mountains, in Pocohontas County.

You may remember, that some time since I wrote you, that I had found Canadian boulders on the summit of the West Front Mts., or Back Bone Mts., in Tucker Co., at the sources of the N. W. branch of the Potomac River. Bearing this in mind, I was on the alert to find signs of glaciers, also, in the Green Briar Valley.

No sooner had the tunnel been passed, and the valley entered, when great masses of true boulder drift were found massed on slates and limestones of the Subcarboniferous group. Beds were seen thirty feet in thickness. These evidences continued as low down as the junction of the Green Briar with New River, at Hinton. At this point there was a good field for observation. Excavations had recently been made for foundations of railroad buildings. Here was seen the crushing, polishing, and grooving action of glaciers upon the hard gray sandstone of the valley, with boulder clays and gravel reposing upon it. There was no doubt left on my mind that glaciers had moved down both of these valleys; one to the South and West, the other to the South and East.

It is an interesting inquiry, where did the Green Briar glacier pass from Hinton? Up the New River into the great valley of Virginia? or down New River and Kanawha River to join the Ohio glacier? Or did it follow the channels of both rivers?

Was the entire crest of the Alleghany Mts., East Front and West Front, with their parallel and associated ranges, the sources of these glaciers? or were they a portion of the great Canadian glacier?

Ascending to the table land in Fayette Co., S.W. from Hinton, up to the height of 1370 feet above the ocean level, I failed to find signs of glacial action along the line of the highway to Fayette Co. court-house. Nor, when following the range of highlands forming the sources of Piney, Paint, Coal, and Guayandotte Rivers, did I find any signs of glaciers.

May not a glacier have once covered all the highlands in these southern latitudes and remained *stationary* on the heights, then, perhaps, and most probably more extensive table lands than at present, and only moved along the water courses where *slopes* obtained to give descent to the sea?

New York, Sept. 25, 1873.

[A subsequent letter dated October 6th, contains the following additional observation.—EDS.]

I have revisited the summit of the Alleghanies at the crossing of the Baltimore & Ohio railroad, and, in the vicinity of Oakland station found evidence of a southward movement in the torn up fragments of the Coal measures, and their transportation southward where they repose upon the upturned edges of Rogers No. XI. The opening of many coal banks in the vicinity of Oakland, Deer Park and Strawberry Summit have given greater facilities for observation of superficial deposits than I enjoyed in 1867. Oakland station is about 30 miles north of the locality where I found, in the year above mentioned, a true Canadian boulder of real feldspathic gneissoid granite.

ART. XLII.—*On the Hypsometric work of the U. S. Geological and Geographical Survey of the Territories*, F. V. HAYDEN, *U. S. Geologist in Charge;* by JAMES T. GARDNER, *Geographer of the Survey.*

FINDING that Colorado Territory, the field of action designated by Congress, was the center of greatest elevation in the whole chain of the Rocky Mountains, it was determined to place the hypsometric results as far as possible beyond question. The experience of the Geological Survey of California, under Prof. J. D. Whitney, and of the U. S. Geological Survey of the 40th Parallel—Clarence King, U. S. Geologist in charge—has shown that the determinations of heights of high points with the mercurial barometer were liable to errors varying from 150 to 300 feet, even when the base barometer was at the foot of the peak, and not over 3,000 feet below the summit. In consultation with Prof. J. D. Whitney, who has for the past three years been making a connected series of observations in the Sierra Nevada, to discover, if possible, a method of correcting the errors of barometrical work, the present system was adopted. We chose four points, at successive elevations of from 1000 to 4000 feet, till 14,000 feet was reached. These stations were connected by lines carefully run with the spirit-level, and the lower station is also connected with the sea by spirit-level line.

Permanent meteorological stations were established at these points, whose observations are taken at 7 A. M., 2 P. M. and 9 P. M. The observations taken by field parties are classified according to heights, and each class is referred to the base station which is nearest their own elevation.

The lowest station is Denver, where the U. S. Signal Service have one of their most careful observers. It is about 5000 feet above the sea, connected with it by three spirit-level lines, one running to the Pacific and two to the Atlantic.

The second station, Cañon City on the Arkansas River, at about 6000 feet high, is 90 miles south of Denver. The observations of the classes to which these stations belong, that is, those between 5000 and 8000 feet, will almost all be taken within 60 miles of the base stations.

The third station is Fairplay, in the South Park, 60 miles S.W. of Denver, and about 10,000 feet above the sea.

The fourth is Mt. Lincoln, 10 miles from Fairplay. On the summit, 14,000 feet high, are a number of silver mines, owned by Capt. Breese, under whose charge this station is placed. The observations to be referred to the 10,000 feet and 14,000 feet stations are all within 90 miles; and the peaks over 14,000 feet high are all within 70 miles of Mt. Lincoln. It is the central position of this peak among its compeers that so admirably fits it for a base of reference for all their heights.

The observers at Cañon City, Fairplay and Mt. Lincoln are all acting assistants of the Geological and Geographical Survey, and the observations will probably be continued through two entire years, for the purpose of climatological as well as hypsometrical investigation.

The U. S. Signal Service have recently established a permanent meteorological station on the summit of Pike's Peak, about 14,000 feet high. The observations at this point will be reported daily by telegraph, and will be of the greatest popular and scientific interest. Unfortunately, the station was established too late to be used as a base for hypsometric purposes this season; but the results, as compared with lower stations connected with it by spirit-level, will be of vital importance in determining the proper corrections to be applied to the present barometric formula for use in Colorado.

Besides the barometric determination of heights, two connected systems of trigonometric leveling have been carried over the whole area surveyed, one in connection with the primary triangulation and the other with the descending triangulation. The vetrical circles of the "gradienter," with which this work is done, are small—four inches only in diameter; but they are graduated with accuracy to minutes, and the attached levels are four inches long, and very sensitive, intended by their maker, Mr. Wm. Wurdeman, of Washington, to do the best of leveling.

The check observations are so arranged that the probable error can be easily determined, and it is hoped that the system will prove accurate enough to throw some light on the amount of refraction in these high altitudes. The comparison of the barometric system with the trigonometric will undoubtedly prove how each can be used to the best advantage. Many of these results can be prepared for the next Annual Report; but as the survey of Colorado is only partially completed, many of our experiments will be repeated for verification next year, and such changes made as this summer's experience may prove advisable.

By these methods the heights of many thousand points have been determined, from which to construct a map in "contours" 200 vertical feet apart, on a scale of two miles to one inch.

Colorado Territory is the greatest center of elevation known on the continent; and it is the intention of the Survey to have its maps render with accuracy the general form and sculptured features of the great and varied mountain ranges, whose wonderful structure will be a subject of investigation to the geologist for years to come.

ART. XLII.—*On a New Arrangement of Shutters for a Dome for an Equatorial Telescope*; by EDWARD S. HOLDEN.

IN the mounting of equatorial telescopes, particularly those of large size, much difficulty has been met with in providing suitable shutters for closing the openings in the dome through which the observations are to be made.

The conditions to be fulfilled in the slit and shutters are mainly as follows:

1st. The *slit* must be wide enough to allow the passage of currents of air near its edges, without much disturbance near the center of the opening. It has been thought necessary in some recent structures to make this opening six feet wide.

2d. The *slit* must be long enough to allow of a complete view of the whole heavens, when the dome is turned in different directions. If it extends from the base of the dome to three or four feet beyond the zenith, it is sufficiently long.

3d. The *shutters* must be light enough to be managed by one man with ease. They must be waterproof; they must not be liable to get out of order. It should be necessary to lift as little weight as possible; if practicable, the whole of the slit should be uncovered at once. Various styles of covering for large telescopes have been contrived, in the endeavor to fulfill these conditions. Perhaps the most typical forms are:

1st. The sliding roof, like that of the Cincinnati Observatory.

2d. The turret dome, like that of the Poulkowa Observatory.

3d. The hemispherical form, such as is now used at West Point, Washington, and other places. It is probable that the sliding roof will not be used for the largest class of instruments.

The turret form also is objectionable for large instruments, as the shutters (if made and operated like those of Poulkowa) become very heavy for a six foot slit; and the extra material required for this form is also expensive.

The 3d or spherical dome is almost universally used in America; and from recent constructions it is plain that it can be made cheaply of almost any size. The new dome of the Naval Observatory at Washington is forty-one feet in interior diameter. The only difficulty then in providing a suitable shelter for a large instrument is in the shutters. Many forms of these have been proposed, to all of which there seem to be objections, and as the structure increases in size these objections become more important.

At the Observatory at Harvard College, the shutters are made in sections and slide *back over the highest part* of the dome. They have, it is believed, always worked well; but, if made long and large, their weight might become an objection. The shutters of the West Point dome (and of many similar ones, as at Washington, that of Mr. Lewis Rutherfurd in New York and others) open by cords from the inside, until they are at right angles with the surface of the dome, and are made in four or five sections. The objection to these, again, is their great weight if used to cover a wide slit, and the surface which they present to the wind when open.

It is conceived that by constructing the slit and shutter in the following way, many of the objections will be obviated. The slit is to extend from the highest point of the dome to the junction of the hemispherical part with the upright portion or *drum.*

The shutter is of one piece covering this, and is fastened at its upper end to an upright pintle which passes through an eye in the upper edge of the shutter. The bottom of it is furnished with several wheels with broad flanges, which run on a railway extending around the dome. These flanges must be turned inward toward the roof. The instrument is to be mounted with the center of its object-glass, when the telescope is vertical, two or three feet south of the center of the dome. To open the slit, the shutter must be revolved one hundred and eighty degrees round the vertical diameter of the dome as an axis. If the slit is turned southward, the whole southern part of the meridian is visible, with a few degrees (say α degrees) beyond the zenith toward the north. To view the northern meridian, the dome must be revolved one hundred and eighty degrees, and in this way all that part of the northern meridian included between the horizon and $90-\alpha$ degrees of altitude will be seen. A portion of the meridian near α degrees of north zenith distance will not be well viewed. If any object in that place is to be examined, the dome must be revolved about ninety degrees from the first position above described. In this way, by turning the dome in four positions, *all* parts of any vertical circle can be examined.

It is evident that with an instrument eccentrically placed the dome has to be slightly larger than in the ordinary case. To accomplish this, some additional expense must be incurred, but it is believed that this expense will be a small item if it allows the construction of a better form of shutter.

All the conditions of easy motion are in this form fulfilled. The weight of the shutter rests on a railway, and not a pound has to be lifted. The friction on the railway and on the pintle can be reduced to a very small quantity. There should be no danger of the shutter running off the track, if the inside flange is wide enough. It can be easily operated by machinery so simple that no description is necessary. Finally, the precautions to be taken to make it waterproof are evident, and not too difficult. It is believed that a shutter of this form would satisfy the wants of practical astronomers, and would make the handling of large telescopes much easier than at present.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS AND CHEMISTRY.

1. *On the Chemical Activity of Zinc on which Copper has been deposited.*—Several months ago, GLADSTONE and TRIBE announced that zinc on which copper had been deposited, was capable of decomposing water at ordinary temperatures. More recently they have studied the action of this "copper-zinc couple" upon ethyl, amyl and methyl iodides. The couple was prepared by pouring a solution of cupric sulphate, containing about 1·5 per cent of the salt, upon a crumpled piece of zinc foil, about the thickness of writing paper, and 14 inches by two in size, contained in an ounce flask. The solution loses soon its blue color; it is then decanted and replaced by a fresh portion; and this is repeated two or three times. The coating of copper deposited upon the zinc should adhere firmly, and should present somewhat the appearance of black velvet. It is well washed, first with water, then with alcohol and with ether, and dried in a current of dry carbonic gas. When ethyl iodide is poured upon this couple, but little action takes place at ordinary temperatures; but, at the temperature of the water-bath, some combustible gas is evolved, and there is produced a crystalline body, apparently Frankland's zinc ethiodide. The action was continued with an upward condenser until all the ethyl iodide disappeared. The crystalline body was then heated in a current of carbonic gas, and the zinc-ethyl which distilled over was

received in water, where it was at once decomposed. Its amount was estimated by the amount of zinc oxide produced. The theoretical amount of zinc-ethyl obtainable from 9·5 grams ethyl iodide is 3·74 grams; in five experiments with the zinc-couple, the mean quantity was 2·17 grams, the maximum 2·61 grams. The best results were obtained under the ordinary atmospheric pressure. The gaseous products which were yielded by the crystalline body on decomposition, were ethyl hydride and ethylene in equal volumes. When water is present with the ethyl iodide and the couple, evolution of gas takes place at once, even at 14° C., amounting in the course of 36 hours to nearly the theoretical quantity, and being pure ethyl hydride containing a trace of hydrogen. Alcohol acts similarly. On amyl iodide, the couple acts readily at about its boiling point, 146° C., five c.c. of it being converted in fifteen minutes. Volatile bodies, proved to be amyl hydride and amylene, distil over, and the flask contains a liquid distilling at a higher temperature—which proved to be Frankland's amyl—and a white crystalline body, decomposing at or about 160°, yielding also pure amyl. By modifying the experiment so as to retain the volatile hydrocarbons in the flask till the reaction is concluded, and then rapidly distilling, zinc-amyl was obtained, but only 28 per cent of the theoretical quantity. By distilling from a paraffin bath and in vacuo, this yield was increased to 43·5 per cent. When water or alcohol is present with the iodide, the action is decided at 100° C., being complete in an hour and a half; pure amyl hydride is the sole product. Methyl iodide alone, was decomposed very slowly; but mixed with water or alcohol, pure methyl hydride (marsh gas) was rapidly evolved. In a third paper, the authors consider the nature of this black deposit upon the zinc. They show that, so long as the solution contains copper, the deposit consists solely of that metal; but, after it has all been deposited, a precipitation of zinc oxide, and even of metallic zinc, takes place upon the copper crystals. In one experiment, 7·4 per cent of metallic zinc was thus precipitated. Under the microscope, the minute crystals of metallic zinc are seen studding the branches of crystallized copper. In the ordinary method of preparing the couple, no zinc would, of course, be deposited; and such a couple, as experiment proves, is the most active. The black color of the deposit is due to its minute division.—*J. Chem. Soc.*, II, xi, 445, 452, 678, May and July, 1873. G. F. B.

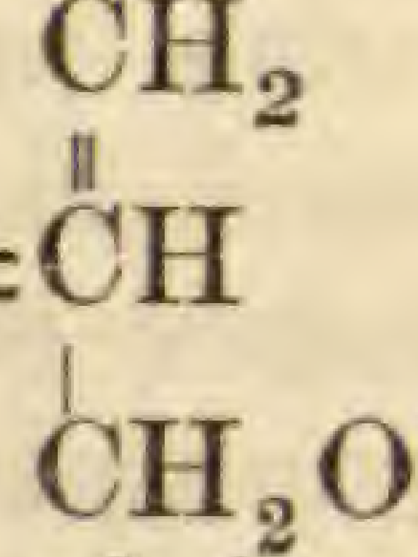
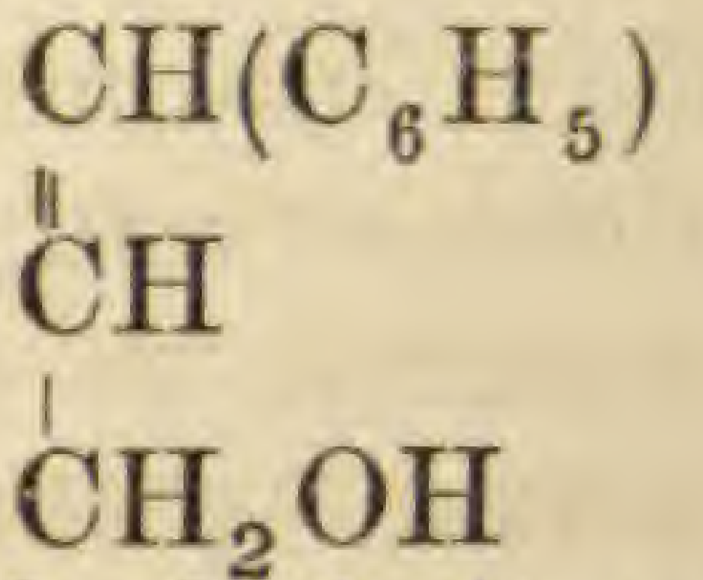
2. *On a Method of Estimating Nitric, Chloric and Iodic Acids.*—THORPE has ingeniously applied the copper-zinc couple above described, to the determination of nitric, chloric and iodic acids. When a small quantity of niter is added to the water surrounding the couple, and the whole is gently heated, no hydrogen is evolved, but a distinct odor of ammonia is perceived, and the liquid in the flask becomes alkaline from the production of potassium hydrate. Quantitative experiments showed that the conversion of the nitrogen into ammonia was complete. They were conducted as follows: 40 grams of thin sheet zinc were placed in a

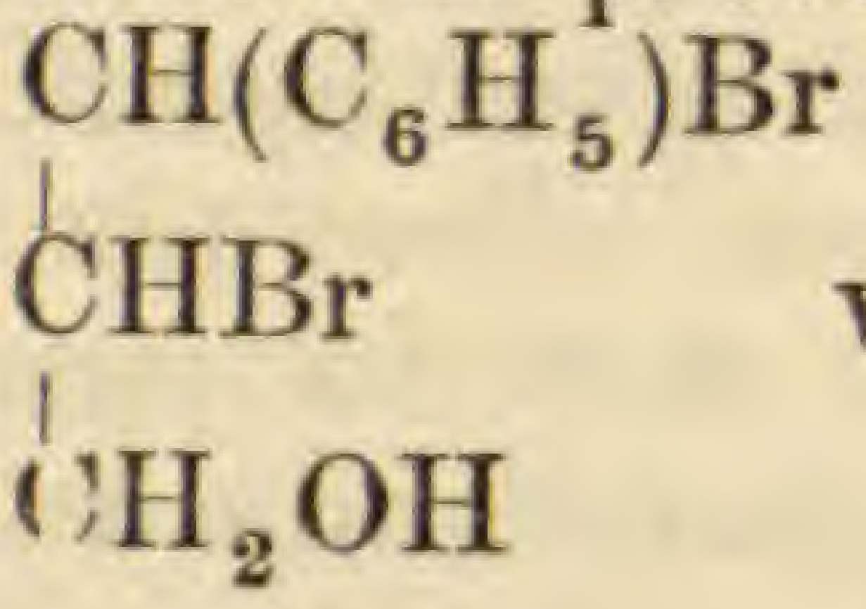
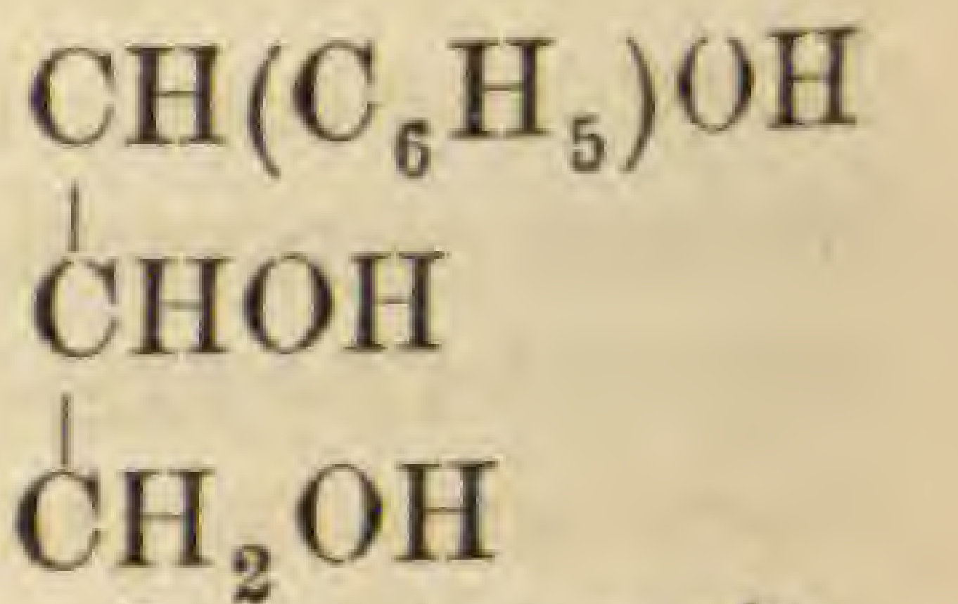
flask, and coated with copper by the action for 10 or 15 minutes of a tolerably concentrated solution of copper sulphate. After careful washing, the weighed quantity of potassium nitrate and 40 c.c. of water were added, and the flask connected with a three bulbed U-tube containing dilute hydrochloric acid. After boiling the contents of the flask for an hour, the ammonium chloride in the U-tube was determined as platino-chloride; 0·5090 grm. KNO_3 gave 1·0498 grms. $PtCl_4(NH_4Cl)_2$, equivalent to 0·50908 grm. KNO_3. The action is not influenced by the presence of alkali-chlorides or sulphates. Experiment showed the applicability of the method to the determination of nitrates in potable waters. Moreover, by the action of the copper-zinc couple upon potassium chlorate and upon ammonium iodate, potassium chloride and ammonium iodide were readily produced, and directly determined.—*J. Chem. Soc.*, II, xi, 541, June. G. F. B.

3. *On the Theory of the Continuous Chlorine process.*—DELALANDE and PRUDHOMME have experimentally investigated this question in the laboratory of M. Schützenberger. They placed 10 grams of sodium chloride and 10 grams boric acid in porcelain boats, and heated them, in earthenware tubes glazed interiorly, to bright redness for three hours, a current of dry air being transmitted through the tube. When the substances were contained in separate boats, but a trace of chlorine was evolved; but when they were mixed together and thus heated, as much as 15 per cent of the chlorine present was set free. If the boat be withdrawn with the contents still in fusion, they are found neither dissolved nor mixed; but the undecomposed salt floats upon the boric acid and the borate produced. The decomposition takes place, therefore, only at the points of contact of the two. Upon analysis, the amount of sodium combined as borate corresponded nearly to the chlorine collected. Ferric oxide was observed to be without any similar action upon the chloride. From these results, the authors draw the general conclusion that oxygen will displace chlorine from the chlorides at a red heat, in presence of an acid which will unite with the oxide produced. They make it general, because they have obtained the result with boric, silicic, phosphoric and stannic acids and with alumina. If now the mixture be not made directly, but indirectly; that is, if a salt of any of the above acids be heated in presence of a current of hydrochloric acid gas and air, the chloride is first formed and then reacts with the oxygen of the air in the manner above indicated. In order, therefore, for the continuous action to take place, it is necessary that the salt used should be acted upon by the hydrochloric acid. If, for example, pumice be submitted to the prolonged action of the gases, it loses rapidly its decomposing power, because the chlorides formed, being volatile, are soon removed. This power, however, is at once restored, by immersing the pumice in a solution of common salt or of any other alkali-salt. In this the authors explain easily the continuous chlorine process of Deacon, which, as is well known, consists in passing a mixture of hydrochloric gas and air over frag-

ments of brick soaked in a solution of cupric sulphate.—*Bull. Soc. Ch.*, II, xx, 74, July, 1873. G. F. B.

4. *On a Glycerin of the Aromatic Series.*—In 1870, GRIMAUX discovered the first glycol or diatomic alcohol of the aromatic series. He now describes the first glycerin or triatomic alcohol of the same series. Considering cinnamic alcohol or styrone as phenyl-allylic alcohol—being allyl alcohol in which one atom of hydrogen is exchanged for phenyl, thus:

Allyl alcohol =  $\begin{array}{l} CH_2 \\ \| \\ CH \\ | \\ CH_2OH \end{array}$ Phenyl-allyl alcohol  $\begin{array}{l} CH(C_6H_5) \\ \| \\ CH \\ | \\ CH_2OH \end{array}$

Grimaux considered it probable that, like allyl alcohol, it would unite directly with two atoms of chlorine or bromine to produce the chlorhydric or bromhydric ether of a glycerin. Experiment confirmed this prevision; bromine produced the desired bromhydrin  $\begin{array}{l} CH(C_6H_5)Br \\ | \\ CHBr \\ | \\ CH_2OH \end{array}$ which was readily saponified by the action of boiling water, yielding the corresponding glycerin  $\begin{array}{l} CH(C_6H_5)OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}$

To this pheno- or phenylglycerin, the author gives the name *stycerin* to indicate its origin. He points out its three isomers, derived respectively from trimethylbenzene, methyl-ethyl-benzene, and isopropyl-benzene. The stycerin ethers with chlorine, bromine and acetyl are also described.—*Bull. Soc. Ch.*, II, xx, 118, Aug., 1873. G. F. B.

5. *Elements of Physical Manipulation;* by EDWARD C. PICKERING, Thayer Professor of Physics in the Massachusetts Institute of Technology. New York (Hurd and Houghton), 1873. pp. xii, 225, 8vo.—For the student engaged in the investigation of the problems of physical science by actual observation and experiment, the want of some manual which should give the best and simplest modes of conducting the researches, the manner of using the apparatus employed, and the modes of testing the results obtained, has been hitherto very imperfectly supplied. Books like Frick's Physical Technics and the various treatises on chemical manipulation afford indeed many useful hints for the performance of special experiments, and the construction of simple forms of apparatus; and directions for the use of special apparatus are scattered through numerous treatises and journals, in the different departments of physical science. Professor Kohlrausch's excellent little book, "Leitfaden der praktischen Physik," is almost the first and only one that treats of physical investigation in a practical and systematic manner, but it is somewhat limited in its plan, and is intended for students having already some familiarity with the work, many of the details of adjustment and manipulation being omitted.

Professor Pickering's treatise is intended as a hand-book for students at work in the physical laboratory, and is admirably adapted to supply the want already referred to. It contemplates such a course of instruction that the student, at the close of it, will not only have become familiarly acquainted by personal experience with the apparatus, but will know how to use it, how to interpret the results, to calculate the errors, and to anticipate and avoid the various sources of error.

An introductory chapter is occupied with descriptions of general modes of investigation, in which are treated, first, the analytical methods of computing means, probable errors and the like; methods of interpolation, etc.; second, graphical methods, which are somewhat extensively developed, and include some novelties; third, the modes of measuring the different physical magnitudes. The succeeding chapter treats of certain general experiments in the preparation, adjustment and use of apparatus, preliminary to the special experiments, which are systematically arranged under the appropriate heads in the following chapters, where are given numerous practical exercises in the subjects of "Mechanics of Solids," "Mechanics of Liquids and Gases," "Sound" and "Light." Each exercise begins with a statement of the apparatus and materials required, after which follow minute directions for the conduct of the research in question.

Although the reader may miss some things which he might expect to find in such a treatise, the range of experiments is very large, and will certainly more than realize the author's modest hope that it may aid "in any way those engaged in physical investigations." Many a teacher will thank him for an indispensable aid in his work, and many a student will derive from it an encouragement and a stimulus of the greatest value. A second volume, including the subjects of heat and electricity, is promised, and will be looked for with interest. A. W. W.

II. GEOLOGY AND NATURAL HISTORY.

1. *Results of the Earth's contraction from Cooling.*—On page 172 of this volume I have attributed a principle connected with the formation of mountains to Professor LeConte; and on page 304 have modified the former statement, giving credit for part of the view to Professor Hunt. I have been referred by Prof. Hunt to an article of his which appeared in this Journal in 1861 (vol. xxxi, p. 392), in which he brought out the whole principle in the form presented by LeConte (except his adopting Hall's view of subsidence from the gravity of accumulating sediments), both recognizing the weakening effect on the bottom of the subsiding trough through the heat from below, and the opportunity which was thus afforded for the lateral pressure from the earth's contraction to finish the folding. One of its paragraphs reads as follows:

"The accumulation of a great thickness of sediment along a given line would, by destroying the equilibrium of pressure, cause the somewhat flexible crust to subside; the lower strata becoming altered by the ascending heat of the nucleus would crystallize and contract, and plications would thus be determined parallel to the line of deposition. These foldings, not less than the softening of the bottom strata, establish lines of weakness or of least resistance in the earth's crust, and thus determine the contraction which results from the cooling of the globe to exhibit itself in those regions and along those lines where the ocean's bed is subsiding beneath the accumulating sediments. Hence we conceive that the subsidence invoked by Mr. Hall, although not the sole nor even the principal cause of the corrugations of the strata, is the one which determines their position and direction, by making the effects produced by the contraction, not only of sediments, but of the earth's nucleus itself, to be exerted along the lines of greatest accumulation."

Professor Hunt is therefore entitled to the credit given in the place mentioned to Professor LeConte. J. D. D.

2. *United States Geological Survey of the Territories under the Department of the Interior*, F. V. HAYDEN, United States Geologist, in charge.—The following volumes connected with the survey have recently been issued.

(1.) *First, Second and Third Annual Reports* for the years 1867, 1868 and 1869. This is a reprint of these reports, in order that the series, now in much demand because of its intrinsic value, may be accessible from its beginning to the public. The survey commenced in 1867 in Nebraska, on an appropriation of $5,000, was continued in 1868 in Wyoming, on a like sum; and was extended in 1869 to Colorado and New Mexico on an appropriation of $10,000.

(2.) Of the five volumes of Reports in quarto of the same expedition which are in progress, there have appeared Part 1 of Vol I, extending to 358 pages, and including thirty-seven plates,—on *Fossil Vertebrates*, by Dr. J. LEIDY; and part of volume V, comprising 262 pages, treating of the *Acridideæ* or Grasshoppers, by Dr. CYRUS THOMAS. The wonderful character of the terrestrial vertebrate life of the region which is now the center of the Rocky Mountains, and the equally wonderful profusion of their remains, give great interest to a volume like this by Dr. Leidy, and alike to its companion, in course of preparation, by Mr. Cope. Dr. Leidy has here presented in detail, and with full illustrations, the descriptions of species from the collections of the survey and some other sources, which have appeared, in brief, mainly in the Proceedings of the Philadelphia Academy. Dr. Leidy refers Marsh's *Dinoceras* to his own earlier genus *Uintatherium*, stating that the differences are too slight for generic distinctions.

In addition to Mammals, the volume contains descriptions of various species of fossil reptiles and fishes.

Dr. Thomas's work is a general synopsis with descriptions of the Acrididæ of the United States and also of those of other parts of North America. A number of species are described as new; but the volume is in the main a compilation.

These volumes are handsomely printed, and the plates of Dr. Leidy's report—the only one of the two illustrated—are excellent.

(3.) *Meteorological Observations during the year* 1872 *in Utah, Idaho and Montana.* Prepared for publication by HENRY GANNETT. 120 pp. 8vo. Washington, 1873.—The reports consist of tables containing the results of observations under the heads of barometer, dry bulb, wet bulb, dew point, relative humidity, direction of the wind, character and amount of the clouds,—together with general remarks.

3. *Sphagnum as a Peat-maker.*—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 vegetation only. 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 bases to the tops of high mountains, as 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. No one 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 own country, the same phenomenon is repeated in those naked places called glades, on the slopes of the Alleghany and 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 the growth of 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.

If one 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:

(1.) 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 over-grown by bushes or conifers, as is often the case, these mosses ascend against the trunks or above the roots, forming tufts or hillocks, around and upon them.

(2.) 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.

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 solid ground, the same species grow in compact mass, all their stems erect, closely pressed together.—*L. Lesquereux in Hayden's Rep. for* 1872.

4. *Challenger Expedition.*—About 114 miles west of Fayal, Western Islands, the dredge brought up, from a depth of 1000 fathoms, a gray sandy ooze, containing dead shells of Pteropods, many foraminifers, and pebbles of pumice; also large Schizopod crustaceans. At the same depth, between the islands of San Miguel and Santa Maria, the bottom was Globigerina ooze, and stony corals were unusually abundant; two specimens of a large species of *Flabellum* were obtained, and other kinds. West of Madeira, 376 miles, the bottom at a depth of 2025 fathoms was Globigerina ooze, the temperature 1·5° C.—*Nature*, Sept. 18.

5. *Reliquiæ Aquitanicæ, being contributions to the Archæology and Palæontology of Périgord and the adjoining provinces of Southern France.* By EDOUARD LARTET and HENRY CHRISTY. Edited by THOMAS RUPERT JONES, F.R.S., F.G.S., etc., Prof. Geol. Roy. Military and Staff Colleges, Sandhurst. Part XII. July, 1873. pp. 157–172, and (descriptive of the plates) 145–152, with plates A, xxxv, xxxvi, B, xxiii, xxiv, and C, vii, viii.—This valuable work, whose publication has been for awhile suspended, has commenced again to be issued. Part xii contains the commencement of a paper by John Evans, Esq., on Bone and Cave Deposits of the Reindeer Period in the South of France. The plates contain engravings of flint chippings and of bones or horns etched or covered with carvings, and among the latter are the outlines of various animals.

The prospectus states that this work will be completed in about 15 parts, each to contain 6 plates. The cost of each is 3s. 6d.

6. *Note on Huizinga's Experiments on Abiogenesis;* by Dr. BURDON-SANDERSON.—Under the title of a "Contribution to the Question of Abiogenesis," Prof. Huizinga has very recently published (Pflüger's Archiv. vol. vii, p. 549) a series of experiments which deserve notice as constituting a new and carefully worked out attempt to support the doctrine of spontaneous generation.

Prof. Huizinga begins his paper with the words *Multa renascentur quæ jam cecidere*, using them as an expression of the recuring nature of this question. He then proceeds to say that he was induced to undertake his inquiry by the publication of the well-known work of Dr. Bastian (whom he compliments as having awakened the exhausted interest of physiologists in the subject), his special object being to repeat the much-discussed turnip-cheese experiment.

Every one knows what Dr. Bastian's observation is. It is simply this, viz: that if a glass flask is charged with a slightly alkaline infusion of turnip of sp. gr. 1015, to which a trace of cheese has been added, and is then subjected to ebullition for ten minutes and closed hermetically while boiling, and finally kept at fermentation temperature, Bacteria develop in it in the course of a few days. This experiment has been repeated by Huizinga with great care, and the accuracy of Dr. Bastian's statement of facts confirmed by him in every particular; yet, notwithstanding this, he thinks the evidence afforded by these results in support of the doctrine so inadequate, that he, desiring to find such evidence, has thought it necessary to repeat the experiment under what he regards as conditions of greater exactitude.

Huizinga's objections to Bastian's experiment are two. First, that when a flask is boiled and closed hermetically in ebullition, its contents are almost entirely deprived of air, and (2) that cheese is a substance of mixed and uncertain composition. To obviate the first of these objections, he closes his flasks, after ten minutes boiling, not by hermetically sealing them, but by placing over the mouth of each, while in ebullition, a porous porcelain plate which has just been removed from the flame of a Bunsen's lamp. The hot porcelain plate is made to adhere to the edge or lip of the flask by a layer of asphalt, with which the edge has been previously covered. The purpose of this arrangement is to allow air to enter the flask, at the same time that all germinal matter is excluded. It is not necessary to discuss whether this is so or not.

To obviate the second objection he alters the composition of the liquid used; he substitutes for cheese, peptone, and for turnip infusion, a solution containing, in a liter of distilled water—

Grape sugar, - - - - - -	25	grams.
Potassium nitrate, - - - -	2	"
Magnesium sulphate, - - - -	2	"
Calcium phosphate, - - -	0·4	"

The phosphate is prepared by precipitating a solution of calcium chloride with ordinary sodium phosphate, taking care that the chloride be in excess. The precipitate of neutral phosphate so obtained is washed and then added to the saline solution in the proportion given. On boiling, it is converted into soluble acid phosphate, and insoluble basic salt, of which the latter is removed by infiltration. Consequently the proportion of phosphate in solution is less than that above indicated.

To the filtrate, peptone is added in the proportion of 0·4 per cent.

The peptone is obtained by digesting egg-albumen at the temperature of the body in artificial gastric juice made by adding the proper quantity of glycerin extract of pepsin to water acidulated with hydrochloric acid. The liquid so obtained is first rendered alkaline by the addition of liquor sodæ, then slightly acidulated with acetic acid and boiled. The syntonin thus precipitated is separated by infiltration from the clear liquid, which is then evaporated to a syrup and poured in a thin stream into strong alcohol, with constant agitation. The precipitated peptone is separated after some hours and washed with alcohol, and redissolved in a small quantity of water. The solution is again precipitated by pouring it into alcohol in the same way as before, and the precipitate washed and dried.

Flasks having been half filled with the liquid thus prepared (in 1,000, 2 each of niter and Epsom salts, a trace of phosphate of lime, 25 parts of grape sugar, and 4 parts of peptone), each is boiled for ten minutes, closed while boiling, with the earthenware plate as above described, and placed as soon as it is cool in the warm chamber at 30°C. The experiment so made "gave, without any exception, a positive result in every case. After two or three days the fluid was crowded with actively moving *Bacterium termo*."

The readers of Nature are aware that in June last I published a repetition of Dr. Bastian's experiments, with a variation not of the liquid, but of the mode of heating, (see Nature, vol. viii, p. 141.) Instead of boiling the flasks for ten minutes—over the open flame and closing them in ebullition, I boiled them, closed them hermetically, and then placed them in a digester in which they were subjected to ebullition under a pressure of two inches or more of mercury. The result was negative. There was no development of Bacteria.

Since the publication of my experiments, Huizinga's have appeared. His result, regarded as a proof of spontaneous generation, is clearly not superior to Bastian's. The substitution of a soluble immediate principle for an insoluble mixed product like cheese, and the use of a definite solution of sugar and salts, are not material improvements. The question is not whether the germinal matter of Bacteria is present, but whether it is destroyed by the process of heating. Consequently what is necessary is not to alter the liquid, but to make the conditions of the experiment as regards temperature as exact as possible. In this respect Huizinga's experiment is a confirmation of Bastian's and nothing more.

I have recently repeated it with the same modifications as regards temperature as those employed in my repetition of the turnip-cheese experiments. The result has been the same. In all other respects I have followed the method described by him in his paper. I have prepared the solution of salts, grape sugar and peptone in exact accordance with his directions. To obviate his objection as to the absence of air, I have introduced the liquid, not into flasks, but into strong glass tubes closed hermetically at each end and only half filled with liquid, the remainder of the tube containing air at the ordinary tension. Each of these tubes, after having been subjected to the temperature of ebullition under two inches of mercury for half an hour, has been kept since September 10 at the temperature of fermentation (32°C.) Up to the present time, no change whatever has taken place in the liquid.

As a control experiment, I opened one of the tubes immediately after boiling, and introduced a drop of distilled water. It became opalescent in twenty-four hours.

In conclusion, let me observe that I still maintain my resolution to take no side whatever in this controversy. I do not hold that spontaneous generation is impossible. I do not regard heterogenists as scientific heretics. All I say is, that up to the present moment I am not aware of any proof that they are right.—*Rep. Brit. Assoc.*, 1873, *Nature*, *Oct.* 2.

7. *Cumacea of the Josephine Expedition;* by G. O. SARS. 57 pp. 4to, with 20 plates. From the Svenska Vetenskaps-Akademiens Handlingar, Bandet ix. Stockholm, 1871.—This valuable memoir contains minute and detailed descriptions of ten species of Cumacea collected in the Atlantic ocean by the Josephine Expedition, and is a very important contribution to our knowledge of this group of crustaceans. It is specially interesting to the American student, as six of the species are from our own coast, having been dredged near Long Island and off the coast of New Jersey. All the species are very fully and most beautifully figured from drawings by the author; and nine of the plates are devoted to a single species, *Diastylis sculpta*, which is found upon the whole New England coast. S. I. S.

8. *Cumacea from the Arctic Ocean and the West Indies.*—Dr. Sars has also, in two short papers in the Oefversight af Kongl. Vetenskaps-Akademiens Förhandlingar for 1871, enumerated the species of Cumacea from the deep water collections of the Swedish Arctic Expeditions in 1861 and 1868, and has described a new genus and several new species from the West Indies. Among the arctic forms are two new species of *Diastylis* from 950 and 2,600 fathoms, a species of *Leucon* from 1,400, and one of *Campylaspis* from 1,050 fathoms. S. I. S.

9. *Monographi over de ved Norges Kyster Forekommende Mysider;* by G. O. SARS. Parts I and II, pp. 98, 4to, with 8 plates. Christiania, 1870 and 1872.—This monograph of the Mysidæ, of which only the first two parts have appeared, constitutes No. 1 of Dr. Sars' "Carcinologiske Bidrag til Norges Fauna." These two parts contain a general account of the family, with a conspectus of the twelve genera found upon the coast of Norway, and very complete descriptions and figures of twelve species belonging to five of the genera. The generic descriptions are also very full. The plates are crowded with finely executed figures of the entire animals of both sexes, and many highly magnified figures of the details. Dr. Sars has added more than any one else to our knowledge of this family; and nearly all the species were first made known by him, but are now first brought together and figured.

Among the most remarkable forms made known are the deep water genera *Amblyops* and *Pseudomma*, in which the ocular peduncles are rudimentary, lamelliform, and wholly without faceted eyes. One of the species of the latter genus, *P. roseum*, occurs also upon the American coast, having been dredged in the Gulf of St. Lawrence by Mr. Whiteaves. S. I. S.

10. *The Composition of Lichenes* (*Recherches sur les Gonidies des Lichens*); by E. BORNET. An article in the Ann. Sci. Nat., April, 1873; with ten plates.—It must be left for the adepts to decide whether the results of Dr. Bornet's investigation are to be received as settling the question concerned; but the presentation is admirably clear and appears to be wholly convincing. The result is that Lichens of all sorts are composite; the green cells (*gonidia*) are *Algæ*, of species which are of common independent occurrence; the filamentous tissues (*hypha*), which bear the fructification, belong to *Fungi*. The latter are parasitic upon and live at the expense of the former. By germinating the Lichen-spores on slips of glass or fragments of pottery, the hypha can be developed as a byssoid network; and the same is produced from bits of Lichen similarly treated. The gonidia increase by cell-division, and sometimes resolve into zoospores.

The resemblance of the gonidia of certain Lichens to *Protococcus viridis* has long been familiar; also the affinity of *Collema* with *Nostoc*. This has been thought to be mere resemblance, or else that such *Algæ* were rudimentary or imperfect and sterile states of Lichens. But after Schwendener had shown (in 1867) that such parallelisms were numerous, Famintzin and Baranetzky, extracting the green cells from various Lichens, saw them develop autonomously and produce zoospores, and especially when it was found that the gonidia in many cases represented *Algæ* of as high grade as *Confervaceæ*, this view could no longer be entertained. It was DeBary who, in 1866, first suggested that the gelatinous Lichens are *Algæ* with *Fungi* parasitic upon them. Schwendener developed the hypothesis, applied it generally, and indicated as many as eight types of *Algæ* in Lichens. He demonstrated the incorrectness of the observations from which it had been inferred that gonidia were produced upon the tip of filaments of the hypha, and showed that the latter attached themselves, as they grew, to the green cells, often forming a network over their surface. We have not seen Schwendener's papers. According to Bornet, he has no figures which clearly show, in their natural state, the mode of connexion of the hypha with the gonidia, and the only one which was satisfactory is that by Woronine, in 1871, which is reproduced in Ann. Sci. Nat., 5th ser., p. 317, tab. 14, fig. 1. Dr Bornet has abundantly supplied this deficiency in the present memoir. Nothing can be clearer than the whole matter as exhibited in his numerous and admirable figures and expounded in the text. His investigations have extended to 60 genera, representing almost every kind of Lichen; and his conclusions, which it seems impossible to resist, are: 1. That the gonidia of every Lichen examined may be identified with some species of *Algæ*, mostly with the very commonest species and those most tenacious of life. 2. That the relations of these with the hypha are such as to preclude all possibility of the one being produced by the other; and that the theory of parasitism alone offers a satisfactory explanation of the facts. A. G.

11. *Rubus deliciosus* Torr.—This attractive species is figured in the October number of the Botanical Magazine, t. 6062, but with more jagged petals than we ever saw in the plant cultivated for several years past in the Botanic Garden of Harvard University; and the shading which the artist has introduced detracts from their natural appearance. The object of this note is not so much to call attention to this ornamental shrub, which ought to be generally cultivated, and proves to be perfectly hardy in New England, as to record a new fact respecting its geographical range, which needs confirmation. In this recent number of the Botanical Magazine, this species is said to have been introduced into cultivation in England by Mr. Henry of Hay Lodge, Edinburgh, "who received the seeds from N.W. America, in lat. 44°, and flowered the plants he raised from them, in May, 1870;" and the fruit was produced in July last. Now this parallel of latitude crosses the northern part of Wyoming and the center of Idaho Territories, three or four degrees higher than that part of the Rocky Mountains, in Colorado Territory, in which this species has been collected by American botanists, and where it abounds, not, however, "on alpine ridges," but at lower elevation. We shall be interested to know if Dr. Parry, who has just returned from a botanical tour in Wyoming and Montana, has there met with this species so familiar to him in Colorado. It was he who rediscovered it on Dr. James's ground, in 1861, and whose name was, no doubt, intended to have been cited in the Botanical Magazine instead of "James," who was at the Rocky Mountains only in 1822. From seeds gathered by Dr. Parry, and sent to Kew, to Mr. Thompson of Ipswich, etc., the plant was first raised in England (where we believe it was flowered several years ago) as well as in New England. The species was, however, rediscovered as early as the year 1851, in New Mexico, by Charles Wright; but it was described as a new species (*R. Neo-Mexicanus* Gray); the failure of identification having resulted from some misunderstanding, fifty years ago, between Dr. James and Dr. Torrey, through which the petals of *R. deliciosus* were said to be "purple." The correction was made in the account of Parry's collections, in this Journal, 1862. The fruit, by the way, is mawkish, and far from "delicious." The natural explanation of its having been termed so by Dr. James is that, in his hurried rush for the mountains, in the too restricted time allowed him by Major Long, he was so nearly starved that any edible fruit must have been to him delicious. A. G.

12. *Spiranthes Romanzoviana.*—This North American species was known in Europe only at a single station, on the southwestern shore of Ireland. Mr. T. Allin, in Trimen's Journal of Botany for

October, 1873, announces his discovery of a second station, in the county of Cork. He speculates whether and how the plant has traveled from the one station to the other,—not comprehending that most probably these are merely the last, or among the last lingering stations of a species once common to both continents, but which has almost died out of the Old World. A. G.

13. *Hybridation in Mosses affecting the Sporangium, etc. of the female parent.*—Among the Cryptogamia, hybrids are known in Ferns. It appears from a paper by Professor Philibert of Aix, in Ann. Sci. Nat., June, 1873, that he has detected hybrid Mosses, especially of *Grimmia tergestina* fecundated by *G. orbicularis.* The more interesting point is, however, his discovery of the immediate action of the antherozoids upon the archegone of the female parent, so that the resulting sporangium, seta, etc., take after the fertilizing parent, while the foliage, calyptra, etc., remain unaffected. This is analogous to the action of foreign pollen upon the seed-coat of beans, or the pericarp of Cucurbitaceæ, and the like; and, if really established, is very interesting. A. G.

14. *Normal Formation of fatty substances in Chlorophyll;* by G. Briosi, (Bot. Zeit., xxxv, 547.)—The following is a summary of the results:

(1.) In the chlorophyll of *Strelitzia* and *Musa* no starch granules are formed.

(2.) In the chlorophyll of these plants there exists an oily substance.

(3.) This oil occurs, in minute subdivision, between protoplasma-molecules of the chlorophyll.

(4.) The oil usually appears in the chlorophyll granules in the form of drops, only after the addition of water, or of iodine in a solution of potassium iodide. G. L. G.

15. *Physiological Researches in regard to Germination;* by Ph. Van Tieghem, (Ann. Sci. Nat., 1873, p. 204.)—The author reports the results of his investigations respecting both the degree of mutual dependence of the different organs of the embryo, and that of the entire embryo upon its albumen. By mutilation of the embryo of the common Sunflower (*Helianthus annuus*), he was able to study the independent development and regeneration of the organs. The character of the investigations will be readily understood from a full account of the first experiment.

The following measurements are given as the average length of the different parts of the embryo of *Helianthus annuus:* Radicle proper, ½ millimeter; caulicle, 1 millimeter; cotyledons, 5½ millimeters. By transverse section the radicle was separated from the caulicle, and the latter from the two cotyledons, in the case of ten embryos. These fragments were placed on moist "wadding," kept at a temperature of 22°–25° Cent. With these, under the same bell-glass, he put two uninjured embryos to serve as a standard. After twenty-four hours the amputated radicle had developed a root of 8–11 mm. These roots were covered with long, white hairs at the older part, and were very slender. They had no rootlets. They grew a little on the second day, then remained stationary and became mouldy. Their structure was the same in every particular as that of the root in the standard seeds. The root acquired, in its solitary development, all the anatomical characters which belong to it, when attached to the rest of the embryo. Separated from the radicle and the cotyledons, the caulicle increased in length by interstitial growth until after three days it was 15–20 mm. long, after which it became stationary. These caulicles possessed the same structure as the normal ones, but, on the fifth day, there were seen on the lower cut surface of most of them, three or four small adventitious roots, which continued to grow until they were from 20–30 mm. long. . . . . The isolated cotyledons grew green steadily, just as well as those of the standard seeds, and after eight days were intensely green. They also increased in size, becoming appreciably larger than the normal ones, so that on the seventeenth day of germination, while the cotyledons of the uninjured embryos were 10–12 long and 6–7 broad, the isolated cotyledons measured 19–20 mm. in length and 9–10 mm. in breadth, or as 8 to 20. Upon the isolated cotyledons adventive roots and buds appeared, and there is good reason to believe that by great care two plants can thus be obtained from one embryo.

The three fundamental organs of the embryo have in themselves the force of their own development, and can germinate independently, developing with a vigor and duration proportionate to the store of assimilable food which each possesses at the moment of separation. Moreover, each one can, in the same proportion, replace the two others and thus constitute a complete plant. The other experiments will now be referred to briefly.

(2.) Five embryos had the radicle removed. After eight days the plantlets were firmly rooted by adventitious roots, and the plumule had begun its development. This experiment was variously modified with nearly the same results.

(3.) Fragments made by horizontal and vertical section of the different organs were placed under conditions favorable to speedy germination, and it was seen that each fragment germinated independently of the others. One embryo of the sunflower gave thus eight plants.

(4.) The entire embryo was divided in lateral halves by vertical section. Each half grew, but with less than natural vigor.

The next series of experiments deals with embryos deprived of albumen. Four-o'clock and Indian corn gave the most satisfactory results. The three organs of *Mirabilis* (Four-o'clock) developed when isolated just like those of the sunflower, and the experimenter does not doubt that each will, under favorable conditions of nutrition, replace the others. The embryo of Four-o'clock developed into a green plant without the help of the albumen. The albumen affects merely the rapidity of germination and the evolution of the plumule. The nutritive tissue, so-called, can be replaced up to a certain point, by a paste formed of the crushed substance or made up from foreign albumen of analogous chemical composition, or even from starch to which nitrates and phosphates have been added.

G. L. G.

III. ASTRONOMY.

1. *Note on the Meteors of November 14th;* by DANIEL KIRKWOOD. (Communicated for this Journal.)—As the display of shooting-stars on November 14th occurs in but five or six consecutive years, the nebulous cloud from which the meteors are derived cannot extend around more than one-fifth of its orbit. But meteoric phenomena have been occasionally witnessed about the 13th of November, when the principal group was near its aphelion. The following dates, for instance, are given by Humboldt:

1787, November 9th–10th.
1818, November 12th–13th.
1822, November 12th.
1823, November 12th–13th.
1846, November 12th–13th.
1847, November 12th–13th.
1849, November 12th–13th.

Can these displays, remote from the regular epochs, be satisfactorily accounted for?

The meteors of 1818, 1822 and 1823 may be regarded as all derived from a single extended swarm. Those of 1787 were probably due to a former return of the same cluster, as the intervening period was about 33 or 34 years.[*] The short interval of 12 years (1787 to 1799) cannot be explained on the hypothesis of a single group. We infer accordingly that the *Leonids* entered the solar system as two separate masses, to which the disturbing influence of Uranus gave slightly different periods.

The meteors of 1846, 1847 and 1849, observed after the periodicity of the shower had been recognized, were noticed in consequence of a watch instituted for the purpose. Their numbers were not great, nor did they conform with any exactness to the radiant in Leo. In regard to these straggling members of the group, it is sufficient to remark that, whenever the earth passes through the meteoric current, its disturbing influence changes the orbits of such meteoroids as happen to be moving in its immediate vicinity. These disturbed portions of the ring, at their subsequent returns, must pass through the point of greatest perturbation. As the periods will vary within very wide limits, we have an obvious explanation of the phenomena in question.

2. *Recently discovered Comets.*—While, in the year 1872, only one comet was discovered, namely, the fragment of Biela's comet seen by Mr. Pogson, at Madras, just after the star shower of Nov. 27th, during the present year there have already appeared six of these bodies.

1873, a.—Mr. Stephan, at Marseilles, on the 3d of April, found the comet 1867, b. (II), originally discovered by Tempel, a comet

---

[*] Another shower from this meteor-cloud may be expected between 1885 and 1889.

of short period. It had been close to the planet Jupiter, probably within a distance of 0·33, and its time of perihelion passage had been altered thereby nearly two months.

1873, b.—On the 3d of July, Mr. Tempel, at Milan, discovered a comet of which Dr. Schulhof gives the following elliptic elements.

$$\begin{array}{l} T=1873,\ \text{June}\ 25\cdot38179\ \text{m. Berlin time.} \\ \left.\begin{array}{l}\pi=306^\circ\ \ 4'\ 52''\cdot6 \\ \Omega=120^\circ\ 54'\ 40''\cdot8 \\ i=\ 12^\circ\ 44'\ 27''\cdot8\end{array}\right\}\ \text{mean Eq. 1873·0} \\ \varphi=\ 33^\circ\ 21'\ \ 7''\cdot0 \\ \log a=0\cdot474867 \\ \mu=688''\cdot1867. \end{array}$$

This body is therefore a new comet of very short period.

1873, c.—Another comet was discovered by Mr. Borelly, at Marseilles, on the 20th of August. From the observations of the first week, Dr. Peters gives the parabolic elements:

$$\begin{array}{l} T=1873,\ \text{Sept.},\ 10\cdot7022\ \text{m. B. t.} \\ \pi=\ 64^\circ\ 21'\ 42'' \\ \Omega=230^\circ\ 55'\ 45'' \\ i=\ 95^\circ\ 33'\ 58'' \\ \log q=9\cdot90163 \end{array}$$

1873, d.—Again another comet was discovered by Mr. Paul Henry at Paris, on the 23d of August, in the northern sky. It passed rapidly southward, increasing in brilliancy.

1873, e. (1846 III.)—On the morning of Sept. 1st, Mr. Stephan, of Marseilles, obtained a view of Brorsen's comet. It was excessively feeble.

1873, f.—(Faye's comet.) Mr. Stephan obtained an observation of this comet on the 3d of September. It was still exceedingly small and faint, and was only about 9″ from its computed place.

It is especially gratifying to be able to add to the number of observed telescopic comets. The disintegration of Biela's comet, and the appearance of one portion as a star shower last November, press anew many questions respecting the nature of comets. To answer these we need more facts, and especially facts respecting the fainter comets. Persons who have the use of a comet seeker may do good service to astronomy by searching for them. The Vienna Academy has very justly appreciated this service to science, and continues to offer its gold medal to discoverers. May we not hope that some of these prizes will be secured by American observers?

The arrangements of the Smithsonian Institution for telegraphing the discovery of comets should serve as an additional incitement.

2. *Spectroscopic observations of Borelly's and Henry's Comets.*—Dr. Vogel of Bothkamp has obtained several good observations of the spectra of two of the recent comets. From his report (Astron. Nach., 1958) we mention a few particulars. The spec-

trum of comet 1873, c, consisted of three bands in the yellow, green, and blue. The relative intensity of the bands in order from the red was indicated by the numbers 3, 7, and 2. Each of the bands shaded off very markedly toward the violet, the greatest intensity being toward the red. Only one observation was obtained, and then the comet was near the horizon.

Of the comet 1873, d, Dr. Vogel obtained several observations. The spectrum consisted of the three ordinary bright lines, which were, however, sharper than usual toward the red. Their relative brightness was represented by the numbers 1, 3, and 1, or 5, 12, and 4. The lines were sharply limited on the side of the red, and these limits were at the following wave lengths, 561·5; 516.7; 472·6 millionth millimeters. The bands ended at 541, 500, and 464 mill. mm., and bear a close resemblance to the carbon spectra, with which Dr. Vogel gives a detailed comparison.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Deep Sea Exploration.* (Report Brit. Assoc. in Athenæum for Sept. 27.)—The largest audience of the week was gathered together on Tuesday morning (the final sitting), to hear Commander J. E. Davis discourse "On the recent Achievements of the Challenger Deep-Sea Expedition." This paper was followed by one "On the Physical Geography of the Caspian Sea," by Dr. W. B. Carpenter, who also entered largely into the subject of oceanic geography in the discussion which followed Capt. Davis's communication. These two papers were the only subjects of the day which our space will permit us to discuss. Capt. Davis confined himself to the proceedings of the Challenger Expedition north of the Equator, which formed a natural section of the voyage. The operations with which he chiefly dealt were the deep-sea soundings viewed in their relations to physical geography rather than to zoology, which, as is well known, occupies a large portion of the attention of the scientific staff of the Expedition. He described and exhibited to the meeting the various mechanical contrivances adopted to sound the greatest depths with accuracy, ascertain the temperatures, and bring up mineral and zoological specimens from the bottom. In the course of the voyage outward from the Thames to Gibraltar, and thence to Madeira and the Canaries, the first interesting set of soundings were taken off the entrance to the Straits of Gibraltar. The soundings over a large area in this section are as follows: just beyond the meridian of Cape St. Vincent, due west of the Straits, 2,500, 2,125, and 2,250 fathoms; and, again, between Madeira and the Canaries 2,350, 2,400, 2,200, and 1,975 fathoms; but westward and northward, outside this area, the depths diminish to 1,525, 1,400, 1,550, and 1,650 fathoms. These results seem to indicate the existence of another deep basin outside the Mediterranean, circumscribed by a ridge similar to the two deep basins within that sea. Great depths were found close up to the islands of the Madeira and Canaries group, but a much

more abrupt elevation from the sea-bed was presented in Bermuda. The deepest sounding yet made in the ocean was at a point eighty miles distant from these islands, where a depth of 3,875 fathoms was found. Five miles of rope was run out with the sounding apparatus, taking one hour and twelve minutes in its course. The other soundings taken around Bermuda prove it to be a peak, formed by coral animals, rising abruptly from the abysmal depth of 1,500 to 1,820 fathoms—comparable, as Dr. Carpenter observed, to the Matterhorn. Between the West Indies (St. Thomas) and the Canaries, nearly in the middle of the Atlantic, shallower depths were found, showing that a submarine ridge here exists. The depths over the ridge are 1,900 and 1,950 fathoms, whilst on either side of it a broad basin extends, deepening to 2,650 fathoms in the western basin, and 3,150 fathoms in the eastern. In crossing from Bermuda to the latitude of New York, especial attention was directed to the Gulf-Stream, both as to the depth and temperature of the current. A sounding of 2,425 fathoms was obtained just within the southern edge of the famous stream. From serial temperatures taken at various depths in the stream, it was found that in this part of its course the warm water does not extend beyond 100 fathoms in depth. It was found to be 57 miles broad, rapid only along the western edge, where there was a belt of water 15 miles wide, running 3½ to 4 miles an hour, and 3° Fahr. higher in temperature than the other parts of the stream.

In the discussion which followed, Dr. Carpenter expounded to the Section his theory of oceanic circulation, *i.e.*, the slow movement of the cold Polar waters along the depths of the ocean toward the Equator, and the compensating movement of the warm equatorial water toward the poles; and showed how all the deep-sea observations recently made corroborated his views. He ventured to predict that when the deep-sea temperature of the North Pacific was examined, it would be found to be much less than that of the Atlantic, as a natural consequence of the narrowness and shallowness of the only opening, Behring Straits, by which Polar water could move toward the great Pacific basin. His paper "On the Physical Geography of the Caspian" had equally a bearing on the truth of his circulation theory; for, according to the theory, inland seas, excluded either by land or a shallow entrance from the influx of the cold deep water of the ocean, must increase in saltness, and the waters sinking in consequence of this greater specific gravity must give rise to an in-flowing surface current from the ocean, the deep waters of the inland sea remaining of high temperature. This had been his explanation with regard to the Mediterranean, and, owing to the explanation being objected to, on account of the excessive evaporation it demanded, he now brought forward the Caspian as corroborative. He showed, from the observations of Von Baer, how enormous is the evaporation from the surface of the Caspian. The Gulf of Karabogas, at the northeastern end, is the receptacle for a great portion of the waters, which pour over the shallow bar like a river at certain seasons, and annually evaporate, leaving the water so saturated with salt that the mineral deposits itself in crystals on any object immersed in it. Formerly, Von Baer has shown, the Caspian was connected with the ocean by way of the White Sea, and marks of erosion are now visible on rocks at an altitude of 80 feet above the present water-level. These 80 feet corresponded exactly with the present level of the ocean, and it is a remarkable fact that no marks of erosion were found between that line and the present level of the waters. This shows that the sinking of the waters by evaporation is a process too rapid to leave any records, and took place soon after the severance of its connexion with the White Sea.

2. *On the Electrical Phenomena which accompany the Contractions of the leaf of Dionæa muscipula;* by Dr. BURDON-SANDERSON.—It is well known that in those structures in the higher animals which are endowed with the property of contracting when stimulated, viz: nerve and muscle—this property is associated with the existence of voltaic currents which have definite directions in the tissue. These currents have been the subject of very careful observation by physiologists. They require delicate instruments for their investigation, but the phenomena dependent on them admit of the application of the most exact measurements. The constant current which can be shown to exist in a muscle is called the normal current. The most important fact with reference to it is that it exists only so long as the muscle is alive, and that it ceases during the moment that the muscle is thrown into action. Other characteristics of the muscle currents were referred to, which we have not space to mention.

In certain plants said to possess the property of irritability, contraction of certain organs on irritation occur which strikingly suggest a correspondence of function between them and the motor organs of animals. Among the most remarkable are those of Drosera and some other plants belonging to the same natural order, particularly the well-known Venus' Flytrap (*Dionæa muscipula*). The Sensitive Plant, the Common Monkey Flower, the Rock Cistus, afford other examples.

Strange as it may seem the question whether these contractile movements are accompanied with the same electrical changes as those which occur in the contraction of muscle and in the functional excitation of nerve has never yet been investigated by vegetable physiologists. Mr. Darwin, who for many years has devoted much attention to the animal-like function of Dionæa and Drosera, kindly furnished plants for the purpose of the necessary experiments, which have been made by Dr. Sanderson in the laboratory of University College, London. The result has been that the anticipations he had formed have been confirmed as to the existence of voltaic currents in these parts, and particularly in the leaf of Dionæa. By a most remarkable series of experiments (which will be published subsequently) made with the aid of Sir W. Thompson's galvanometer, he has shown that these currents are subject, in all respects in which they have been as yet investigated, to the same laws as those of muscle and nerve.—*Brit. Assoc.*, 1873, *Nature, Oct.* 2.

3. *Ascent of Mount Whitney by Messrs. Rabe, Crapo, Hunter and others ;* by W. A. GOODYEAR.—After my ascent with M. W. Belshaw, on the 27th of July last, of the peak which for several years has been erroneously supposed to be Mount Whitney, he resolved to send a party at his own expense to attempt the ascent, and obtain if possible a measurement of the altitude of Mount Whitney itself. He therefore engaged Charles Rabe, an attaché of the State Geological Survey, who taking with him a couple of Green's cistern barometers, and a supply of thermometers, etc., went to Lone Pine in Owen's Valley. Leaving one of the barometers at Lone Pine for observations there, he started for the peak in company with W. L. Hunter, William Crapo and Mr. McDonald, all of Cerro Gordo. This party reached the summit of Mount Whitney on the 6th day of September, 1873, and obtained there a series of ten barometric observations extending from 9.20 A. M. to 2 P. M., of that day.

The altitude of Mount Whitney above Lone Pine, as computed by me from a comparison of these observations with the nearly simultaneous series taken on the same day at Lone Pine itself, is 10,981·5 feet. Add to this the altitude of Lone Pine above the sea, which, according to the best determinations yet made, is 3,917 feet, and we have for the total height of Mount Whitney above the sea, 14,898·5 feet, or say in round numbers 14,900 feet.—*San Francisco Evening Bulletin*, Sept. 27.

4. *Annual Report of the Board of Regents of the Smithsonian Institution, for the year* 1871. 474 pp. 8vo. Washington, 1873.—After the Report on the operations, expenditures and conditions of the Smithsonian Institution by the Secretary, Prof. Henry, there follows a list of the meteorological stations and observers of the institution for the year, and a catalogue of meteorological articles and works received during the year and deposited in the library of Congress. The next volume commences the General Appendix, whose contents are, Memoir of Sir John Frederick William Herschel, by U. S. Dodge; Memoir of Joseph Fourier, by M. Arago; On Prof. Thomas Graham's Scientific Work, by Wm. Odling; On the Relation of the Physical Sciences to Science in General, by Dr. Helmholtz; Alternate Generation and Parthenogenesis in the Animal Kingdom, by Dr. G. A. Kornhuber; Present state of our knowledge of Cryptogamous plants, by H. W. Reichardt; Recent researches on the secular variations of the Planetary Orbits, by J. N. Stockwell; Some methods of interpolation applicable to the graduation of irregular series, such as tables of mortality, etc., by E. L. De Forest; Report on the Transactions of the Society of Physics and Natural History of Geneva, 1870–71, by H. de Saussure; Instructions to Captain Hall, with reference to the Expedition to the North Pole; Ethnology; Meteorology.

5. *Late Meeting of the American Association.*—An excellent report of the proceedings, with abstracts of the papers and a publication of some papers entire, including the Address of the President, has been issued, in a special extra of the New York Tribune.

6. *Critiques and Addresses;* by THOS. HENRY HUXLEY. 318 pp. 12mo. 1873, New York. (D. Appleton & Co.)–Huxley's subjects are Administrative nihilism; school-boards; medical education; yeast; formation of coal; coral and coral reefs; methods and results of ethnology; some fixed points in British ethnology; Paleontology and the doctrine of evolution; Mr. Darwin's critics; genealogy of animals; Bishop Berkeley on the metaphysics of sensation.

7. *Volcanic Energy: an attempt to develop its true Origin and Cosmical Relations;* by ROBERT MALLET, F.R.S. From the Transactions of the Royal Academy, before which the memoir was read June 20, 1872.—This most important contribution to geological science, read before the Royal Society June 20, 1872, has recently been issued. A notice of it is deferred to another number. The views have been briefly mentioned in the last volume of this Journal.

8. *The Unity of Natural Phenomena;* a popular Introduction to the study of the Forces of Nature: from the French of M. Saigey, with an Introduction and Notes by TH. F. MOSES, A.M., M.D., Prof. Nat. Sci. Urbana University. 254 pp. 12mo. Boston, 1873. (Estes & Lauriat).

9. *Comets and Meteors: their phenomena in all ages; their mutual relations; and the theory of their origin;* by DANIEL KIRKWOOD, LL.D., Prof. Math. Indiana Univ. 93 pp. 12mo, with excellent illustrations. Philadelphia, 1833. (Lippincott & Co.)—A notice is deferred to another number.

OBITUARY.

LEWIS WHITE WILLIAMS, died at West Chester, Penn., on the 19th of September, 1873, aged 69. Mr. Williams was extensively known as one of the best collectors of minerals in the country, and but few cabinets of any note are without specimens of minerals from Chester and Delaware Counties, Penn., furnished by him. He paid particular attention to the minerals associated with the chrome iron at Texas, and to those found in the northern part of Chester Co.

The work in which he took the most pride, was the discovery of the rich deposits of corundum near Unionville, Chester Co.

He accompanied the Mexican Boundary Survey as mineralogist, but unfortunately the greater part of his collection made at that time was lost while crossing a river, by the drowning of his mule. He made a number of very fine collections of suits of minerals, one of which formed the foundation for the well known cabinet of Wm. W. Jeffries. The *Williamsite* of Shepard was named in his honor.

S.

Prof. DONATI, the director of the Astronomical Observatory in Florence, died of cholera at Vienna, Sept. 20th.

M. COSTE, member of the Institute of France, author of numerous physiological works, prominent in the science of the artificial production of fish, and inspector-general of fluvial and coast fisheries, died recently at Paris, at the age of sixty-six.

Prof. CZERMAK, the physiologist, died at Leipsic, Sept. 16th.

APPENDIX.

Star Photographs at Cordoba. (Letter to the Editors from Dr. B. A. Gould, dated Sept. 6, 1873.)

Yesterday brought me the July number of the American Journal of Science, in which I saw with surprise an article which at first seemed to require comment from me. On reflection, however, I think it better simply to state the facts of the case and ask you to publish them.

You are aware of my efforts to obtain by subscription the means for securing an extended series of photographs of southern star clusters, and also that these efforts had not the success which I desired. But my parents, by blood and marriage, sympathizing with my desires, authorized me to draw upon them for a sum adequate to the necessities of the case. Mr. Rutherfurd, who, before I left home, had kindly offered his assistance in engaging a photographic operator, and giving him the needful instructions for the telescopic work, now engaged one in New York, and caused him to be carefully instructed by his own assistant, Mr. Chapman. Meanwhile I asked and readily obtained from the Argentine Government official permission to employ the large telescope for making photographs for my private use, at such times as might not be inconsistent with the regular work of the Observatory.

The person engaged was the author of the paper referred to, Dr. C. Schultz-Sellack, who had received a scientific education in his native country, and gladly availed himself of this opportunity for devoting himself to scientific avocations. An engagement was made with him, and he came out as soon as he had acquired the requisite training. Fortunately, it was not necessary for me to avail myself of the permission to draw upon my friends at home, and Dr. Sellack's expenses, including a salary considerably larger than that promised him, have been defrayed from my own earnings. The apparatus and materials were my personal property, and the plan of the work was my own.

These facts I should not mention but for the communication cited, the author of which has undertaken to publish in his own time and way, without my permission or even knowledge, results which were in no sense whatever his own.

In October last I determined to provide a new photographic object-glass, from the private resources at my disposal, to replace the broken one; and forwarded the order to Mr. Fitz, for whose use Mr. Rutherfurd had the goodness to calculate the necessary curves. At a later date, both President Sarmiento and Dr. Avellaneda, the Minister of Public Instruction, sympathizing with my disappointment, and with the large outlays fruitlessly made, desired to do its utmost to aid in the photographic work, and with this view desired to order the new object-glass and to provide for the pay of my photographic assistant. The place of Professor of Physics in the scientific corps now organizing here was not yet filled; and I was informed that if I deemed Dr. Sellack a fit person, he should be appointed at once, with orders to go on with the photographic work under my direction, absolving him for a season from all duties inconsistent therewith. This arrangement was about to be put into effect when circumstances which I refrain from relating, and in which I had no part (nor indeed knowledge at the time), led the authorities to desire that some other person than Dr. Schultz-Sellack be selected. Dr. Burmeister, who had engaged the other four professors, had retired from this commissionership, and I was therefore requested to propose some suitable person competent to teach physics after the photographs should be completed. Dr. Sellack had, however, worked with much industry during the earlier months of his sojourn in Cordoba, and for this, as well as other manifest reasons, I urgently pressed and finally obtained his appointment, which dated from the beginning of the present year, and was accompanied by the instructions already mentioned.

This simple narrative of facts seems to be called for under the circumstances, and obviates all necessity of comment upon the propriety or contents of the article to which I refer—from which I will cite a few paragraphs:—

"Under an arrangement made with Mr. Rutherfurd in New York, at the expense of some gentlemen from Boston, I went to Cordoba, to take in the Argentine National Observatory photographs of southern star clusters."

"As the circumstances have been utterly unfavorable, ... the results of the enterprise could not fulfill the legitimate expectations of the liberal originators."

"I selected and photographed some twenty star clusters."

"The elaboration of the results which the plates are capable of giving has been reserved to Dr. Gould."

"The Argentine Government is going to provide a new photographic lens for the National Observatory, and has asked me to continue the experiments with the new lens."

I likewise waive all comment upon those statements of the same paper which possess a scientific bearing. Mr. Rutherfurd has always freely communicated such of his methods and inferences as he has not published. As for myself, never having yet made what is called a scientific reclamation, I am indisposed to begin on this occasion;—and it is certainly not incumbent upon me to correct such of the statements as are erroneous.

Fig. 1.

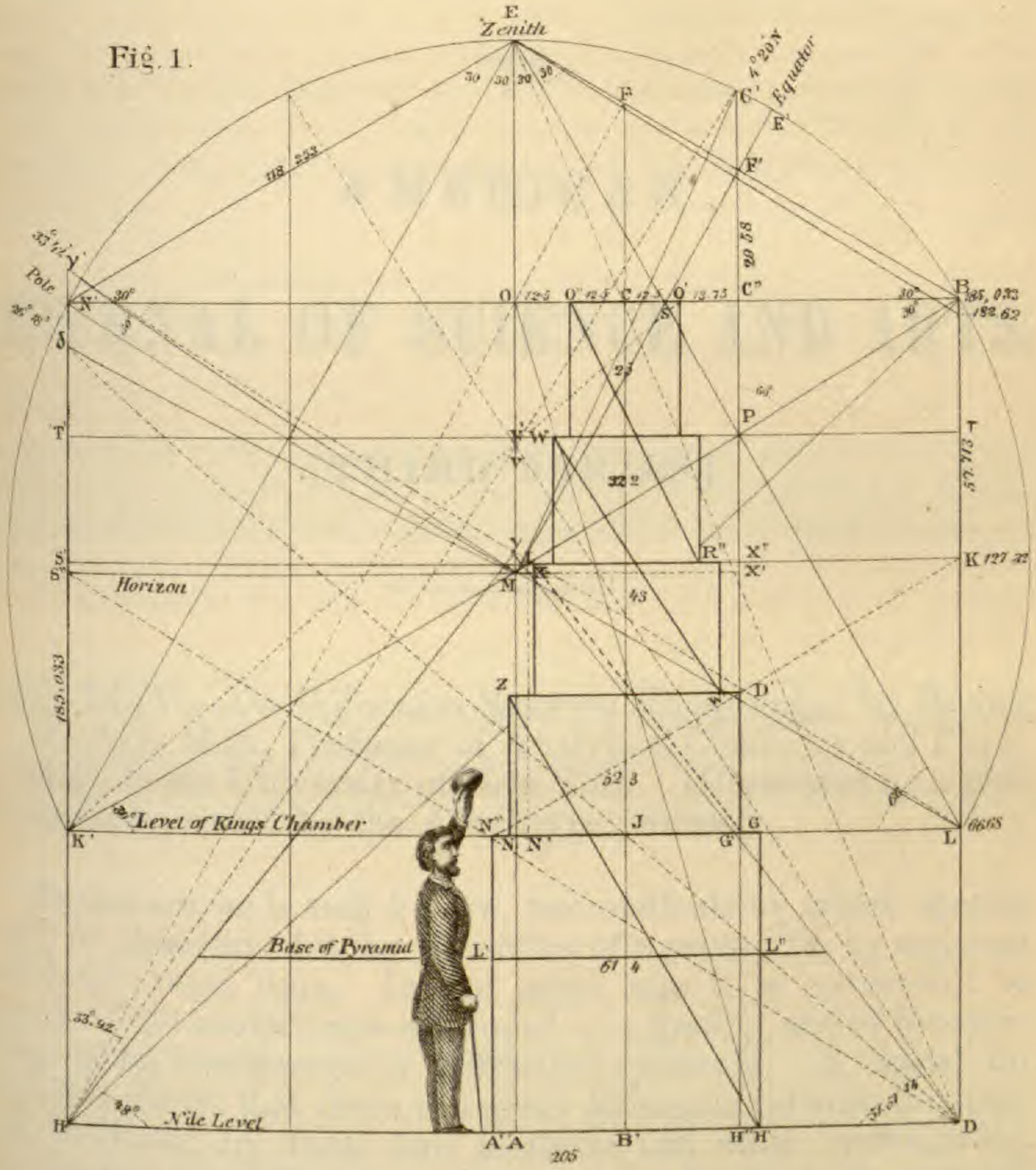
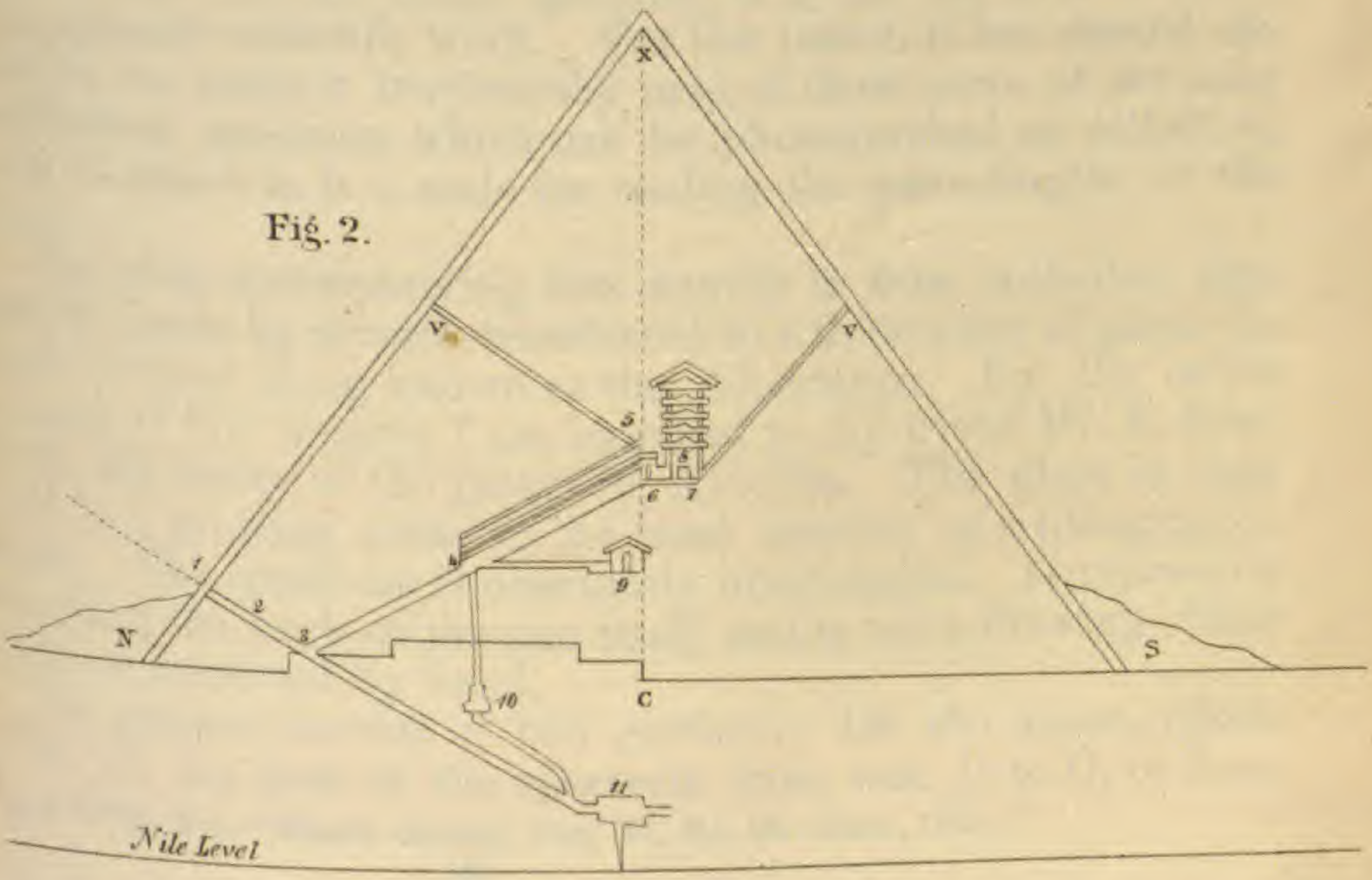

E
Zenith
30
30
30
30
F
G'
4°20'N
Equator
E'
F'
118.333
33°12' Y'
Pole
N'
30°
36°18'
δ
O
12.5
O'
12.5
C
12.5
Q'
12.75
C"
29.58
B
85.033
182.62
30°
30°
S'
23
60°
P
T'
V'
W
V
32.2
T
57.713
S'
S"
Horizon
Y
M
K
R"
X"
X'
K 127.32
43
185.033
Z
W
D'
52.3
Level of Kings Chamber
K'
N"
N
N'
J
G
G'
L
6668
Base of Pyramid
L'
L"
61.4
33°42
H'
49°
Nile Level
A'
A
B'
H"
H
D
205
51°51'14"

Fig. 2.


X
V
V'
5
8
6
7
4
9
1
2
3
N
S
C
10
11
Nile Level

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

Art. XLIV.—*On Diffraction Spectrum Photography;* by Henry Draper, M.D., Professor of Analytical Chemistry and Physiology in the University of New York. (Illustrated by a photograph printed by the Alberttype process.)

There are, as is well known, two methods by which spectra may be obtained: 1st, by the action of a prism; 2d, by a system of closely ruled lines. In the latter case it is convenient to speak of the contrivance employed as a grating, and of the spectrum as an interference or diffraction spectrum. A casual inspection shows that there is a great difference between the spectra produced by these two methods, and close investigation proves that the diffraction spectrum is by far the more suitable for accurate scientific work. For this reason it has seemed desirable to make a trustworthy map of those parts of the solar diffraction spectrum which can be photographed on collodion, and to attach to it a scale for reading the wave-lengths of the rays.

The plate accompanying this memoir is from collodion photographs made by myself, transferred to a thick piece of glass, the latter process being known as the Alberttype. For the entire success of this transfer I am indebted to my friend Mr. E. Bierstadt, the owner of the patent in America. The glass is then used in a printing press in the same manner as a lithographic stone. The spectrum is absolutely unretouched. It represents therefore the work of the sun itself, and is not a drawing either made or corrected by hand.

The picture consists of two portions; 1st, the upper, which gives all the lines of the spectrum from near G to O, or from wave-length 4350 ten-millionths of a millimeter to 3440. Above that is placed a scale, which is a copy of Angström's from just below G to H_2, with the same-sized divisions carried out from H_2 to O. The 2d, or lower, is a magnified portion of the same negative, having H_1 and H_2 about its middle, and extending from wave-length 4205 to 3736.

It follows therefore that the lines in the solar spectrum are correctly represented in their relative positions. The only errors are those which may have arisen from mal-adjustment of the scale. The precautions that were taken to avoid such errors will be described. With a certain correction, to be mentioned hereafter, it may also be stated that the relative shadings and intensities are preserved.

The value of such a map depends on the fact that it not only represents parts of the spectrum which are with difficulty perceived by the eye, (though they may be seen by the methods of Stokes and Sekulic,) but also that even in the visible regions there is obtained a far more correct delineation in those portions which can be photographed. In the finest maps drawn by hand, such as those in the celebrated "Spectre Normal du Soleil" of Angström, the relative intensity and shading of the lines can be but partially represented by the artist, and a most laborious and painstaking series of observations and calculations on the part of the physicist is necessary to secure approximately correct positions of the multitude of Fraunhofer lines. Between wave-lengths 3925 and 4205, Angström shows 118 lines, while my original negative has at least 293.

For such reasons many attempts have been made to procure good photographs of the diffraction spectrum. The earliest were by my father, J. W. Draper; his results were printed in 1843–44 in a work entitled "On the Forces which produce the Organization of Plants." This memoir was accompanied by plates drawn from his daguerreotypes, and the wave-lengths, which he first suggested as the proper indices for designating the Fraunhofer lines, were used as a scale.

Since that time the most important experiments in this direction have been by Mascart and Cornu. These eminent physicists have, however, resorted to the plan of taking portions of the spectrum on a small scale and subsequently making enlarged drawings therefrom. This course introduces the defects of handwork, and the artistic difficulties of copying intensity and shading, as well as the omission of fine lines.

In the photographs of the spectrum which I have taken, I have tried to get as large a portion as I could at once, and on as large a scale as possible. I have usually obtained images from below G (wave-length 4307) to above O (wave-length

3440) of about 12 inches (·305 meter) long. I have succeeded, however, in photographing from near *b* (wave-length 5167) to T (wave-length 3032) by resorting to a ruled speculum plane and a concave speculum mirror, but the photographic and optical difficulties in securing an enlarged spectrum of that length are great.*

Of course, in such a research as this an essential is a finely and evenly ruled plane of glass or other material. Those which I have used were made by a machine devised and constructed by Mr. L. M. Rutherfurd, whose beautiful lunar and prismatic spectrum photographs are so well known to the scientific world. The plate generally employed is of glass ruled with 6481 lines to the inch; the ruled part is $1\frac{8}{100}$ inch (·027 meter) long, and $\frac{64}{100}$ inch (·016 meter) wide. It is unquestionably much more nearly perfect than similar gratings made by Nobert and others, for the character of the photographs and the uniformity of the orders on either side of the normal, together with its behavior under a searching examination, show that it leaves little to be desired. As it is on glass, and gives a bright transmitted spectrum, I have constructed the remainder of the optical apparatus of glass achromatized, according to the plan used by J. W. Draper in 1843, except that I have not silvered the ruling, and therefore have used the refracted, and not the reflected beam. The slit is $\frac{8}{10}$ of an inch (·02 meter) long, and $\frac{1}{110}$ of an inch (·00023 meter) wide; the jaws are of steel, and there is not only a micrometer screw for separating them, but also one for setting them at an angle. Occasionally I have taken photographs with the jaws $\frac{1}{90}$ of an inch (·00028 meter) apart at the top, and $\frac{1}{130}$ (·00019 meter) at the bottom, so as to obtain different intensity in the two edges of the spectrum.

Most of the photographs have been of the spectrum of the 3d order, which has certain conspicuous advantages. In the first place, it is dilated to such an extent as to give a long image, and yet one not too faint to be copied by a reasonable exposure of the sensitive plate; and in the second place, the spectrum of the 2d order overlaps it in such a way that D falls nearly upon H, and *b* upon O. These coincidences are serviceable in determining the true wave-lengths of all the rays.

The only point of special interest in connection with the photographic part of the operation, is the device for avoiding the unequal action on the sensitive plate of different rays of the spectrum. It has been commonly supposed, until the recent memoirs of J. W. Draper, that there are in the spectrum three

---

* Since writing the above I have succeeded in photographing the lines of the visible spectrum from *b* downward, and the picture comprises not only the regions including E, D, C, B, *a* and A, but also the ultra-red rays. The great groups α, β, γ, below A, discovered by my father in 1843, are distinctly reproduced.

different types of force in three different but overlapping regions. Heat was supposed to be principally found at the less refrangible end, light in the middle, and actinism at the more refrangible. But he showed that this error has partly arisen from using prismatic spectra, which condense the red end and dilate the violet, and do not present the rays in the true order of their wave-lengths, and partly from the nature of our ordinary photographic substances. He proved that actinism, or the power of chemical decomposition, does not particularly belong to the violet end of the spectrum, but is found throughout its whole length. But bromide and iodide of silver, as used in collodion photography, are more readily decomposed by vibrations of certain lengths and periods than by others, and hence the excess of action seen at the violet end is a function of certain silver compounds, and not of the spectrum. Other substances, as carbonic acid, show maxima elsewhere, as in the yellow region. The solar beam is therefore not compounded of three forces, light, heat and actinism, but it is a series of ethereal vibrations, which give rise to one or other of these manifestations of force, depending on the surface upon which it falls.

In order to provide against this excess of action in certain parts of the spectrum, I introduced a system of diaphragms placed in the vicinity of the sensitive plate, and removed at suitable times during the exposure. The region from wave-length 4000 to 4350 only requires about one-tenth of the time demanded by that from 3440 to 3510. In the negative which produced the accompanying plate, the line O had 15 minutes and G $2\frac{1}{2}$ minutes, and the former is under-exposed. These exposures seem at first sight unusually long for a wet collodion surface, but it must be remembered that the slit used was only $\frac{1}{110}$ of an inch wide, and that the diffraction grating gives an almost complete circle of spectra round itself, amongst which this thin band of light is divided. A beam $\frac{1}{110}$ of an inch (·00023 meter) wide is spread out in this case into a streak about 78 feet (23·77 meters) long.

After the production of spectra that were in focus from end to end, it was next necessary to attach a scale to them by which the wave-lengths might be read. At first I tried, by reducing Angström's maps to the proper dimensions, to accomplish this object, but the undertaking proved to be difficult, and was unsuccessful, because, though the original drawing on the stone was undoubtedly correct, the paper proof of it which I had, had stretched unequally in printing, and on applying a photographic reduction to my spectra, coincidence could not be obtained. As, however, the subject of providing a scale for these diffraction spectra is of prime importance in giving value and precision to the wave-lengths presented in this memoir, I propose to describe fully the method eventually employed in fitting a scale to the photograph.

The wave-lengths of the ultra-violet rays have never, as far as I know, been either determined or published except by J. W. Draper in 1844, Mascart in 1866, and Cornu in 1872. J. W. Draper's memoir has a steel engraving of some of the principal lines, from which the wave-lengths may be approximately read.

The large plate which accompanies Mascart's long and valuable memoir is of the prismatic spectrum, but he furnishes in addition the following table of wave-lengths:

L	3819·0
M	3728·8
N	3580·2
O	3440·1
P	3360·2
Q	3285·6
R	3177·5

These numbers do not entirely coincide in all cases with my photograph, as I will show further on.

The detailed results of M. Cornu have not appeared in any publication that has reached me.

I have used as a basis the numbers given by Angström for the rays D_2, b_4 and G, and if there should be any small error in his determinations, my scale will require a proportionate correction, which can easily be effected. At first sight it seemed better to take G and H as fixed points, but the line H is so broad, and has so many component lines, that its position is uncertain, and moreover, being almost at the limit of visibility in Angström's apparatus, it was more open to errors of measurement. These reasons led me to take advantage of the fact that the 2d spectrum overlaps the 3d, the ray D of the 2d being near H of the 3d, and *b* of the 2d near O of the 3d. It is obvious that we have thus the means of ascertaining the wave-lengths of three points, one at each end, and one in the middle of my photograph. As the rays D and *b* cannot impress themselves on collodion by any length of exposure that it is convenient to give, and as in my method of working the ultra-violet rays could not be seen simultaneously with them, it was necessary to resort to the following device. I placed in front of the sensitive plate and close to it two fine steel points, one of which was carefully adjusted to the position of D_2 of the 2d order, and the other to b_4 of the 2d order. When therefore, after a suitable exposure to the ultra-violet spectrum of the 3d order, the collodion picture was developed, there were two sharply defined images of the steel points superposed on the spectrum. The point which had been coincident with D_2 of the 2d order was then found to have cast its shadow on H_2 of the 3d order, and the point at b_4 of the 2d order had impressed itself near O of the 3d order.

By a simple calculation it was thus rendered evident that a given ray in the compound line H_2 was of the wave-length 3930·1 ten millionths of a millimeter, and that another line near O had the wave-length 3444·6. By looking at the photograph, the reader will see that 3930 falls upon a fine division in H_2, which is beautifully shown in both the spectrum with the scale and the enlarged proof below. Of course, the ray G of the 3d order, the wave-length of which is known, had impressed itself photographically on the collodion.

Having thus ascertained the wave-lengths of three fixed points in the photograph, the next step was to apply a scale reading to a single ten-millionth of a millimeter, and, if possible, fractions thereof. After many abortive attempts to use that part of Angström's map which lies between G and H, and to attach thereto an additional length of scale sufficient to extend to the end of the ultra-violet region, I was compelled to resort to a linear dividing engine, and rule a scale which was about twice the length of the photographic reduction shown in the accompanying plate. Of course, this necessitated drawing in by hand the same systems of lines and lettering as are shown on Angström's chart, and this I did as carefully and faithfully as I could.

It only remained to reduce this divided scale to the proper size to fit the spectrum photograph; after many trials it was accomplished.

It is proper in this place to make a criticism on my scale, and to point out a small error, which may be due, however, to an incorrect determination of the wave-lengths that I have used as fixed points. Taking the distance from G (wave-length 4307) in the photograph to the fixed line 3930 in H_2, and dividing it into 377 parts, and then prolonging these divisions toward O, it was found that the third fixed point was not attained, but that there was an error of about two divisions. But if the position of D_2 in Angström's determinations should be incorrect to the extent of one ten-millionth of a millimeter, or if this small error should be partly attributed to D_2, and partly to G, my scale would be correct. Future measures of the wave-lengths of these rays, and of b_4, can alone settle this delicate point, for the determinations of Mascart and Angström and Thalen differ nearly to the extent mentioned above. The same remark is true of Angström compared with Ditscheiner, while the difference between Angström and van der Willigen is more than three times the amount necessary to remove my discrepancy. In any case the photograph is correct, as it is the work of the sun, and is only open to errors arising from imperfect flatness in the field of a fine lens, and that field only subtending an angle of about 4°. The angular aperture of the lens viewed from the sensitive plate is 20 minutes. I trust, therefore, that the photograph may be of permanent value to physicists, for any one can affix another scale if this be slightly erroneous.

An examination of the photographed spectrum shows many points of interest, some of which are best seen in the spectrum with the scale above, and some in the portion enlarged below. The latter is magnified about twice, and comprises the region from wave-length 3736 to 4205. I have also made photographs on the same scale as Angström's map, but have not as yet printed them. The capital letters which are attached to the region above H, are according to the nomenclature of Mascart, although the wave-lengths assigned by him to those letters do not coincide exactly in all cases with the lines in my photograph; for instance, the line L, which he regards as single, is in reality triple, and does not correspond to 3819, but to 3821; M is correctly designated by 3728, but it is double; N is really at 3583, and not 3580. It has been suggested that it would be proper to return to the old nomenclature of Becquerel and J. W. Draper, who simultaneously discovered these lines in 1842–43, but the designation of position by wave-length in reality renders the letters unnecessary.

The spectrum above H, when compared with the region from G to H, is marked by the presence of bolder groups of lines, and most conspicuous are those between 3820–3860, 3705–3760, 3620–3650, 3568–3590, 3490–3530. The first of these groups is strikingly shown in the enlarged photograph. I am not as yet able to offer an opinion as to the chemical elements producing these groups, for almost all the photographs of the ultra-violet spectra of metalline vapors that I have thus far made were produced by a quartz train, and have not yet been reduced to wave-lengths. Indeed, that is a separate field of inquiry, and could not be comprised in a memoir of this length. I have also tried to utilize the photographic spectra of the late Prof. W. A. Miller, published in the Transactions of the Royal Society for 1862, but for some reason, probably insufficient intensity of the condensed induction spark, his pictures do not bring out the peculiarities of the various metals in the striking manner that is both necessary and attainable. The diffraction spectra of metalline vapors that I have made are not yet ready for use.

The probabilities are that each of these groups will be found to be due to several elements, as is plainly seen in the group H. This compound line, which is commonly spoken of as being caused by calcium, iron and aluminum, is in reality much more complex, for there can readily be counted in it more than fifty lines in the original negative, and a careful inspection of the accompanying paper picture shows a large proportion of them. This observation leads us to a more general statement. *The exact composition of even a part of the spectrum of a metal will not be known until we have obtained photographs of it on a large scale.* The coincidences which were so thoroughly examined by Mr. Huggins (Trans. Royal Society, Dec., 1863), will only disappear when we can, in addition to the position of a line, have a clear idea of its size, strength and degree of sharpness or nebulosity. The eye is not able to see all the fine lines, or even if it does, the observer cannot map them with precision, nor in their relative strength and breadth. For example, in Angström's justly celebrated chart, of which the G–H portion is copied in this plate, and in the construction of which the greatest pains were taken by him, many regions are defective to a certain extent. The region from 4101 to 4118 is without lines, yet the photograph shows in the enlarged copy seventeen that can easily be counted, and the original negative shows more yet. The reader of course understands that a paper print of a collodion picture is never as good as the original; the coarseness of grain in the paper, want of contact in transferring, etc., effect such a result. Moreover, the Alberttype process depends on a certain fine granulation which is given to the bichromated gelatine, and this forbids the use of a magnifier upon these paper proofs. It is only just, however, to Mr. Bierstadt to state. that without his personal supervision, such sharp and fine-grained proofs could not have been obtained, and that no other printing-press process that I know of could have accomplished this work at all. As an illustration of the difficulty of depicting the relative intensity of lines, we may examine 3998, which in Angström's chart is shown of equal intensity with 4004, while in reality it is much fainter, and instead of being single, is triple, as is well seen in the enlarged spectrum.

When, however, we compare Angström's chart with the photograph, it requires, as the above remarks show, a critical examination to detect defects, and we have a striking confirmation of the surprising accuracy of the Swedish philosopher.

So also in comparing Mascart's excellent map of the prismatic spectrum with the photograph, the difficulty of depicting all the fine lines is seen. In the group L he shows twelve lines, while even in the Alberttype copy of my photograph twenty-five can be counted, and in the original negative many more. From H to L he exhibits seventy lines; in my plate 138 can be observed, besides many unresolved bands.

In the earlier part of this memoir, it was stated that the relative intensities of the lines in the spectrum were correctly represented if a certain allowance was made. If an unshielded collodion plate were presented to the image of the spectrum, there would be produced a stain very dense from G to H, fainter above H, and still fainter below G. But this stain would not represent the actinic force of the sun; it would merely be the index of the decomposability of a mixture of iodide and bromide of silver. I have for this reason adopted the idea of J. W. Draper, that force is equally distributed through the spectrum, and have tried to produce a photograph of equal intensity throughout. This has been accomplished, as I have before stated, by suitable diaphragms. But whether this view be correct or not, lines which are not far distant from one another are presented virtually without any interference by diaphragms, and must therefore be correct both as to shading and intensity.

Besides the points above mentioned, there are many theoretical considerations suggested by the photograph which it does not seem expedient to enter upon fully at present. Among such is the possibility of arriving at an estimate of the sun's temperature, by interpreting the apparent bands, such as those near G and H, by the aid of Lockyer's researches on the temperature of dissociation of compounds. No one has yet ascertained whether there are or are not unresolvable bands in the solar spectrum. If they do exist, the compounds to which they belong, and the necessary temperature for dissociation, remain to be determined.

It would seem also to be possible to find out whether, as asserted by Zöllner, there is a liquid envelope around the sun, by a search for more diffused bands in its photographed spectrum.

In the hope that this photograph may prove to be of value to scientific men for further investigations upon the sun and the elements, I have caused a number of extra copies to be printed, and shall be glad to present them to any one who can make use of them.

University, Washington Square, New York.

Art. XLV.—*Notes on the West Virginia Asphaltum Deposit*; by Wm. M. Fontaine, Professor of Nat. Hist. Univ. of West Virginia.

In Ritchie County, West Virginia, occurs a remarkable deposit of bituminous matter, for which the name "Grahamite" has been proposed.

This substance, in its chemical properties, is strikingly like the mineral "Albertite," of New Brunswick, while in its geological relations it differs considerably from it. Like

"Albertite," it is mined and used for the production of gas. It is highly valued as an enricher of the common coal used in the manufacture of this substance. The value of the mineral has led to the extensive working of the deposit by a company of Baltimore capitalists, who transport the material by a branch road of their own construction to Cairo Station, on the Baltimore and Ohio Railroad.

The asphaltum deposit occurs in the county of Ritchie, on McFarland's Run, a branch of Hughes River, nearly 12 miles due south from Cairo. To reach it, the branch railroad passes, by a series of zigzags, over hills upward of 500 feet high, thus disclosing quite an extensive series of strata, the nature of which, by means of the railroad cuttings and the excavations at the mines, may be easily made out.

The geological formation here disclosed is that known as the "Upper Barren Measures," being a portion of the strata above the Pittsburg Bed which are unproductive of coal. These barren strata, lying toward the center of the Appalachian coal basin, and being consequently the highest in the series, are in this portion of the State greatly developed, and present some noteworthy features. For this reason, and also because no measurements, as far as I know, have been made of these rocks, I will give the section from the level of the mines to the summit of the hills, which rise some 520 feet above them; the culminating point being 2½ miles distant. In this will be included the strata which lie below the mine level, and have been penetrated by the workings. These have penetrated 160 feet below the surface, which distance, with the 520 feet disclosed along the railroad, gives us a vertical section of 680 feet.

The lowest stratum reached in the mine is a red shale, which has not been penetrated; its thickness is consequently unknown. The section commencing at the bottom is as follows: 1. Red shale, thickness unknown. 2. Gray shale, 20 feet. 3. Sandstone, 30 feet. 4. Gray shale, 55 feet. 5. Sandstone, 95 feet. 6. Gray shale, 55 feet. 7. Sandstone, 35 feet. 8. Gray shale, 45 feet. 9. Sandstone. The strata from 1 to 8 inclusive are embraced within the limits of the mine, and their thickness and nature are well ascertained. The remaining 345 feet of the section, commencing with No. 9, are not so well known, since No. 9 overlies the asphaltum deposit, and caps the hills in the immediate vicinity, while the overlying rocks are imperfectly disclosed along the line of the railroad to the summit. They are, however, sufficiently revealed to show that they are a succession of flaggy sandstones and gray shales, succeeding each other in the same order as is found in the mines. None of the strata denominated shales in this section are purely so. They contain throughout their thickness many very thin layers of sandstone; but the shaly layers vastly predominate. So again, most of the sandstones are flaggy from the intercalation of shaly strata. Two of the sandstones disclosed in the mine, however, present notably different features from these, and from their important influence upon the width of the crevice which penetrates them, deserve a special description. These are Nos. 3 and 5. Both present the same characters; hence we need describe only the more important stratum, No. 5.

The greater portion of the sandstones seen in this section are quite argillaceous, and hence are more or less strongly colored, fragile and flaggy. On the contrary, No. 5 is often quite free from impurities, presenting very compact, heavy bedded, pure white masses of sandstone; sometimes forming a decided conglomerate. The striking physical features of this rock render it a conspicuous feature in the hills, and its indestructible nature causes it to exert a predominating influence on the topography of the region in which it appears. The lofty elevations and precipitous cliffs, seen from the railroad in this section of the State, are due to its appearance in the hills, and the preservation of the underlying strata thus caused. This stratum is much like the great conglomerate, which serves as the floor of the coal formation. It is interesting to note the fact thus indicated, that the conditions of deposit during the last period of the Appalachian coal era, at least in the center of the basin, so closely resemble those prevailing in the earliest.

The dip of the strata is imperceptible, and no indications whatever exist of displacements. Indeed, no evidence exists elsewhere than at the mines of any break in the continuity of the formations, unless it be that more cracks and fractures, on a small scale, exist than are usually found in the sandstones of the Coal-measures. I think that I did observe some such evidences of the rocks being shattered without displacement, but on this fact I cannot insist, as I had no opportunity to make examinations sufficiently extensive to establish it conclusively.

The observer accustomed to the abundant evidences of the former existence of vegetation, as seen in the underlying strata of the productive portions of the coal group, is most forcibly struck with the total absence in these rocks of even discoloration from carbon. The prevailing tint of the sandstones and shales is gray, which in some is changed by weathering to dull brown. No dark shales exist, and in the whole vertical distance, but two thin beds of coal are found, and these present every evidence of turbulent conditions having attended their formation Each of these beds is about 12 inches thick. One, the lower, is seen about a mile from the mine, occurring near the top of the gray shale No. 2. It has not been discovered in working the mineral, being, no doubt, too locally developed to exist there. The second is seen near the mine, and occurs near the top of the gray shale No. 6. Each bed is thus found on the top of a heavy stratum of gray shale, and is capped by a heavy bed of sandstone. The recurrence in regular order of the same character of rocks, in our section, and, so far as they have been measured, with nearly the same thickness, is somewhat singular. We thus see that in the geological horizon of our mineral, and the conspicuous absence of material to produce bituminous matter, we have the exact opposite of the conditions prevailing at the locality of the Albertite deposit of New Brunswick. It will be remembered that this occurs at the base of the Carboniferous formation, and in intimate connection with a heavy stratum of bituminous shale.

Here, also, we have no anticlinal folds, as in the Albertite region.

The cleft which contains the deposit is without doubt caused by the fracturing and slight displacement to one side of the strata. Its direction is 12° north of west. In the vicinity of the mines, it is crossed obliquely by McFarland's Run, a tributary of Hughes River, and here flowing in a southwest direction. This run has trenched the strata quite considerably, having cut out a narrow valley about 200 feet deep. Into this, a smaller stream, called Mine Run, empties near by. This latter flows nearly north and south, and thus cuts the deposit nearly at right angles, at a distance of 1,250 feet from the valley of McFarland's Run. In the sides of the deep ravine, cut by Mine Run, the deposit was first discovered, presenting the appearance of a vertical band, 4 feet wide, cutting the hills from top to bottom. The deposit has been worked vertically through a distance of 300 feet, and, horizontally, of 3,315 feet. Singular to say, all traces of the mineral disappear in crossing the valley of McFarland's Run. Not a sign of the crevice, or mineral, is seen on the east side of this stream, although the deposit continues with unchanged width until it reaches the west side, where it ends abruptly not 100 yards from the east side.

The mineral has been traced about a quarter of a mile beyond the west termination of the works, but it is there reduced to a mere string. If we continue in the direction of the crevice, about seven miles beyond this point, we would intersect at right angles the remarkable line of upheaval along which the oil wells of West Virginia are found, and which is called here the "oil break." No one who examines the crevice containing the asphaltum, and then this belt of rocks, so strangely upheaved in the midst of horizontal strata, can resist the belief, that both these disturbances of the strata had a common cause, and that the same bituminous deposits, lying far beneath the surface, have produced the asphaltum, and now afford the oil of this region. I do not propose to set up any theory to account for this state of things, but will confine myself to a statement of the facts, so far as I could discover them.

As stated, the crevice penetrates vertically the strata from the surface to an unknown depth. Its width varies with the nature of the rocks through which it passes. Its average width in the massive sandstone No. 5 is 4 feet; and in this stratum its dimensions are greatest. We can stand in this portion of the cleft and see the mouth of the adit, 900 feet distant, an evidence of its perfect straightness; while, for the vertical distance of 95 feet (the thickness of the stratum), a plumb line from the top would not touch the sides. On passing into the shales, however, the width is diminished, being sometimes not more than 2½ feet. The direction is also slightly changed from the true perpendicular at the junction of the shales and sandstones. We see, in the shaly portions, slickensides and other evidences of rubbing and sliding. Some of the beds of sandstone have a good deal of shaly matter interstratified, and in these the crevice loses width, and becomes more crooked horizontally; but in no case in the main workings are the variations from regularity very great. In the deepest portions which have been reached, all the rocks have more shaly matter, and hence the greatest width here is only about 2½ feet. Followed to the west, all the strata, even No. 5, become more and more shaly; accordingly, in this direction also, we find the crevice closing up. I followed the opening in this direction, in the stratum No. 5, as far as the work has been carried, and found that here it had become only 8 inches wide, thus being no longer workable. Before attaining this minimum width, the crevice discloses more and more irregularity. The walls are no longer smooth, straight and vertical; zigzags and projecting shoulders are more frequent, while the crevice is continually becoming narrower. "Horses" are found in all parts, but I saw more of them here. I have but little doubt that to the west the inferior compactness of the strata has distributed and confused the action of the rupturing force, and thus prevented the formation of a clear, wide crevice.

We may, I think, from these facts, conclude that this rupturing force could not have been shrinkage.

These facts were observed in the portion of the mines lying to the west of Mine Run. The character of the cleft to the east of the run is similar. This portion is 1,250 feet long, lying in the tongue of land between this stream and McFarland's Run, when, on emerging near the latter, with unchanged width, it suddenly vanishes.

There is a considerable lateral pressure exerted on the mineral from the tendency of the walls to close in. As it is removed by the pick, the sudden yielding of the remaining portions is denoted by a series of pistol-like reports. The movement, however, is imperceptible.

To the casual observer the appearance of the mineral in the cleft is much like that of ordinary bituminous coal. But a closer examination shows, in any given section, that the mass is composed of two portions, quite different in physical properties. These always occupy the same relative position. The one is found only on each side, next to the walls, having a thickness depending on the width of the cleft. The other occupies the central position, and seems to be more independent of the varying width of the crevice, being generally about 15 inches thick. We thus have the entire thickness composed of three bands, the inner differing from the outer enclosing portions.

The outer portions next to the walls have a jet black color and brilliant luster, with eminent cleavage in two directions perpendicular to the walls, causing the substance to break into short prisms. The fracture across, or in the plane parallel with the walls, is flat conchoidal. The color of the streak on porcelain is brownish black, nearly quite black. This portion, as well as the inner, is very friable, causing the production of fine powder on handling.

The inner portion has a dark steel gray color, and resinous luster in part, and in part is dull. This dead-looking inner portion contrasts strikingly with the brilliant outer portion. Its structure in the mass is irregularly and coarsely prismatic, while its intimate structure is finely flat fibrous, intermixed with very small plates, similar in appearance to the outer portion. The change in color and luster of the inner portion seems mainly due to the greater fineness of the texture, though there may be some difference in chemical constitution. As stated, this inner portion seems in its thickness to be more independent of the width of the crevice than the outer portion; for when the mass is reduced to a thickness of 8 inches, this is still 5 inches thick, while it is never more than about 18 inches, even in the most massive portions of the deposit.

The same arrangement of these two varieties of the mineral is seen around the "horses," or fragments of the walls, which have fallen into the mineral, and then become imbedded. We always find a thickness of several inches of the brilliant black portion in contact with the "horse." This seems to show that this modification of the mineral is a species of crystallization, produced next to the cooling or evaporating surface.

These imbedded fragments are always colored throughout their mass a dark gray, from impregnation with bituminous matter. The original color is nearly white. Singular to say, the enclosing walls show this discoloration hardly ever to the depth of an inch. The mineral adheres slightly to the rock, and may be removed with the fingers. It presents much such an appearance as tar would, when hardening in contact with stone, while assuming a prismatic structure.

No "strings," or "feeders," of the main crevice are to be seen, nor does the mineral penetrate at all the shaly partings or crevices along the bedding of the strata, while it insinuates itself into quite small openings running in the direction of the cleft. These paper-like seams are sometimes found between the wall and a loosened fragment. This behavior is very remarkable, and would seem to forbid the idea that the substance could have been very fluid or subjected to much pressure vertically; while it may have been forced along *a tergo.*

Some of these peculiar features may be explained by the following assumptions.

We may suppose an open crevice formed, and then filled by the inflowing of a semi-fluid bituminous compound, which hardened rapidly on coming in contact with the porous sandstone walls. Its fluidity may have been due to the presence of a vaporizable liquid, like naphtha, which could easily penetrate the sandstone walls, thus causing the seeming crystalline structure on the outer portions, and the lack of discoloration of the rock. This evaporating fluid may have met with more obstruction in passing through a stratum of bituminous matter, and hence the present impregnation by it of enclosed fragments of rocks, and hence also the imperfect development of structure in the inner mass.

If this be true, the inner portion should be richer in volatile matter, but so far as I know, no comparison has been made. At least, we know that there do exist heavy oils having nearly the character of our assumed liquid.

I know of but one analysis of the mineral, that by Prof. Wurtz. I am informed that this has been verified, in the main, by subsequent ones. This is as follows: Sp. gr. 1·145. Composition: C 76·45, H 7·83, O 13·46, Ash 2·26, traces of S and N. For the behavior of the mineral with solvents and heat, the article in Dana's Mineralogy, on Grahamite, may be consulted.

It yields theoretically 140 gallons of oil per ton; practically, about 100 may be secured. The fine dust produced by handling the mineral is capable, when very dry, of inflaming from an open lamp. This has led to two accidents from explosion. The dry dust having caught fire in the lower levels, the gasous products became mixed with air in the upper works and exploded.

The facts obtained by me in my examination of this interesting deposit are the more trustworthy and general, from the information afforded me by the intelligent superintendent of the mines, Major Glenn. This gentleman is an accomplished civil engineer, and his training as such caused him to study closely every feature of the deposit, thus enabling him to furnish me with a mass of details which I could not otherwise have obtained.

Morgantown, West Virginia, Oct. 14.

ART. XLVI.—*On the Magnetic Permeability* and the Maximum of Magnetism of Iron, Steel, and Nickel*; by HENRY A. ROWLAND, C.E., Instructor in Physics in the Rensselaer Polytechnic Institute, Troy, N. Y.†

IN all mathematical theories of induced magnetization a quantity is introduced depending upon the magnetic properties of the substance, and without a knowledge of which the problem is of little but theoretical interest; this quantity has always been treated as a constant, although the known existence of the maximum of magnetization showed it to be otherwise: the reason of this may perhaps be traced to a formula which Müller has given to represent the magnetization of an electromagnet, and to the extreme difficulty of treating the subject in any other way. These quantities as used by different persons are as follows:—

k, Neumann's coefficient, or magnetic susceptibility (Thomson).
K, Poisson's coefficient.
μ, coefficient of magnetization (Maxwell), or magnetic permeability (Thomson).

The relations of these quantities are given by the following equations:—

$$k=\frac{4\pi\mathrm{K}}{4\pi\mathrm{K}+3}=\frac{\mu-1}{\mu+2}$$

$$\mathrm{K}=\frac{\mu-1}{4\pi}=\frac{3k}{4\pi(1-k)}$$

$$\mu=\frac{1+2k}{1-k}=4\pi\mathrm{K}+1.$$

Very few determinations of any of these quantities have been made in the case of iron and none in the case of steel,

---

* This word "permeability" has been proposed by Sir. William Thomson to replace "conductivity" as used by Faraday. (Thomson's "Papers on Electrostatics and Magnetism" p. 484. Maxwell's "Electricity and Magnetism," p. 51.)

† Abstract of a paper in the Philosophical Magazine, August, 1873, prepared for this Journal by the Author.

nickel, and cobalt; neither has the form of the function by which these quantities are connected with the degree of magnetization been attempted, except so far as we may consider the erroneous formula of Müller, above referred to, as such an attempt.*

In a preliminary experiment to determine on the mode of experiment to be adopted, it was shown that the distribution of magnetization in an electromagnet varied with the strength of the exciting current, so that no arrangement to measure the magnetization of the bar which is based on the deflection of a compass needle can give correct results. This has been theoretically anticipated by Sir W. Thomson.†

I believe mine are the first experiments hitherto made on this subject in which the results are expressed and the reasoning carried out in the language of Faraday's theory of lines of magnetic force. That my choice is a proper one and my results correct needs no further proof than that given in Prof. J. Clerk Maxwell's "Treatise on Electricity and Magnetism," where this theory is thoroughly worked out and shown to give exactly the same results as the older theories, where the action is assumed to take place at a distance without intervening matter. I believe there are great things in store for this theory, and its excellent working qualities are shown in the method of measuring magnetism in absolute measure adopted, for which I claim that it is the most simple and accurate of any yet devised, and which was suggested to me while thinking of the matter according to this theory.

The absolute units to which I have reduced my results are those in which the meter, gram, and second, are the fundamental units. The unit of magnetizing force of helix I have taken as that of one turn of wire carrying the unit current per meter of length, and is 4π times that of the unit magnetic field. The magnetizing force of any helix is reduced to this unit by multiplying the strength of current in absolute units by the number of coils in the helix per meter of length. These remarks apply only to endless solenoids and to those which are very long compared with their diameter. The unit of number of lines of force I have taken as the number in one square meter of a unit field measured perpendicular to their direction.

In working out the theory of the operation, at first I used an equation which I obtained some time ago for the distribution of magnetism on a bar or ring magnet, but as I cannot here go through with the process of getting the equations, I will give the following method. If n is the number of coils per meter

---

* I do not include here the theoretical formulæ of Weber and Maxwell, as they lack the test of experiment.

† Papers on Electrostatics and Magnetism, p. 512.

of helix and n' the total number on a ring magnet, i the strength of current, and ρ the distance from the axis of the ring to any point in the interior of the ring-solenoid, the magnetic field at that point will be* $2n'i\frac{1}{\rho}$, and at a point within an infinitely long solenoid $4\pi in$. If the solenoid contain any magnetic material of magnetic permeability μ, the field will be for the ring $2n'i\frac{\mu}{\rho}$ and for the infinite solenoid $4\pi\mu in$.

Therefore the number of lines of force in the whole section of a ring-magnet of circular section will be, if a is the mean radius of the ring,

$$Q'=4n'i\mu\int_{-R}^{+R}\frac{\sqrt{R^2-x^2}}{a-x}=4\pi n'i\mu(a-\sqrt{a^2-R^2}),$$

or since $n'=2\pi an$ and M, the magnetizing force of helix, $=in$, we have, by developing

$$Q'=4\pi M\mu(\pi R^2)\left(1+\frac{1}{4}\frac{R^2}{a^2}+\frac{1}{8}\frac{R^4}{a^4}+\&c.\right)$$

For the infinite electromagnet we have in the same way

$$Q'=4\pi M\mu(\pi R^2).$$

When the section of the ring is thin, these two equations become the same and either gives

$$\mu=\frac{Q'}{4\pi M(\pi R^2)},$$

from which the value of μ can be found when we have simultaneous values of Q′ and M in absolute measure.

The apparatus to measure Q′ was based upon the fact discovered by Faraday, that the current induced in a closed circuit is proportional to the number of lines of force cut by the wire. For measuring the induced currents a modified form of Thomson's galvanometer was used: the mirror was quite large and the needle loaded to make it vibrate slowly: the needle was astatic to prevent external magnetic forces from affecting it, and sufficient directive force was given by a magnet above: the deflections were read by a telescope and scale.

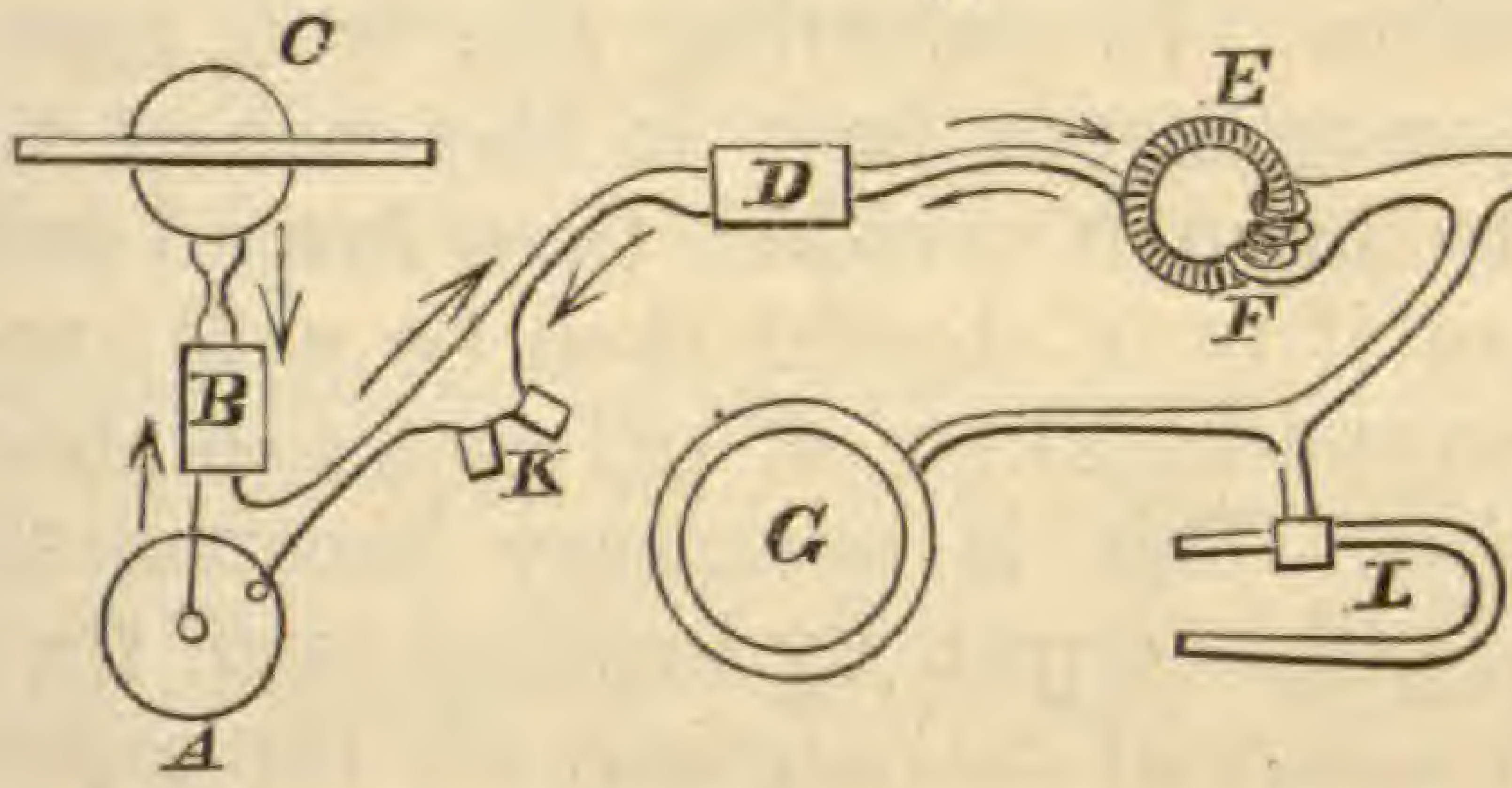
To measure M a tangent-galvanometer was used, but as I wished to measure currents varying in strength several hundred times, several coils were used and connected with binding screws, so that from one to forty-eight turns could be placed in the circuit at pleasure. The value of each coil in producing deflections was experimentally determined by a method which I shall soon publish.

---

* Maxwell's Treatise on Electricity and Magnetism, vol. ii, p. 284.

The magnetizing current made its circuit in the following manner (see fig. 1). The current from the battery A passed to a commutator B, thence to the tangent-galvanometer C, thence to another commutator D, thence around the magnet E (either a ring or a very long bar magnet): in returning it passed through some resistance coils K, by which its strength could be varied, and thence back to the battery. The induced circuit by which the magnetism of the magnet was to be measured included the following: a coil of wire F around the magnet, a large coil of wire G, the Thomson galvanometer H, and a small coil of wire sliding on one branch of a horseshoe magnet L: by sliding the latter back and forth, induced currents could be sent through the wire by which the needle could be brought quickly to rest. The theory of measuring Q′ is as follows. When the current through the magnet E is reversed by the commutator D, a current is induced in the coil F surrounding the magnet due to twice cutting the lines of force passing through the magnet and giving a deflection to the needle of h scale divisions. Now when the coil G, placed on a horizontal surface, is turned over, an induced current is produced due to twice cutting the lines of force which pass through the coil from the magnetism of the earth and giving a deflection to the needle of c units. The induced current in either case is proportional to the number of turns in the helices F or G and to the number of lines of force cut by those helices. It is evident then that the number of lines of force passing through the magnet in the unit we have chosen will be given by

1.



$$Q' = 2n'(6{\cdot}27 \sin 74^\circ\ 50')\pi R_1^2 \frac{h}{2nc},$$

where n' is the number of coils in the ring G, n the number in the helix F, R_1 the radius of G, 6·27 the total magnetism of the earth at this place (meter, gram, second, system), and 74° 50′ the dip. The quantity $2n'(6{\cdot}27 \sin 70^\circ\ 50')\pi R_1^2$ is a constant for the coil and had a value of 14·51.

As a test of the whole arrangement, I have obtained the number of lines of force in a very long solenoid: the mean of two solenoids gave me $Q' = 12{\cdot}67\ M(\pi R^2)$, while from theory we obtain $Q' = 12{\cdot}57\ M(\pi R^2)$, which is within the limits of error in measuring the diameters of the solenoids. &c.

All the rings and bars with which I have experimented have had a circular section. In selecting the iron, care must be used to obtain a homogeneous bar: in the case of a ring I believe it is better to have it welded than forged solid; to get the greatest permeability it should then be well annealed and *afterward* have the outside taken off *all round* to about $\frac{1}{8}$ of an inch deep in a lathe. This is necessary because the iron is "burnt" to a considerable depth by heating even for a moment to a red heat, and a sort of tail appears on the curve showing the permeability which is not normal. To get the normal curve of permeability, the ring must only be used once; and then no more current must be allowed to pass through the helix than that with which we are experimenting at the time. If by accident a stronger current passes, permanent magnetism is given to the ring, which entirely changes the first half of the curve.

In the following tables $Q = \dfrac{Q'}{\text{area of section}}$ has been measured as previously described. It is evident that if, instead of reversing the current, we simply break it, we shall obtain a deflection due to the temporary magnetization alone. In this manner the temporary magnetization has been measured; and on subtracting this from Q we can obtain the permanent or residual magnetization.

The following abbreviations are made use of in the tables, the other quantities being the same as previously described.

C.T.G. Number of coils of tangent-galvanometer used.
D.T.G. Deflection of tangent galvanometer.
D.B. Deflection from helix on breaking current.
Q. Magnetic field in interior of bar (total).
T. " " of bar due to temporary magnetization.
P. " " " " " permanent "

$$Q = T + P.$$

Each observation given is almost always the mean of several. D.T.G. is the mean of four readings, two before and two after the observations for Q′ and T.; D.C. is the mean of from four to ten readings; D.F. mean of three; D.B. mean of two except in table I, where the deflection was read only once. In all the tables the column containing the temporary magnetization, T, can only be accepted as approximate, the experiments having been made more to determine Q than T.

The value of *n* was generally varied by coiling a wire more or less times around the ring, but leaving its length the same.

The change in the value of D.C. is due to change in the resistance of the circuit from change of temperature.

The following tables contain some of my results, the first two being from the same ring.

TABLE I.—"*Burden Best*" *Iron, Normal.*

C.T.G.	D.T.G.	M.	C.	n.	h.	$\frac{h}{2n}$	$\frac{\text{D.B.}}{n}$	Q.	μ.	μ. calculated.	T.
48	4°·5	·1456	23·4	30	6·5	·1083	·08	714·7	390·7	465.2	528·
"	16°·45	·5501			54·6	·910	·59	6005·	868·7	866·2	3894·
"	20°·2	·6815			87·9	1·465	·80	9667·	1129·	1120·	5280·
"	28°·6	1·011	23·3	10	74·2	3·71	1·34	24600·	1936·	1910·	8882·
"	31°·1	1·119			88·2	4·41	1·48	29230·	2078·	2073·	9811·
"	31°·9	1·155			92·6	4·63	1·53	30820·	2124·	2122·	10180·
"	41°·12	1·623		2	29·8	7·45	2·00	49590·	2433·	2446·	13310·
27	28°·35	1·766	23·1		32·8	8·20	2·50	54820·	2470·	2471·	16710·
"	29°·6	1·861			34·6	8·65	2·65	57820·	2472·	2475·	17710·
"	33°·4	2·162	23·1		39·8	9·95	2·85	66510·	2448·	2449·	19050·
"	37°·45	2·512			44·7	11·18	3·05	74730·	2367·	2382·	20·390
"	44°·45	3·223			53·5	13·38	3·85	89430·	2208·	2180·	25740·
9	52°·10	4·225			60·3	15·08	4·85	100800·	1899·	1968·	32420·
"	34°·65	6·744			73·1	18·28	7·10	122700·	1448·	1465·	47680·
"	39°·8	8·136	23.0		77·3	19·32	7·90	129700·	1269·	1284·	53040·
"	44°·3	9·542		1	40·6	20·30	9·10	136300·	1137·	1108·	61100·
"	55°·10	14 04			43·5	21·75	9·8	145400·	824·1	856·3	65510·
3	42°·95	27·18			47·4	23·70	11·5	157700·	461·8	505·3	76540·
"	51°·30	36 60			49·1	24·55	12·7	162700·	353·8	359·9	84180·
"	60°·15	51·18	23·4		50·3	25·15	13·2	166000·	258·0	263·4	87120·
								175000·		0	

TABLE II.—"*Burden Best*" *Iron, Magnetic.*

M.	Q.	μ.	M.	Q.	μ.
·1456	426	232·	2·930	82720·	2247·
·5699	3346	476·	4·210	100900·	1906·
·6962	5700	652·	6·769	122800·	1444·
1·080	24350	1795·	7·273	124300·	1360·
1·191	29280	1956·	7·626	127100·	1326·
1·537	46150·	2389·	11·10	139500.	1000·
1·590	49070	2408·	13·61	144700.	846·
1·933	59680	2456·	22·10	154600.	554·
2·377	71660	2399·			

TABLE III.—*Bessemer Steel, Normal.*

M.	Q.	μ.	T.	M.	Q.	μ.	T.
·1356	327·	192·	309·	2·756	39960·	1154·	13080·
·2793	817·	238·	727·	3·219	50550·	1250·	16350·
·5287	1726·	260·	1471·	3·551	56310·	1262·	15980·
·9398	3833·	325·	3106·	4·469	71380·	1271·	18340·
1·421	7702·	431·	5576·	5·698	85530·	1195·	23610·
1·880	14080·	596·	8972·	11·44	119550·	832·	28020·
1·947	15420·	630·	8938·	20·69	138300·	532·	41360·
2·300	24830·	859·	11320·	38·99	153700·	314·	52930·

TABLE IV.—*Norway Iron, Magnetic.*

M.	Q.	μ.	T.	M.	Q.	μ.	T.
·1344	865·	512·		2·290	105900·	3680·	35240·
·2673	2550·	759·	1892·	4·393	134100·	2429·	54970·
·5161	13000·	2005·	5857·	5·910	142400·	1917·	62810·
·5572	15310·	2187·	8110·	7·874	149100·	1507·	68490·
·6725	30140·	3567·	8921·	13·77	156800·	906·	77060·
·9305	53800·	4602·	13970·	26·84	165800·	480·	84710·
1·362	77700·	4545·	21630·	36·86	168500·	364·	87860·
1·788	93000·	4140·	28200·				

TABLE V.—*Cast Nickel, Normal.*

M.	Q.	μ.	T.	M.	Q.	μ.	T.
1·433	852·	47·4		13·43	27100·	160·6	11260·
2·904	2377·	65·1		16·53	31050·	149·5	13530·
3·527	3685·	85·1		21·02	34950·	132·3	16480·
5·555	10080·	144·4		32·17	41980·	103·8	22300·
6·783	13680·	160·5	5120·	33·92	42650·	100·0	23360·
7·401	15270·	164·2	5614·	60·91	50860·	66·4	29540·
9·273	19600·	168·2	7644·	82·36	53650·	51·8	33460·
11·78	24720·	167·0	9902·	105·2	55230·	41·8	35120·

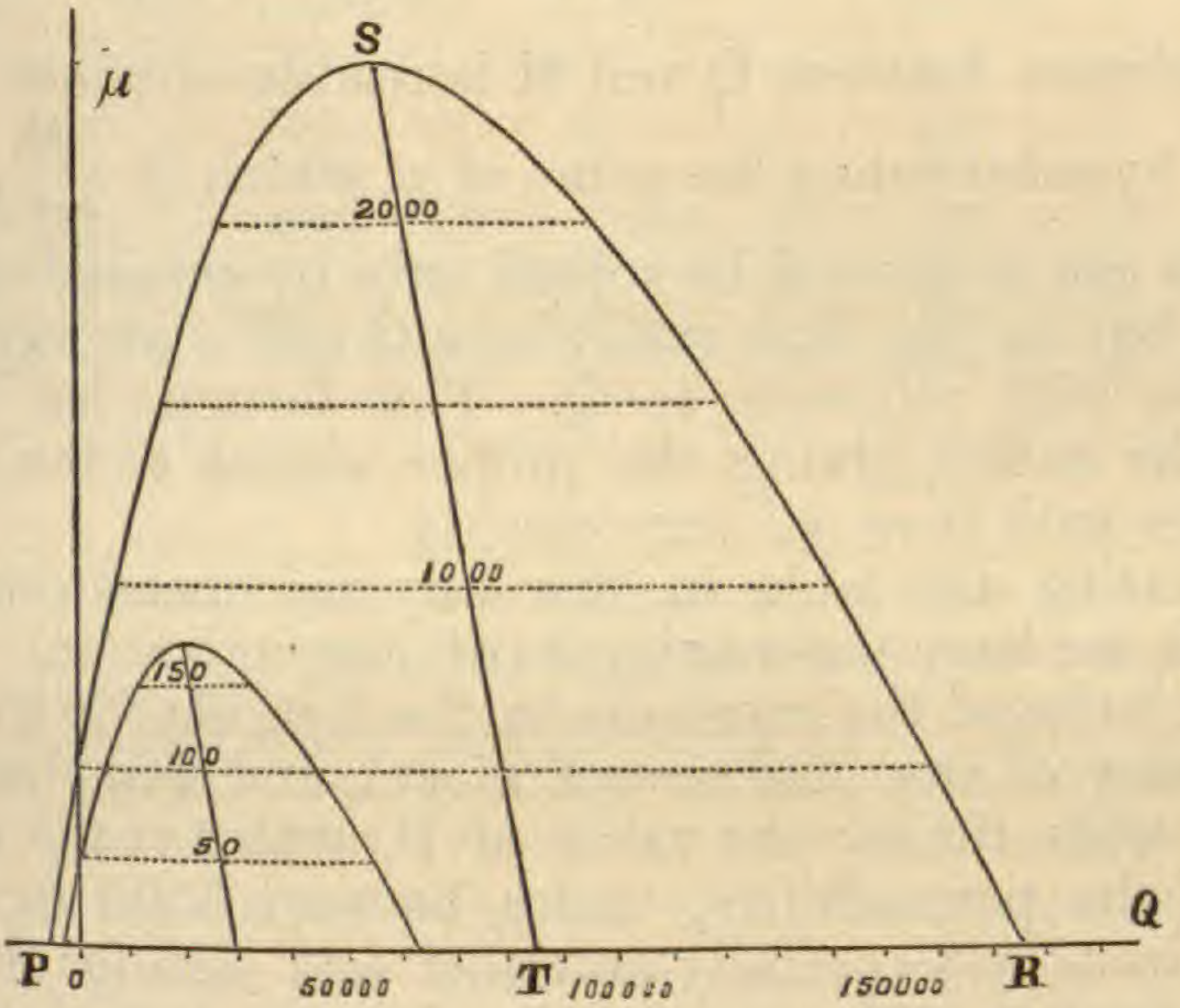
TABLE VI.—*Stubs' Steel Wire, Normal.*

M.	Q.	μ.	T.	M.	Q.	μ.	T.
·1673	159·	75·9		13·65	54300·	316·6	20900·
·6237	678·	86·5	598·	19·35	77770·	319·9	29480·
1·084	1197·	87·9	1101·	27·43	100800·	292·6	38590·
2·043	2448·	95·4	2257·	33·39	111300·	265·4	45110·
2·714	3446·	101·0	3095·	35·58	115000·	256·9	45950·
4·221	6278·	118·4	5145·	38·64	119400·	246·0	48060·
10·26	33700·	261·5	16170·				

The best method of studying these tables is to plot them: there are several ways in which this can be done, but the two best are as follows. The first is to take the value of M as the abscissa and the value of Q, T, or P, as the ordinate, thus obtaining curves showing the variation of the total, temporary, and residual magnetization with the magnetizing force. Müller, from his experiments on iron bars, has deduced a formula to represent this curve for Q, but it fails entirely for weak magnetizing forces even when applied to his own experiments, and when applied to mine it widely diverges from experiment.

Weber and Maxwell* have obtained equations from the theory that the particles of a body are magnetic and merely turn round when the magnetizing force is applied which represent these actions to some extent, but not so closely as might be desired. However it is probable that the theory might be so modified as to agree with experiment.

2.



The second method of studying the tables is to plot them with the values of Q as abscissas and μ as ordinates. In this way we obtain a curve which has some remarkable properties and which has the advantage over the other kind inasmuch as it is of finite dimensions and from it we can obtain the maximum of magnetization easily by a simple measurement. In the figure 2 have given plots of tables I and V, the larger being the curve of iron and the smaller of nickel, the horizontal scale of both being the same, but the vertical scale of nickel being several times larger than that of iron. On plotting a table in this way and then drawing lines across the curve parallel to the axis of Q and bisecting them we notice the strange fact that the center points always fall very exactly on a straight line, which is therefore a diameter of the curve. All the substances which I have tried, steel, iron and nickel, obey this law, and I hope soon to make it general by experiments on cobalt. I have obtained an empirical equation to express this curve, which is of the form

$$\mu = \mathrm{B} \sin\left(\frac{\mathrm{Q}+b\mu+\mathrm{H}}{\mathrm{D}}\right),$$

in which B, H, D, and b, are constants depending on the kin and quality of the metal used. B is the maximum value of

---

* Treatise on Electricity and Magnetism, Arts. 443–4–5.

and gives the height of the curve (see figure); b establishes the inclination of the diameter TS; H is the line P o and D depends upon the distance PR. The following equation, adapted to degrees and fractions of a degree, is the equation from which the values of μ in table I were calculated:

$$\mu = 2475\cdot \sin\left(\frac{Q + 10{\cdot}94\,\mu + 5000}{1000\cdot}\right).$$

The relation between Q and M is readily obtained from this equation by substituting the value of μ, which is $\frac{Q}{4\,\pi\,M.}$ These equations can in general be solved only by successive approximations, but in the first case where Q and μ are involved, we may solve with reference to Q. This formula has been tried for all the tables, giving the proper values to the constants, and agrees with them all very exactly.

On plotting any table in this way and measuring the distance o R, we have the maximum of magnetization.

I have deduced the constants in the formula for no less than twelve cases of iron and two of nickel, and find them to vary between wide limits: the value of B, which is the maximum value of the permeability, varies between 5500 for the best Norway iron very carefully annealed and 330 for Stubs' steel of such temper as the wire is when bought, but of course this would be much less for hardened steel.

I have also obtained the maximum value of Q in many cases, and find it for good, but not pure, iron to be about 175,000 and for nickel 63,000; that is, the magnetization of iron can never exceed 175,000 times the unit magnetic field on the meter, gram, second, system, neither can nickel exceed 63,000 times. These can be reduced to the magnetic moment of a unit of volume by dividing by 4π and subtracting 1; they then become 13,920 and 5010 nearly.

We can also deduce from these quantities the greatest weight which an electro-magnet can sustain. Prof. Maxwell has given * a formula for the tension of the lines of force per square meter of section, which is $\frac{Q^2}{8\pi}$ absolute units of force, or

$$\frac{Q^2}{173\,240\,000} \text{ lbs. per sq. in.}$$

which gives 177 for $Q = 175{,}000$ and 22·9 for $Q = 63{,}000$. Hence we may conclude that the greatest weight which can be sustained by an electro-magnet with an infinite current is for iron 354lbs. per square inch of section, and for nickel 46 lbs.

---

* **Treatise on Electricity and Magnetism, vol. ii, p. 256.**

It is, of course, independent of the length of the iron bar forming the magnet and depends only on the section.

Joule* has made many experiments on the maximum sustaining-power of magnets, and has collected the following table, which I give complete, except that I have replaced the result with his large magnet by one obtained later.

Magnet belonging to		Least area of section in sq. inches.	Weight sustained in lbs.	Weight sustained ÷ least area.	Q.
Mr. Joule,	1	10·00	2775·	277.	154700
	2	·196	49·	250·	147000
	3	·0436	12·	275·	154100
	4	·0012	·202	162·	118300
Mr. Nesbit,		4·5	1428·	317·	165500
Prof. Henry,		3·94	750·	190·	128200
Mr. Sturgeon,		·196	50·	255·	148500

It is seen that these are all below my estimate, as they should be. For comparison, I have added a column giving the values of Q, which would give the sustaining power observed: it is seen that they range about as high as those that I have *actually* obtained, thus giving an experimental proof that my estimate of 354 lbs. cannot be far from correct, and illustrating the beauty of the absolute system of electrical measurement by which, from the simple deflection of a galvanometer-needle, we are able to predict how much an electro-magnet will sustain without actually trying the experiment. The experiments also give the data for other calculations of great interest.

I have in this paper confined myself principally to the discussion of Q, but I hope at some future time to resume the discussion of the results as obtained for T and P.†

---

* Phil. Mag., 1851.

† In order to facilitate the reduction of my units to others, I here give the relation between the letters used by me and those used in Prof. Maxwell's Treatise on Electricity and Magnetism.

Q in this paper = $\mathfrak{B}$ (Maxwell) = magnetic induction. Art. 605.
Q' " " = $\mathfrak{Q}$ " = surface integral of magnetic induction. Art. 402.
$4\pi M$ " " = $\mathfrak{H}$ " = magnetic force. Art. 605.
$\frac{Q}{4\pi}-1$ " " = $\mathfrak{I}$ " = intensity of magnetization. Art. 605.

μ, k, and κ, are the same as in Maxwell's Treatise.

I have throughout spoken of lines of force, &c. in the sense used by Faraday; for a note on the interpretation of these terms see Maxwell's Treatise on Electricity and Magnetism, Art. 404.

ART. XLVII.—*On the Geology of Western Wyoming;* by THEO. B. COMSTOCK, B.S., Geologist of the Northwestern Wyoming Expedition, 1873.

THE Northwestern Wyoming expedition sent out in June last, by General Ord, charged with the exploration of the head-waters of the several rivers having their sources in the north-western corner of Wyoming Territory, having returned from the work in the field, it is proper to make known, in a general way, the results of their explorations. The work of preparing the reports for publication has already begun, but it will require several months for the complete elaboration of the material collected for study.

It is proposed, in this paper, to give a simple resumé of the results of the field labors of the writer, with such references to the general results of the expedition as may be necessary by way of explanation. It will be distinctly understood, however, that the writer is alone responsible for all statements herein made concerning the labors of others as well as his own.

The working corps was organized as follows:

Captain W. A. JONES, U. S. Engineers, Commander.
2d Lieut. S. E. BLUNT, 13th U. S. Infantry, Astronomer.
Dr. HEISMAN, Ass't Surgeon, U. S. Army, Surgeon.
Dr. C. C. PARRY, Botanist and Meteorologist.
Prof. THEO. B. COMSTOCK, Geologist.
LOUIS VON FROBEN, Chief Topographer.
GEORGE C. HITT, Assistant to the Astronomer.
J. D. PUTNAM, Assistant to the Meteorologist.
PAUL LE HARDY, FRED. W. BOND, CECIL GABBETT, Assistants to the Topographer.
CHAS. T. CREARY, FRED. MILLARD, GEORGE JEWETT, General Assistants.

The members of the expedition left Omaha, June 2d, 1873, proceeding, via Union Pacific Railroad, to Fort Bridger, Wyoming Territory, at which point the labors of the scientific corps were begun. While awaiting preparations to move, I visited the Uintah Mts., in order to obtain some idea of the great Tertiary Lake basin through which we were intending to pass on our march northward,* and, if possible, to make the ascent of Gilbert's Peak. Mr. J. D. Putnam accompanied me with a mercurial barometer. With great difficulty we succeeded in reaching Henry's Fork, but found it impassable, running a perfect torrent, and so rapidly rising from the melting of the snow that we were driven out of the narrow valley by the overflow. The sections exposed, however, were sufficient to show the structure of this rim (the southern) of the Green River basin, which is not materially different from that of the Rocky Mountain

---

* See paper by Prof. O. C. Marsh, "On the Geology of the Eastern Uintah Mts." Amer. Jour. Science, III, vol. i, March, 1871.

system in general, except that the rocks of Mesozoic age cover the older formations to a greater extent than common. Overlying these, with a very slight dip, and jutting against the northern slope of the Uintahs, are the immense fresh water Tertiary deposits, now eroded to an almost incredible extent over the whole basin, which has an area of over 20,000 square miles. The junction of these beds with the older deposits is much obscured by an accumulation of drift material, but at several points along Henry's Fork of Green River, rocks underlying conformably the red sandstones, which I have referred to the Mesozoic, are seen.* The surface Tertiary beds of the southern and western portion of the basin appear to belong to Hayden's "Bridger Group," of Upper Miocene age,† being composed of dull-colored clays with beds of sandstones of considerable thickness, usually brownish, or dull yellow or gray, and having more or less of a concretionary structure.

Upon our return to Fort Bridger, the train moved northeast through South Pass to Camp Stambaugh. Along our route the Bridger group is exposed at the surface over a considerable extent of country northward and eastward from Fort Bridger, as far as Little Sandy Creek and beyond, forming the top layers of numerous isolated "buttes,"‡ giving them, when the clays predominate, the so-called *grizzly* aspect alluded to by Prof. Marsh.§ It is impossible, without more extended study, to *define* the lower limit of the Bridger group, but it passes gradually into a series of marls and limestones containing quantities of the remains of fresh water forms of life, with laminated layers literally filled with the remains of land plants. The famous "petrified fish bed," well exposed near Green River station, Union Pacific Railroad, belongs to this group, which, following Hayden, is called the Green River group. The buttes of this formation not crowned by a considerable thickness of the beds of the Bridger group, have not the grizzly appearance of the latter beds. The Green River beds are of Lower Miocene age,

---

* The red sandstones which I here refer to the Mesozoic are regarded by Marsh as of Cretaceous age, from the fact that "they have below them, farther down the stream, calcareous beds containing undoubted Jurassic fossils." (Marsh, this Journal, vol. i, March, 1871, p. 3.) The rocks which I noticed below the red sandstones are mainly laminated shales, abundantly ripple-marked, but containing no fossils that I was able to detect.

† "Geol. Survey of Wyoming," etc., by F. V. Hayden, 1870: Washington, 1872, pp. 55, 58.

‡ The term "butte" is used indiscriminately in the west to designate *all* isolated hillocks or eminences standing out prominently in the topography of a country, if the breadth does not exceed the height. In this paper, its use is restricted to *hills of erosion* in stratified rocks.

§ Those *buttes* which are largely composed of indurated clays are scored by numerous water channels or gullies, which run down their sides in a branching and radiating manner, causing, at a little distance, that peculiar shaggy appearance which has given them the name of "Grizzly Buttes."

and overlie conformably a thick deposit of sandstones and arenaceous rocks, which, though varying sufficiently to admit of division into minor groups, are best considered here under the comprehensive name of Eocene. Careful notes and collections have been made, which will enable me to classify these beds.

On the western slope of the Wind River Mountains, near South Pass, no signs of strata older than the Tertiary were discovered, but the evidence of powerful glacial action is abundant. Several comparatively low ridges or folds in the metamorphic rocks are passed over before reaching the main divide or axis of the range, beyond which the original structure is very largely obliterated by various kinds of erosion, and the filling in of the gravels and finer material of the drift. In the metamorphic schists and gneissoid slates of the Wind River Mountain nucleus, occur the auriferous quartz veins of the Sweetwater mines. Several days were spent in company with Capt. Jones in a somewhat detailed survey of the various mines in this vicinity, including a study of the veins in the neighborhood of Miner's Delight, beyond Camp Stambaugh. The gold of this region occurs in thick veins of impure quartz, associated with considerable silver, and more or less of iron pyrites. The greater portion is disseminated through the vein rock, but it not unfrequently is found native in cavities in the quartz, in fair sized nuggets.

From Camp Stambaugh the route lay northwest along the eastern base of the Wind River Mountains, as far as Camp Brown on the Little Wind River, thence across the Wind River Valley, over the Owl Creek Mountains, and across the valley of Owl Creek above the junction of its forks.

The geology of the eastern slope of the Wind River Mountains is quite simple, affording many fine sections exposing representatives of all of the great groups of sedimentary rocks, from the Silurian to the Cretaceous inclusive, conformable to each other, and dipping away from the underlying metamorphic rocks at an angle of 20°. On one of my trips into these mountains I discovered limestone strata of Silurian age, containing remains of Trilobites and Corals not yet determined, but which for the present I refer to the Potsdam Period. The Devonian strata are best represented by the Oriskany sandstone, containing quite abundant remains of *Spirifer arenosus*. The rocks belonging to the Carboniferous age would seem to be almost wholly Subcarboniferous, containing *Orthis Michelini*, *Lithostrotion Canadense*, a *Chonetes*, and a species of *Poteriocrinus?*. Other fossils collected, but undetermined, may prove the existence of later Carboniferous strata, however.

A problem of no little difficulty is the definition of the lines of junction of the Triassic with the Jurassic, and the Jurassic with the Cretaceous. It is sufficient, however, for our present purpose, to state that the Triassic beds are represented by thick deposits of bright red sandstones, which are overlaid by lighter, or buff-colored sandstones of Jurassic age, and these again by sandstones and shales, with interstratified brown lignite beds, and occasional seams of coal, which, I cannot doubt, are of Cretaceous age.* Special attention has been given to this question, and it is hoped that ample material has been collected for its solution.

An interesting and peculiar fold in the sedimentary strata, making a parallel ridge to the mountains, causes a kind of trough to be formed, with a double exposure of the Mesozoic beds, thus greatly aiding human industry by bringing to the surface again the valuable deposits of gypsum, which occur abundantly in the Triassic rocks, as well as the more or less valuable coal deposits before alluded to. To this folding of the strata may also be traced another economically important result to this highly favored section. I refer to the existence of hot and cold sulphur springs, and oil springs producing by evaporation a valuable asphaltum. I shall have more to say of this and other features of the Wind River Valley on some future occasion.

Fine exposures of the Jurassic and Cretaceous rocks are seen in the outlying ridges of the Owl Creek Mountain system, with numerous fossils. A species of the Lamellibranch genus *Gryphæa* is remarkably abundant in the Jurassic limestones, which are here nearly vertical.

The fresh water Tertiary beds jut against the older deposits almost exactly as those of the Green River basin overlie the red sandstones of the Uintah Mountains, and like them they are nearly horizontal. In composition, they are buff sandstones and conglomerates, with a few beds of marls and limestones; the irregular but excessive erosion to which they have been subjected has left them so poorly exposed along our route as to make their study quite difficult. Enough material has, however, been gathered to determine their age, and probably to divide these beds into groups. I can only say at present, that the evidence seems to point toward a division of the series into at least two groups, the latter being characterized by the occurrence of shore deposits of soft sandstones and conglomerates in beds of considerable thickness, which contain scarcely any fossils, and which it may not be hazardous to regard as Upper Eocene. The upper group would then be made to include a considerable thickness of interstratified marls and laminated calcareous beds rich in the remains of land plants, apparently of Lower Miocene age.

* Dr. Hayden, "Geol. Surv. of Wyoming," 1870; "Geol. Surv. of Montana," 1871, refers coal beds of the same horizon to the "Lower Tertiary or Upper Cretaceous."

The metamorphic nucleus of the Owl Creek range is not well exposed, being covered, except in a few isolated localities, by the early sedimentary rocks.

Continuing our march, we crossed the three forks of Owl Creek, passing through an excessively rugged country, affording numerous exposures of the various sedimentary strata, as well as interesting studies in dynamical geology. I can scarcely imagine a more favorable locality for the study of surface geology than this section between the Owl Creek Mts. and the Stinking Water River. I have said nothing of the magnificent terraces, the enormous deposits of the drift, the cañons and gorges cut by the streams, nor of the no less interesting proofs of the power of the wind; and yet these are but the half of the agencies whose actions are here so plainly indicated.

From Grey Bull River to the Stinking Water Valley our course lay through a less rugged country until we reached an eminence which gave us a view of some of the minor tributaries of the South Fork, when we were obliged to descend by a very steep trail to the valley below. From this point our march was comparatively easy to the north branch of the South Fork, which we ascended to its source in the mountains east of Yellowstone Lake. Passing through a narrow pass in this range, we descended on the other side to the lake, then marched down the Yellowstone River to the bridge, and crossed, a portion of the party visiting the hot springs of Gardiner's River. From the bridge we passed up the river to the falls, from which point we struck across westward, over the divide to the East Fork of Madison River, thence through the Lower and Upper Geyser Basins of Firehole River. Ascending the Firehole River, we then crossed the divide to Yellowstone Lake at the Southwest extremity, following pretty closely its shore until we reached the Upper Yellowstone River, which we ascended to the "Two Ocean Water." This is a mountain stream which flows down into a little valley, where it curiously splits into two rivulets, which shed their water, the one into the Pacific Ocean by way of the Snake and Columbia Rivers, the other into the Gulf of Mexico via the Yellowstone, Missouri, and Mississippi. Descending for a short distance one of the tributaries of Snake River, our Indian guide *To-goh-te* led us through an easy pass to the head-waters of Wind River, down which we marched, returning to Camp Brown to disband.

The head-waters of the Stinking Water,* rising in the very

---

* It is to be regretted that many of the geographical names in the West are so often repeated, rendering it difficult to distinguish between localities, without tedious explanation. For instance, the names Muddy, Sandy, Clear, Dry, Sage,

rugged range of volcanic origin east of the Yellowstone Basin, have cut narrow cañons through this material for a distance of more than seventy-five miles, affording rare opportunities for the study of the effects of subterranean forces. The great mass of the range is made up of a volcanic breccia, with numerous dykes and veins of porphyrite, and hornblendic trachyte. This material in some places covers unconformably the underlying aqueous rocks, thus proving its age, as would seem probable, to be later than the Cretaceous. But there is evidence, again, which points to outflows at a much earlier date; and, while there are proofs of eruptions between the close of the Cretaceous and the deposition of the Pliocene beds, there is also conclusive evidence of the outpouring of igneous material upon these same beds of Pliocene age. I do not claim that I have been able to unravel the whole of this intricate problem, but I am confident that sufficient material has been collected for a more complete elucidation of this subject than it would have been possible to reach without a survey of the section traversed during the past summer. I am extremely loth to commit myself to any decided opinion, however, until I can make a more complete study of notes and specimens.

The minor volcanic phenomena of geysers, solfataras, and hot springs, so abundantly manifested within the area reserved for the National Park, have received their due share of attention, and a large quantity of material has been collected for study. This leads me to speak of another important branch of geology, too frequently overlooked, I think, in our surveys, and yet a department of the science, as interesting as it is important, i. e., chemical geology. Throughout the trip, I have taken special pains to observe, and collect as much material as possible in this department, and I believe that I have succeeded in obtaining much valuable information by this means, which would otherwise have escaped my notice. Some interesting facts concerning the formation of chalcedony and the moss agate, the deposition of the so-called "alkali," and the silicification of the immense quantities of "petrified" wood in this region, have thus been collected, besides a mass of material concerning the erosion and weathering of the rocks, and the forces affecting or affected by the physical geography of the country. One fact, which I consider of much importance, is the abundance of ozone in the atmosphere, to which I trace much of the external reddening of many of the yellow and brownish sandstones containing iron.

Cottonwood, Beaver, etc., are each used to designate several streams within a comparatively small area. It is therefore necessary to note that the Stinking Water River to which I refer in this paper, is the important tributary of the Big Horn (Lower Wind) River, by that name, and *not* the tributary of Jefferson River, which bears the same name.

The comparatively recent discoveries of immense deposits of coal in the Rocky Mountains makes the study of its modes of occurrence, its quality, and the conditions of its formation, a subject of great economic and scientific interest, which it is desired to present in the most satisfactory manner. For this purpose, specimens from all of the important outcrops along our route have been carefully obtained, and minutely recorded. Having some opportunities for observation and study of the language, manners and customs of Washakie's band of Shoshones or Snake Indians, I was enabled to collect also a few notes, which may serve, in a small way, to assist in preserving some records of their peculiarities, ere the onward march of civilization shall forever, by conquest or assimilation, destroy their *Indian* charateristics. All of these subjects, when properly elaborated, will be incorporated in my report to the chief of the expedition, to be given to the public in due time.

In conclusion, my thanks are due to each member of the party, including the officers of our escort (Company I, 2nd U. S. Calvary) and to the officers and others at Fort Bridger, Camps Stambaugh, Camp Brown and Fort Ellis, to whom I am indebted for kindnesses too numerous for recital.

Cherishing the hope that my humble labors in the cause of science may prove of some value to others, I leave this resumé in the hands of my fellow-workers for their verdict.

Cleveland, O., Oct. 25, 1873.

ART. XLVIII.—*The Number of Classes of Vertebrates and their Mutual Relations*; by Prof. THEODORE GILL.

(Abstract of a Communication to the National Academy of Sciences made Oct. 29, 1873.)

THE mind, untrained in scientific logic, in its generalizations respecting the animal kingdom, if we may judge by the vague ideas elicited by inquiry and by the history of science, instinctively associates its subjects into groups determined by the nature of their habitat; and hence we have had the vertebrates differentiated into (1) those especially adapted for progression on land (Quadrupeds); (2) those especially fitted for progression through the air (Birds); and (3) those adapted for life in the water (Fishes); while the residue, not readily combinable with either of those classes, are tacitly overlooked, or, as the Serpents, annexed as a kind of appendix to the Quadrupeds, because they most resemble certain of those animals—the lizards. It was, therefore, a great advance when Linnæus established a peculiar class (Mammalia) for the typical viviparous quadrupeds and the whales, and thus for the first time subordinated habitat and adaptation therefor to structure. While at the present day, the ancient ideas have almost entirely disappeared from the system of nature so far as regards the terrestrial vertebrates, they are still to a great extent prevalent in the appreciation of the relations of the aquatic ones. For those vertebrates confounded by most naturalists under the name of Fishes, are very dissimilar among themselves, and so much so even that the differences are more marked and radical than those between any of the superior classes of the branch. If, indeed, considerations of differences of structure are to guide us in the appreciation of the relations and subordination of animals, the current classification must be entirely changed, and the subordination of the highest groups, first suggested by Häckel, should be adopted with some modifications, while as respects the combination of the "higher" or more specialized classes into superior groups, other principles should guide. One of the chief points to be reconsidered is the association of the Batrachians with Fishes rather than with the true reptiles. Although no distinction may be possible between the first two when the class of Fishes has the wide range generally allowed, there is no difficulty in their discrimination with the limits here to be assigned to them. We may then group the classes as follows:

On the one hand is *Branchiostoma* or *Amphioxus*, distinguished by the extension of the notochord (which is, of course, persistent) to the anterior end of the vertebral column, the attenuation of the spinal cord forward and its simple structure, the absence of auditory organs, the simple tubular structure of the heart, and the development of the liver simply as a diverticulum of the intestine. This type is called by Häckel the *Subphylum Leptocardia* or *Acrania*.

On the other hand are all the other Vertebrates, which agree in the termination of the notochord behind the pituitary fossa, the enlargement of the spinal cord forward into a brain, the development of auditory organs, the division of the heart into (two to four) chambers, which in part (one or two) specially receive the blood, and in part (one or two) specially distribute it to the body again, and the differentiation of the liver as an independent and highly specialized organ. This group is named by Häckel the *Subphylum Pachycardia* or *Craniota*.

The numerous forms belonging to the last "subphylum" are also divisible into two great groups.

In one, the skull has no cincture girdling the mouth and consequently no lower jaw, there are no pectoral members or scapular girdle, and there is but one nasal sac, which has a median external aperture. To this section belong the Lampreys and Hags, the representatives of the class of *Marsipobranchs*.

In the other, the skull has a cincture surrounding the mouth, its inferior portion being specialized as a lower jaw; they have (archetypically at least) a pectoral member and a shoulder-girdle developed; and there are two nasal sacs, each having an olfactory nerve distributed to an external aperture. These Vertebrates are again divisible into three groups or superclasses.

1. In the first (*Lyrifera*) the shoulder-girdle forms a lyriform or furcular-shaped apparatus, the scapulæ and their adjuncts of both sides being connected together below along the median line, and an air bladder (sometimes lung-like) is attypically developed (sometimes, however, atrophied) and (1) either connects with the œsophagus by a single duct or (2) is entirely closed. To this superclass belong the classes of Fishes and Elasmobranchiates.

2. In the second (*Quadratifera*), the shoulder-girdle is represented by the scapulæ and their appendages, which are limited to the respective sides, a sternum is differentiated, and instead of an air bladder are two lungs, each with a special canal, which communicate with the pharynx. The lower jaw is compound and is articulated with the skull by the intervention of a special bone—the os quadratum. In this superclass belong the Batrachians, the Reptiles, and the Birds; the last two forming the group *Sauropsida.*

3. In the third (*Malleifera*), the shoulder-girdle is represented by composite scapulæ, limited to the sides or back; a sternum is developed; respiration is entirely effected by highly specialized lungs communicating with a common trachea, and the lower jaw is composed of simple rami, and articulated directly with the skull, the os quadratum of the other vertebrates being converted into one of the auditory ossicles (the malleus). This superclass is represented by a single class—the Mammals.

The more these groups are studied in all their relations the more natural do they appear.

As to other questions, that is, whether the true Fishes and Selachians are not separate classes, there is much to be said on both sides, and perhaps the arguments in favor of the class value of the Selachians may be even more weighty than those against them. If, however, the Birds and Reptiles are differentiated as distinct classes, similar rank can scarcely be consistently withheld from the Fishes and Elasmobranchiates. If I have heretofore hesitated, it is because of Dr. Günther's very adverse views.

Without prejudice to the reconsideration of the question as to the systematic value of the group of Selachians or Elasmobranchiates, the classes of Vertebrates may then be distributed, in a descending series, as follows:—

Branch VERTEBRATA.
  A. Sub-branch CRANIOTA.
    Superclass MALLEIFERA.
      I. Class Mammalia.
    Superclass QUADRATIFERA.
      (Sauropsida.)
      II. Class Aves.
      III. Class Reptilia.
      (Batrachopsida).
      IV. Class Batrachia.
    Superclass LYRIFERA.
      V. Class Pisces.
      VI. Elasmobranchiates.
    Superclass MONORRHINA.
      VII. Class Marsipobranchia.
  B. Sub-branch ACRANIA.
      VIII. Class Leptocardia.

The most nearly related pair of classes are those of Birds and Reptiles, and pre-eminently the most homogeneous is that of Birds, all the living representatives of which seem to be members of a single order (which may be distinguished by the name Eurhipidura), and at most divisible into two suborders—the Carinatæ and the Ratitæ. Other orders are represented by extinct types, viz.: Saururæ, and (if the vertebræ are peculiar to the group) Odontornithes.

ART. XLIX.—*Brief Contributions to Zoölogy, from the Museum of Yale College.* NO. XXV. *Results of recent Dredging Expeditions on the Coast of New England. No.* 3; by A. E. VERRILL.

THE investigations of the marine life and physical conditions of the waters of our coast, under the auspices of the U. S. Commissioner of Fisheries, Prof. S. F. Baird, was continued during the past season, under even more favorable circumstances than during the two previous years. This year the headquarters were established at Peak's Island, at the entrance of the harbor of Portland, Maine, and about four miles from the city. This proved to be a very favorable locality, on account of its central position, allowing us to dredge in all parts of Casco Bay and the connected bays and fiords, and to visit any of the numerous islands for which Casco Bay is so famous, without too great loss of time; and to take advantage of favorable weather for longer trips to the deeper waters outside the bay. The littoral animals of the island itself, owing to the diversity of the shores and purity of the water, also proved to be numerous and interesting.

The scientific party was quite large during the greater part of the time while active operations were carried on.

The fishes and the investigations more immediately connected with the fisheries were attended to by Prof. Baird, aided by his secretary, Mr. Rockwell, Prof. Theodore Gill, Dr. Edw. Palmer, Mr. G. Brown Goode, Mr. Spencer Biddle and others. The dredging operations, the examination of the food of fishes, and all investigations concerning the invertebrate animals generally, were in charge of the writer and Mr. S. I. Smith, aided by Prof. Wm. N. Rice and Mr. Goode, of Wesleyan University; Prof. J. E. Todd, of Tabor College, Iowa; Prof. H. E. Nelson, of Ohio Wesleyan University; Mr. J. H. Emerton, Salem, Mass.; Mr. J. K. Thacher, of Yale College; Mr. Franklin Benner, Astoria, N. Y.; and for a short time by Dr. P. P. Carpenter, of Montreal; Dr. Holder, of New York, and several others.

Much of the success of the expedition was due to the interest taken in such scientific researches by Secretary Robeson, who caused a small U. S. steamer, the "Blue-light," to be specially fitted out for our dredging operations, under Commander L. C. Beardsley, U. S. N. This steamer was provided with a steam windlass for hoisting the dredges and trawls, and with other conveniences, which greatly facilitated our operations, and enabled us to make much longer excursions to the outer waters, and to do much more work during the summer, than would otherwise have been possible. Captain Beardsley took great interest in our investigations and did all in his power to aid us in various ways. His constant endeavor was to make the steamer as useful as possible to us. Our thanks are also due to Mr. Cook, the executive officer, and to all the other officers and men for the hearty good-will with which they coöperated in our work and executed all our plans.

Ample wharf privileges were found at "Trefethen's Landing," and a building upon the wharf was speedily converted into a rather rude but comfortable laboratory. An excellent set of apparatus was provided by the Fish Commission, including a large assortment of dredges, rake-dredges, tangles, trawls, towing-nets, seines, sieves of various kinds, and all other kinds of apparatus and improvements which our past experience had proved useful or desirable. Sets of the apparatus such as were used by the English expeditions, on the "Porcupine" and "Challenger," were also imported by Prof. Baird, but were not found to offer any advantages over those which we had used in previous years. The English "accumulator" we found no occasion to use in our work, for a simple "check-stop," devised by Capt. Beardsley, proved equally efficient and far more convenient and simple, as well as quite inexpensive.* This

---

* This arrangement and the dredges, tangles, trawls, rakes, and other apparatus used by us, were described and illustrated in several letters to the New York Tribune by Mr. Wyckoff, one of the editors, who spent some time with us at the island, and accompanied us on several excursions. These letters are brought together in the "Tribune Extra," No. 10, Scientific Series.

was found to answer every purpose in dredging or trawling at all depths down to 100 fathoms, and undoubtedly would do equally well at far greater depths. With a larger vessel, in heavy weather, or at very great depths, the rubber accumulator would doubtless prove advantageous, but it is quite superfluous for working in less than 500 fathoms, in moderate weather. Therefore, any party undertaking such dredgings as can be carried on with small vessels off our coast, need not encumber themselves with this expensive piece of apparatus, for which a few fathoms of small or weak rope, applied in the form of a "check-stop," may be substituted!

Deep-sea thermometers, water-bottles for obtaining samples of the bottom-waters, and other physical apparatus, were also provided and frequently used.

Mr. Emerton was employed during the two months of active work in making drawings of the more interesting new and rare animals, from life. These drawings are remarkably accurate and life-like, and number nearly three hundred. They constitute one of the most valuable results of the expedition. As Mr. Emerton had drawn large numbers of our common marine animals for us during the two previous years, a considerable portion of his time was this year devoted to the free-swimming larval stages of crustacea, etc., and to the smaller and less known species in various classes. The soft parts of many species of mollusks were also well figured.

In consequence of the liberal coöperation of Prof. Pierce, superintendent of the U. S. Coast Survey, and other officers of the Survey, the U. S. Coast Survey steamer Bache was despatched, during the month of September, on several dredging expeditions to the deeper waters and distant banks off the coast of Maine, which we could not well reach with the "Blue-light." The dredges and other apparatus necessary for this work were provided by Prof. Baird, and the dredging on the Bache was under the superintendence of Dr. A. S. Packard, of the Peabody Academy of Science, Salem, Mass., aided by Mr. Caleb Cooke, also of the Peabody Academy. They were very successful in these investigations, and made several collections of great interest. The results of their work will be referred to in another article.

One of the most interesting regions examined was in the deeper waters outside of Casco Bay, 15 to 30 miles southeast from Cape Elizabeth. To this region we made several excursions, and dredged at depths varying from 40 to 95 fathoms, the depth gradually increasing with the distance from the shore. In these localities the bottom was generally of soft mud, with more or less numerous, scattered boulders. On one occasion we brought up in the trawl from 65 fathoms an angular boulder, estimated to weigh over 500 lbs. These boulders were probably transported from the adjacent coast by shore-ice in spring. They were usually covered with sponges, bryozoa, ascidians, hydroids, *Terebratulina*, etc. The bottom temperature of these waters was remarkably low, varying from 36° to 40° F., while the surface was usually between 55° and 65°, or even higher. The temperatures obtained here are quite as low as those that we obtained in the deeper parts of the Bay of Fundy last year, and the fauna proved to be correspondingly arctic in character, and agrees pretty closely with that at the mouth of the Bay of Fundy, and also with the dredgings made last year, in 85 to 150 fathoms, near St. George's Banks. In fact, these three regions may be regarded as distant parts of one great basin, referred to in a former article as "Saint George's Gulf," and this region is throughout its whole extent bathed in cold water of nearly uniform temperature at corresponding depths. The deepest parts of this gulf seldom exceed 150 fathoms, and are perhaps nowhere more than 200 fathoms. Whether the nearly ice-cold water filling the deeper parts of this cold-area can be regarded as constituting a definite current, or offshoot from the great arctic current, flowing southward along our coast in deep water off shore, or whether it is a portion of the great body of cold water filling the ocean basin at great depths, which is brought into this partially closed basin by the powerful tidal currents, is still uncertain. But it is important to have established the fact that this body of cold water approaches so closely to the coast of Maine as to manifest itself most distinctly within 12 or 15 miles of Cape Elizabeth, both by its highly arctic fauna and its icy temperature, even in midsummer. Moreover, there can be no doubt but that the constant admixture of this cold bottom-water with the warmer surface-waters, by means of the strong tides and local wind currents, causes the remarkably low temperatures observed in the shallow waters of these* shores, and even in the smaller bays and harbors along the entire eastern and northern coast of New England. It is also evident that a strong wind blowing from the shore for some time will have the effect to cause an ascending current of cold water along the submerged slope of the shore, to supply the place of the surface-water driven seaward by the wind; while an easterly wind will force the warmer surface-water toward the shore, and cause a descending current along the slope, partially forcing the cold water away from the shallows. Our observations, both in Vinyard Sound and Casco Bay, show that such an action does take place, and that the

---

* The temperature of the bottom-waters in the deeper channels among the islands, in 15 to 25 fathoms, was usually from 42° to 50° F.; while the surface was usually between 55° and 65° in July and August.

temperature of the water near the shore is rapidly lowered by a westerly or off-shore wind, and is as quickly raised by an easterly wind, independently of the temperature of the air.[*] But the effect is often somewhat masked, in summer, by reason of the much higher temperature of the westerly winds, which quickly warm the water close to the surface. Observations made early in the morning, before the effect of the direct heat of the sun becomes apparent, are the best for detecting the influence of tidal and wind currents.

The following are some of the species obtained in these localities in 50 to 95 fathoms: of Fishes, *Raia lævis*, *Sebastes viviparus*, *Pomatopsetta dentata;* of Crustacea, *Hyas coarctata*, *Pandalus borealis* of large size, *P. annulicornis*, *Sabinea septemcarinata*, *Hippolyte spina*, *H. Fabricii*, *Eupagurus Krogeri*, *Mysis*, (?) new species, *Praniza cerina*, *Asselodes alba*, *Haploops*, sp.; *Nymphon giganteum;* of Annelids, *Aphrodite aculeata*, *Nychia cirrosa*, *Pholoë minuta*, *Ninoë nigripes* V., *Nothria opalina* V., *Gattiola*, sp.; *Sternaspis fossor*, *Goniada*, sp.; *Pista cristata*, *Terebellides Stroëmi*, *Ampharete gracilis*, *Melinna cristata*, *Amphitrite Grœnlandica*, *A. cirrata*, *A. Johnstoni*, *Maldane Sarsii*, *Nicomache lumbricalis*, *Vermilia serrula*, *Potamilla oculifera*, *Arenia*, new species, *Scalibregma inflatum*, *Anthostoma acutum* V., *Chætozone setosa*, *Ammotrypane fimbriata*, *Phascolosoma tubicola* V., *P. cœmentarium*, *Chætoderma lucida;* of Nemerteans, *Meckelia lurida* V., *Nemertis affinis*, and a gigantic species 8 feet long, belonging to a new genus;[†] of Mollusca, *Octopus Bairdii* V. from 68 fathoms, *Neptunea curta* (*Islandica* Gould), *N. pygmæa*,[‡] *Aporrhais occidentalis*, *Turritella erosa*, *Lepeta cæca*,

---

[*] See the Report of the U. S. Fish Commission for 1871, p. 436, for a fuller discussion of this subject by the writer. Rev. J. W. Chickering also informs me that he has made series of observations at Hampton Beach, N. H., which establish such a coincidence. The change sometimes amounts to 10° F. in a few hours.

[†] *Macronemertes gigantea* Verrill. Body much elongated, subterete, a little depressed, thickest anteriorly, gradually tapering posteriorly, becoming very slender toward the end. Integument very soft, secreting a large quantity of mucus. Head not distinct from body, obtusely rounded in front, with a terminal pore; upper surface with two longitudinal fossæ; below with two rather indistinct transverse grooves, or fossæ, in advance of the mouth. Ocelli numerous, arranged in six clusters; a pair of large clusters on the anterior lateral border of the head; a pair of smaller lateral clusters farther back; and a pair of small clusters on the dorsal surface, between the longitudinal fossæ. Color, when living, bright orange-red above, flesh-color below. Length, about 8 feet, in extension; diameter, anteriorly, ·30 of an inch.

Off Cape Elizabeth, 68 fathoms, soft mud, Aug. 12.

[‡] An examination of the dentition of this and the preceding species shows that they are true Buccinidæ, and quite different from the *Tritonium Islandicum* of Lovén (=*Fusus Berniciensis*, t. Jeffreys), which has been regarded as the type of *Sipho*. Our American shell, usually called *Islandicus*, but which has been named *Fusus curtus* by Jeffreys, is a genuine *Neptunea* closely allied to *N. despectus*, etc. The *pygmæa* differs considerably in its dentition from the typical forms of *Neptunea*, as well as in having a woolly epidermis, and ought to be separated as a distinct genus, or subgenus, which I have elsewhere described under the name of *Neptunella*. (See Report of U. S. Fish Commission, for 1871.)

Bela decussata, *Natica clausa*, *Schaphander puncto-striata* (of large size), *Entalis striolata*, *Dentalium occidentale*, *Cardium Islandicum*, *Astarte lens*, *A. elliptica* (one specimen), *Yoldia thraciformis* (large and fine, living), *Y. obesa*, *Y. sopotilla*, *Dacrydium vitreum*, *Macoma sabulosa*, *Neæra arctica* (large and fine), *Crenella decussata*, *C. glandula*, *Panopæa Norvegica*, *Pecten Islandicus* (several fine specimens), and many other northern shells, including one new species, allied to *Pleurotoma;* numerous Bryozoa, including *Flustra solidula* St., *Idmonea pruinosa*, *Caberea Ellisii*, etc.; many Ascidians, among which were *Glandula fibrosa* St., *Molgula retortiformis* V., *Eugyra pilularis* V., a large, new species of *Ascidia*, *Ciona tenella*, a fine new species of *Botryllus* of a deep purple color, etc.; of Echinoderms the most abundant species was the starfish, *Ctenodiscus crispatus*, of which we obtained about a thousand in one haul with the trawl, but *Ophioglypha Sarsii* and *O. robusta* were also abundant, *Hippasteria phrygiana* occurred twice, *Ophiocnida hispida*, *Schizaster fragilis*, *Thyone*, sp., *Molpadia borealis* (?) Sars, and several other interesting species also occurred; among the Polyps were *Cerianthus borealis* V., *Edwardsia farinacea* V., *E. sipunculoides*, *Urticina nodosa* Fabr. sp. (=*? Tealia digitata* Gosse),* *U. crassicornis*, *Bolocera Tuediæ* Gosse, very large and fine. The last species had not been known from the American coast before, except from a few detached tentacles dredged last year near St. George's Bank, and *U. nodosa* had not been previously found, except last year, when it was dredged by Mr. Smith east of St. George's Bank, in 430 fathoms, and by Mr. Whiteaves in the deeper parts of the Gulf of St. Lawrence. The specimens obtained this year are much larger, some of them being 6 inches high and 4 in diameter. Of Sponges, several very interesting species occurred; among them a large specimen, two feet broad, of the *Halichondria ventilabrum* of the earlier English writers; a species apparently belonging to the genus *Trichostemma* of G. O. Sars; and over twenty specimens of *Hyalonema longissimum* M. Sars, some of them of unusually large size; these were all obtained in 95 fathoms, about 30 miles east-southeast from Cape Elizabeth. This last species had not been dredged before on the American coast, with the exception of a single specimen dredged last year by Messrs. Smith and Harger, off St. George's Bank, in 430 fathoms. Mr. Whiteaves writes me that he has also dredged it in the Gulf of St. Lawrence this summer; and it was also subsequently obtained by Dr. Packard. A small specimen, belonging apparently to the genus *Holtenia*,

---

* It seems to me very doubtful whether the *Actinia digitata* of Müller was actually the species that commonly bears that name in recent European works. The description would apply better to the *Bolocera Tuediæ* of Gosse. The species referred to above is certainly the *A. nodosa* of Fabricius, who well described it in 1870, as from deep water off the Greenland coast.

was obtained with the *Hyalonema*, and also several other remarkable forms of sponges.

At another locality, about nine miles south-southeast from Seguin Island, in 75 fathoms, the same kind of bottom was found and the fauna was nearly identical with that described above. At this place the finest specimen yet observed of *Cerianthus borealis* V. was obtained in good condition, and was kept alive several days, until a colored drawing was made by Mr. Emerton. This specimen, in extension, was about 20 inches long, and the expanse of its tentacles was over six inches. The color of its body was deep olive-brown. This species was not discovered until last year, but it was met with at several different localities this year, and seems to be not uncommon on muddy bottoms in 20 to 100 fathoms, though seldom obtained of full size by the dredge, owing to its living deeply buried.

[To be continued.]

ART. L.—*Age of the Rocky Mountain Coal or Lignitic Formation.*

[As the age of the Lignitic formation of the Rocky Mountain region is far from decided, owing mainly to the contrary evidence afforded by the fossils of the vegetable and animal kingdoms, we propose to cite the arguments from different sources bearing on the subject, in order, if possible, to bring about agreement on this most important point in American geology. We here give first the conclusions of Mr. L. Lesquereux from the fossil Plants, published in Hayden's Report for 1872.—EDS.]

I. *Views of L. Lesquereux.*

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, 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 *Liriodendrons*, *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 *Populous*, *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 reappear, 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 Bronguiart 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. * * *

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, indicating 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

---

* 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. chamæropifolia* Gópp, 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.

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.

The American Eocene, moreover, is 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 degrees 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 of the Paris basin has also some rich beds of lignite. Does not this read like a true epitome of the descriptions given of our Eocene?

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

---

[*] **Herr Urwelt der Schweitz, p. 241.**

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 section 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.

Mr. Lesquereux follows his descriptions of species with a table giving the distribution of the species, a brief abstract of which is here presented. He refers the Lignitic beds of Washakie, Carbon Station, Evanston and Sage Creek to the *Upper* Eocene; those of Raton Mts., Golden, Marshall's Mine, etc., California, Black Butte, Spring Cañon and some other localities to the Lower Eocene. In the following table U stands for Upper Eocene, L for Lower, M for Mississippi, where the Lignitic beds of the same age are at the bottom of the Tertiary; E^1 for European Eocene and E^2 for European Miocene.

---

* F. V. Hayden's Geological Report, 1870, p. 69.

Spheria lapidea Lx.		L			
Myricæ Lx.		L			
Sclerotium pustuliferum H.	U				
rubellum Lx.		L			
Opegrapha antiqua Lx.		L			
Chondtites subsimplex Lx.		L			
bulbosus Lx.		L			
Delesseria fulva Lx.		L			
incrassata Lx.		L			
lingulata Lx.		L			
Halymenites striatus Lx.		L			
major Lx.	U	L		E^1	
minor F. O.		L		E^1	
Omoclea sensibilis L.		L			
Pteris anceps Lx.		L			E^2
erosa Lx.		L			E^2
Aspidium Fischeri H.					
Sphenopteris Eocenica E.		L		E^1	
Gymnogramma Haydeni Lx.		L			
Lygodium compactum Lx.		L			
Fern, species	U				
Equisetum limnosum (?) L.		L			
Taxodium occidentale Ny.		L			
dubium St.	U				E^2
Glyptostrobus Europeus Br.		L			E^2
Sequoia Heerii Lx.	U				
Langsdorfii Br.		L			E^2
Thuja gracilis Ny.		L			
Abietites dubius Lx.		L			
Abies setigera Lx.		L			
Salisburia binervata Lx.		L	M		
Arundo Gœpperti A. Br.		L			E^2
Phragmites Oeningensis A. Br.	U	L			E^2
Alaskana H.		L			
Juncus, species	U				
Cyperites angustior A. B.		L			E^2
Cyperus Chavanensis H.	U				E^2
Carex Berthoudi Lx.		L			
Similax grandiflora U.	U				E^2
obtusangula H.		L			E^2
Sabal Grayana Lx.			M		
Campbellii Ny.		L			E^2
Goldiana Lx.		L			
Flabellaria Zinkeni H.		L			
latania H.		L		E^1	
Eocenica A. B.		L		E^1	
Calamopsis Danai Lx.			M		
Palmacites, species		L		E^1	
Acorus brachystachys H.	U				
Caulinites sparganiodes Lx.	U	L			
fecunda Lx.		L			
Populus Arctica H.	U	L			
decipiens Lx.	U				
attenuata A. B.	U	L			E^2
cuneata Ny.		L			
cordata Ny.		L			
acerifolia Ny.		L			
Nebrascensis Ny.		L			
genetrix Ny.		L			
nervosa Ny.		L			
monodon Lx.		L	M		
æqualis Lx.	U				
Populus mutabilis repando-crenata H.	U	L	M		E^2
lancifolia H.		L			E^2
balsamoides G.		L			E^2
ovalis G.	U				E^2
latior var. transversa A. B.	U				E^2
latior var. cordifolia A. B.	U				E^2
leucophylia U.		L			E^2
Zaddachi H.	U				
Salix Grœlandica H.		L			
Evanstoniana Lx.	U				
densinervis Lx.			M		
tabellaris Lx.			M		
Myrica ambigua Lx.		L			
Torreyi Lx.		L		E^1	
Alnus Kefersteinii G.	U	L			E^2
serrata Ny.		L			
Ulmus irregularis Lx.		L			
Betula caudata G.	U				E^2
Stevensoni Lx.	U				E^2
Planera microphylla Ny.		L			E^2
Celtis brevifolia Lx.			M		
Quercus angustiloba A. B.		L		E^1	
Moorii Lx.			M		
Lyellii H.			M		E^2
retracta Lx.			M		E^2
chlorophylla U.		L	M		E^2
triangularis G.		L			E^2
stramineus Lx.		L			
platania H.	U	L			
aemulans Lx.	U				
negundoides Lx.	U				
drymeja U.	U				E^2
acrodon Lx.	U	L			
Wyomingiana, Lx.		L			
Olafseni H.		L			
Haydenii Lx.	U				
Gaudini Lx.		L			E^2
Ellisianus Lx.		L			
Pealæi Lx.		L			
Godeti H.		L			E^2
Laharpi G.		L			
Saffordi Lx.			M		
dubia Ny.		L			
crassinervis U.		L			E^2
Corylus grandifolia Ny.		L			
orbiculata Ny.		L			
Americana W.		L			
McQuarryi H.	U	L			
Fagus Antipofi H.	U	L			
Deucalionis U.	U				E^2
Feroniæ U.		L			E^2
ferruginea (?) M. (fruit)			M		
Ficus Schimperi Lx.			M		
cinnamomoides Lx.			M		
tillæfolia A. B.	U	L			E^2
planicostata Lx.		L			
Clintoni Lx.		L			
asarifolia E.		L			E^2
lanceolata H.	U				E^2
oblanceolata Lx.	U				

Ficus multinervis H.	U			E^2
arenacea Lx.	U			E^2
Gaudini Lx.	U			
spectabilis Lx.		L		
corylifolia Lx.		L		
ulmifolia Lx.		L		
Haydenii Lx.		L		
auriculata Lx.		L		
Morus affinis Lx.	U			
Platanus nobilis Ny.		L		
Raynoldsii Ny.		L		
Haydenii Ny.		L		
heterophylla Ny.				
Guillelmæ G.	U	L		E^2
aceroides G.	U	L		E^2
Coccoloba lœvigata Lx.	U			
Laurus obovata W.		L		E^2
pedata Lx.		L	M	
Persea lancifolia Lx.			M	
Benzoin antiquum H.		L		E^2
Cinnamomum affine Lx.	U	L	M	E^2
Mississippiense Lx.	U	L	M	E^2
Scheuzeri H.	U	L		E^2
Eleagnus inæqualis Lx.			M	E^5
Banksia Helvetica H.			M	E^2
Aristolochia cordifolia Ny.		L		
Andromeda Grayana H.	U			
dubia H.			M	E^2
reticulata H.		L		
vacciniœfolia U.			M	
Diospiros lancifolia Lx.	U			
stenosepala H.		L		
brachysepala H.		L		E^2
anceps H.		L		E^2
Sapotacites Americanus Lx.			M	
Echitonium Sophiæ (?) Web.		L		E^2
Viburnum marginatum Lx.		L		
Wymperi H.		L		
contortum Lx.		L		
dichotomum Lx.		L		
asperum Ny.		L		
lanceolatum Ny.		L		
Fraxinus denticulata H.		L		
Prunus Carolinianus Mx.			M	
Aralia triloba Ny.		L		
Cornus incompletus Lx.		L		
acuminata Ny.		L		
Studeri H.	U			E^2
rhamnifolia,		L		E^2
Nyssa lanceolata Lx.		L		
Cissus lævigatus Lx.		L		
lobato-crenatus Lx.		L		
Vitis tricuspidata H.		L		E^2
Olriki H.	U			
Islandica H.		L		
Magnolia, species				
Hilgardiana Lx.	U	L	M	
laurifolia Lx.			M	
Lesleyana Lx.		L	M	
ovalis Lx.			M	
cordifolia Lx.			M	
Magnolia Inglefieldi H.		L		
Asimina Eocenica Lx.	U			
leiocarpa Lx.			M	
Terminalia radobojensis U.		L		E^2
Eucalyptus Haeringiana E.		L		
MacClintockia Lyallii H.		L		
Dombeyopsis trivialis Lx.		L		
occidentalis Lx.		L		
obtusa Lx.		L		
acquifolia G.		L		E^2
Acer, species		L		
trilobatum H.	U			E^2
var productum H.				E^2
secretum Lx.	U			
Negundo triloba Ny.		L		
Sapundus affinis Ny.		L		
membranaceus Ny.		L		
undulatus A. B.			M	E^2
caudatus Lx.		L		
Aleurites Eocenica Lx.		L		
Ceanothus fibrillosus Lx.		L		
Paliurus Colombi H.	U			
Zizyphoides Lx.		L		
Zizyphus Meekii Lx.	U			
hyperboreus H.	U			
Berchemia parvifolia Lx.		L		
Rhamnus elegans Ny.		L		
marginatus Lx.			M	
obovatus Lx.	U	L		
salicifolius Lx.		L		
intermedius Lx.		L		
rectinervis H.		L		E^2
Dechenii W.		L		E^2
Cleburni Lx.		L		
Goldianus Lx.		L		
var. latior	U	L		
discolor Lx.		L		
acuminatifolius W.		L		
deletus (?) H.		L		E^2
Fischeri Lx.		L		
Tilia antiqua Ny.		L		
Rhus deleta H.	U			E^2
Evansii Lx.	U			
nervosa Ny.		L		
bella H.		L		
Xanthoxyium dubium Lx.		L		
Juglans appressa Lx.	U		M	
Saffordiana Lx.			M	
acuminata (?) H.	U	L		E^2
rugosa Lx.	U	L		
obtusifolia (?) H.	U			E^2
thermalis Lx.		L		
rhamnoides Lx.	U	L		
Schimperi Lx., and fruit		L		
Smithsoniana Lx.		L		
Baltica (?) H.		L		
denticulata H.	U	L		E^2
Carya antiquorum Ny.	U	L		
Cercis Eocenica Lx.		L		
Cassia concinna Lx.	U	L		
phaseolites U.		L		E^1E^2

Among the species of the Lignitic beds, thirty-two are stated by Lesquereux to occur also in the Arctic; and, of these Arctic species, *Sequoia Langsdorfii*, *Phragmites Oeningensis*, *Poacites lævis*, *Cyperites Deucalionis*, *Carex tertiaria*, *Populus lancifolia*, *Alnus Kefersteini*, *Quercus Lyellii*, *Q. drymeja*, *Fagus Deucalionis*, *Ficus tiliæfolia*, *Platanus Gulielmæ*, *P. aceroides*, *Cinnamomum Scheuchzeri*, and *Juglans acuminata*, have been afforded by the *Miocene* of Europe. Of the few European Eocene species found in the Lignitic beds, none have been reported from the Arctic.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Velocity of Sound in Gases as a means of determining their Molecular Weights.*—The fundamental importance of molecular weight in modern chemical theory gives interest to any methods looking toward its more convenient or more accurate determination. Heretofore, the molecular weight of a body has been determined from its vapor-density, from its diffusibility, or from its specific heat. BENDER now proposes to use the velocity of sound to accomplish this result. In gases, this velocity has the well-known relation to their density expressed by the formula $v=\sqrt{\frac{es}{\delta}}$, in which e represents the elasticity of the gas, s the coefficient 1·41, obtained by dividing the specific heat at constant pressure by the specific heat at constant volume, and δ the density. For any other gas of density δ' we should have $v'=\sqrt{\frac{es}{\delta'}}$; whence $v : v' :: \sqrt{\delta'} : \sqrt{\delta}$, or the velocities of sound in the two gases are inversely proportional to the square root of the densities. Now since e is the same for all gases under similar conditions, and since, by Avogadro's law, the molecular weights of gases are proportional to their densities, it follows that the velocity of sound in any gas is inversely proportional to the square root of its molecular weight. In order to measure the velocity of sound in the given gas, Bender proposes to make use of the exceedingly ingenious method of Kundt.[*] A glass tube about a meter long is filled with the gas, some lycopodium powder[†] is thrown in, and the ends of the tube are hermetically sealed. If now this tube be grasped at its middle point and a wet cloth be drawn over it from the center toward the end, it will be thrown into longitudinal vibrations, and the lycopodium dust will arrange itself in a series of heaps at the nodal points. Now, since the distance between two nodes represents half a sound wave in the given gas, the number of such sound waves is one-half the number of nodes. But the length

---

[*] Pogg. Ann., cxxxv, 337. Tyndall on Sound, pp. 202–209.

[†] Mr. W. E. Geyer uses successfully precipitated silica, well dried.

of the sonorous wave in glass is double that of the tube. Hence the number of nodes or half waves in the gas within the tube, bears the same relation to the tube itself, or a half-wave in glass, that the number of waves in the gas bears to the number in glass. Moreover, the number of vibrations per second being the same in both, the velocity of sound in the two media must be as the number of waves. For example, if the tube contains 16 nodes, a half wave in the enclosed gas is $\frac{1}{16}$ as long as a half wave in the tube; whence it follows that the velocity of sound in the gas is $\frac{1}{16}$ of that in the glass. If the tube be grasped midway between its center and one of the ends, it gives, when rubbed, the octave of the first note, and the number of nodes is doubled. By using a series of tubes containing air, carbonic gas, illuminating gas, hydrogen and ether vapor, respectively, Kundt observed that the number of dust heaps, and therefore the velocity of sound, in each, was represented by the numbers 32, 40, 20, 9 and above 50. Or taking the velocity in air as unity, the velocities in the other gases are 0·8, 1·6, 3·56 and 0·64 respectively. These numbers correspond closely with the inverse squares of the densities of these gases, except in the case of the ether vapor, which, as the experiment was conducted at the ordinary temperature of the air, was not a true gas. In order to apply the method to cases requiring higher temperatures, Bender suggests the use of Kundt's improved method, in which the vibrating tube or rod slides within a wider glass tube in which the dust heaps are formed. The following table shows the results which this sound-method is capable of giving:

Gas.	Mol. formula	Mol. weight.	$\sqrt{\text{Mol. wt.}}$	Velocity.	$\sqrt{\text{Mol.}} : \sqrt{H_2}$.	Velocity in gas : V. in H.
Air	----	----	----	1092′	----	----
Oxygen	O_2	32	5·65	1040′	4 : 1	1 : 4
Hydrogen	H_2	2	1·41	4164′	----	----
Carbonic gas	CO_2	44	6·63	858′	4·7 : 1	1 : 4·8
Carbonous oxide	CO	28	5·29	1107′	3·7 : 1	1 : 3·7
Hyponitrous ox.	N_2O	44	6·63	859′	4·7 : 1	1 : 4·7
Ethylene	C_2H_4	28	5·29	1030′	3·7 : 1	1 : 4·0

These results coincide very well with those required by theory.—*Ber. Berl. Chem. Ges.*, vi, 665, June, 1873. G. F. B.

2. *On the existence of Sulphurous Chloride.*—MICHAELIS and SCHIFFERDECKER have succeeded in preparing and isolating sulphurous chloride, SCl_4. 67·5 grams pure $S_2\ Cl_2$, cooled to −20° or −22° was treated with a slow stream of dry chlorine gas for ten hours, the whole apparatus being tared so that the increase of weight could be observed. At the end of this time the gas ceased to be absorbed, a quantity amounting to 106 grams having been taken up. The formula SCl_4 requires 106·5 grams. It was analyzed by withdrawing a portion from the vessel containing the mass, and decomposing this with nitric acid, the chlorine and sulphur both being determined. As the mean of two analyses, the substance contained 81·59 of chlorine, and 18·41 of sulphur; theory

requires for SCl_4, 81·61 Cl and 18·39 S. Sulphurous chloride is a mobile, yellowish-brown liquid, essentially lighter in color than hyposulphurous chloride, SCl_2. Withdrawn from the freezing mixture, it evolves chlorine with effervescence, becoming so cold that the tube containing it, though immersed in a freezing mixture at $-10°$, covered itself, in the concentrated salt solution, with a thick crust of ice. After the boiling ceased, the liquid, removed from the freezing mixture—the surrounding air being at 0°—showed a temperature of $-12°$, which it retained sensibly for an hour. On saturating S_2Cl_2 with chlorine at various temperatures and analyzing the product, the authors determined the rapidity of the dissociation of SCl_4. Sulphuric oxide acts on sulphurous chloride thus:

$$SCl_4+(SO_3)_2=SOCl_2+S_2O_5Cl_2.$$

Equal molecules act thus:

$$SCl_4+SO_3=SOCl_2+SO_2+Cl_2\,;$$

then the thionyl chloride acts on the SO_3:

$$SO\,Cl_2+S_2O_6=SO_2+S_2O_5Cl_2.$$

Sulphurous chloride therefore actually exists at low temperatures, and like phosphoric chloride easily dissociates into SCl_2 and a molecule of chlorine.—*Ber. Berl. Chem. Ges.*, vi, 993, Sept., 1872.

G. F. B.

3. *On Sulphur Oxytetrachloride.*—Millon long ago described white crystals resulting from the action of moist chlorine upon sulphur chloride; and Carius confirmed the fact. MICHAELIS and SCHIFFERDECKER have recently attempted its production by Millon's method; but obtained only a yellowish pasty mass. Reflecting upon the matter, they concluded that a substance of the composition $S_2O_3Cl_4$ could have but two possible rational formulas:

$$\overset{\text{IV}}{S}Cl_3\text{---}O\text{---}\overset{\text{VI}}{S}O_2Cl$$

or

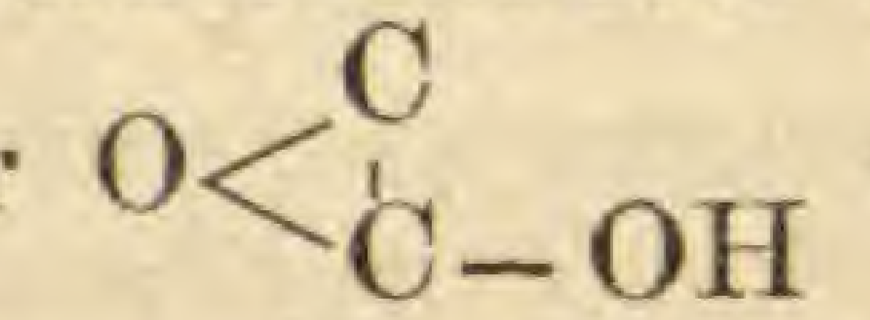
$$\overset{\text{VI}}{S}Cl_3O\text{---}O\text{---}\overset{\text{IV}}{S}OCl.$$

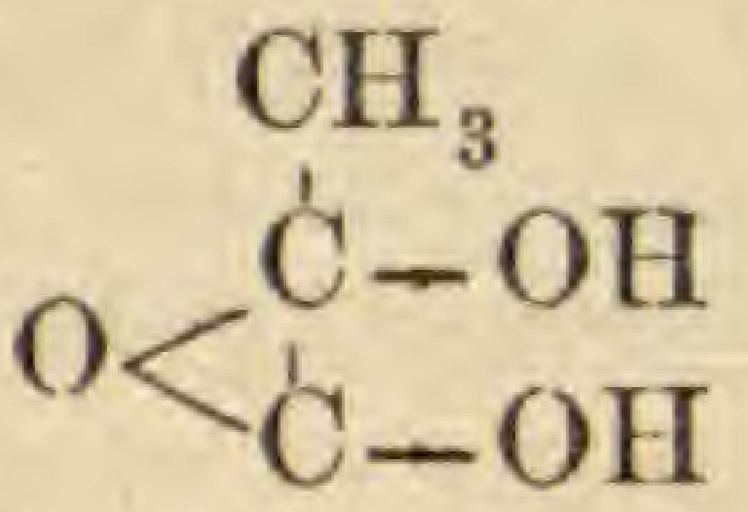
In case the former formula were the true one, the body ought to be formed by the action of sulphurous chloride upon sulphuric chlorhydrate thus:

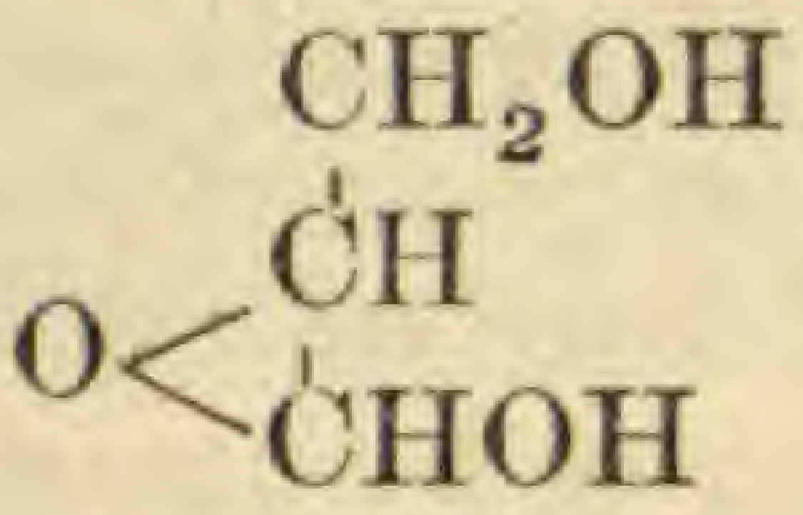
$$SCl_4+SO_2\left\{\begin{matrix}OH\\Cl\end{matrix}\right.=SO_2Cl\text{---}O\text{---}SCl_3+HCl.$$

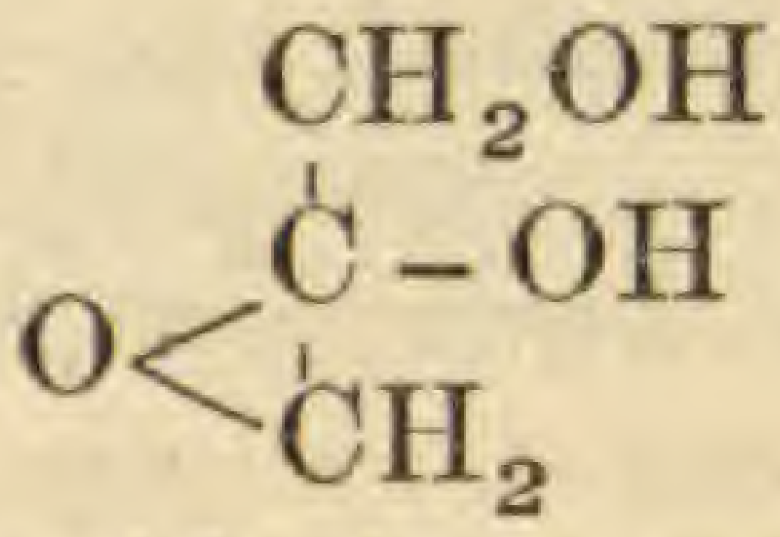
Experiment resulted in the production of the compound at once in almost the theoretical amount. Sulphuric chlorhydrate was prepared by the action of chlorine upon a mixture of phosphorous chloride and sulphuric acid, and was mixed in equal molecules with the sulphurous chloride in a freezing mixture, a stream of chlorine being passed through it. Hydrochloric acid was evolved, and a white solid collected, first on the delivery tube and then on the walls of the vessel. When the contents of the flask have become semi-solid, the temperature is raised to $-13°$, and the current of chlorine continued with frequent agitation. After complete solidification, the flask is removed from the freezing mixture, the chlorine is continued till the mass becomes white, and is then displaced by carbonic gas. From 135 grams S_2Cl_2 and 233 grams SO_3HCl, 480 grams (instead of 508) $S_2O_3Cl_4$ were obtained. Sulphur oxytetrachloride is a white crystalline substance, with a peculiar pungent odor, strongly attacking the mucous passages. Cold water decomposes it with hissing, yielding sulphuric, sulphurous and hydrochloric acids. It fuses at 57°, evolving chlorine and sulphurous oxide, a portion at the same time volatilizing and condensing in fine white needles. By keeping, even in hermetically sealed tubes, it changes to a yellow liquid, possibly its isomer above given. With CS_2, it evolves $COCl_2$.—*Ber. Berl. Chem. Ges.*, vi, 996, *Sept.* G. F. B.

4. *On the Isomerism of the Lactic acids.*—WISLICENUS has recently published the results of several years' research upon the isomerism of lactic acid. He has proved that sarco-lactic acid is not a simple body but is a mixture of two different acids, easily separable from each other by the different solubility of their zinc salts in dilute alcohol. The one which is most abundant, is not identical either with ethylene-lactic acid, with ethylidene-lactic acid, or with the acid obtained from β iodopropionic acid, as is shown by its rotatory power and also by the different solubility of its salts and the different quantities of crystal water which they contain. The other acid appears to be identical with that derived from β iodopropionic acid, though also different from ethylene and ethylidene-lactic acids. This latter acid was first prepared from β iodopropionic acid by Beilstein, by the action upon it of moist silver oxide. He gave it the formula $C_{12}H_{22}O_{11}$ and the name hydracrylic acid. The author prepared it after his method, taking care not to add the silver oxide in excess or to boil it too long. The filtrate from the excess of silver, almost neutralized with sodium hydrate and evaporated, became no more strongly acid nor evolved acid vapors. The dry mass was extracted with boiling 95 per cent alcohol, which dissolved it almost completely, leaving a small residue of sodium dipimalate, acrylate, and dihydracrylate. This solution on cooling deposited crystals of sodium hydracrylate, which were purified by recrystallization from hot alcohol. These crystals are anhydrous and have the formula $C_3H_5NaO_3$; they are very deliquescent, and melt without loss at 142°–143°. Heated to 300°, they lose a molecule of water and a body is produced having the composition of sodium acrylate, but mixed with isomers which take up water again and regenerate the hydracrylate. The calcium, the zinc, the zinc-calcium and the silver salts of this acid and the acid itself are described. The latter on heating yields acrylic acid, and not a trace of lactide. On oxidation, hydracrylic acid yields neither glyceric acid as a glyceric aldehyde would do; nor malonic acid as ethylene-lactic acid does. Chromic acid and nitric acid converted it into carbonic, formic and oxalic acids. Silver oxide gave once carbace-toxylic acid, but generally oxalic and glycollic acids. Melted potassium hydrate produced formic, acetic, oxalic and glycollic acids. Heated with iodhydric acid in closed tubes, β iodo-

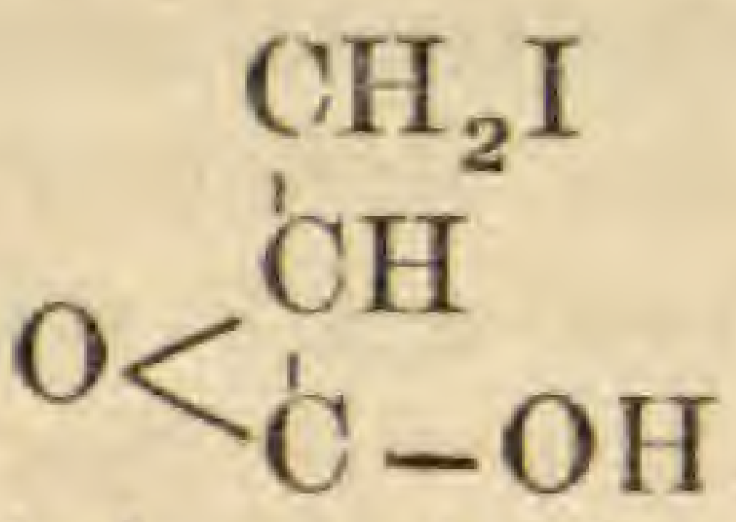
propionic acid was regenerated. On the question of its rational constitution, Wislicenus remarks: that as there can exist only two monobasic and diatomic acids $C_3H_6O_3$ containing the group COOH, and these two are known, being respectively ethylene and ethylidene-lactic acids, it follows that hydracrylic acid, differing as it does from both of these, must contain a different grouping. He therefore maintains that the carboxyl group COOH, is not the only one which can give an acid character to a molecule; but that the group C_2OOH or better  not only may do so, but actually does so in the case of hydracrylic acid. Of the three formulas possible upon this hypothesis,



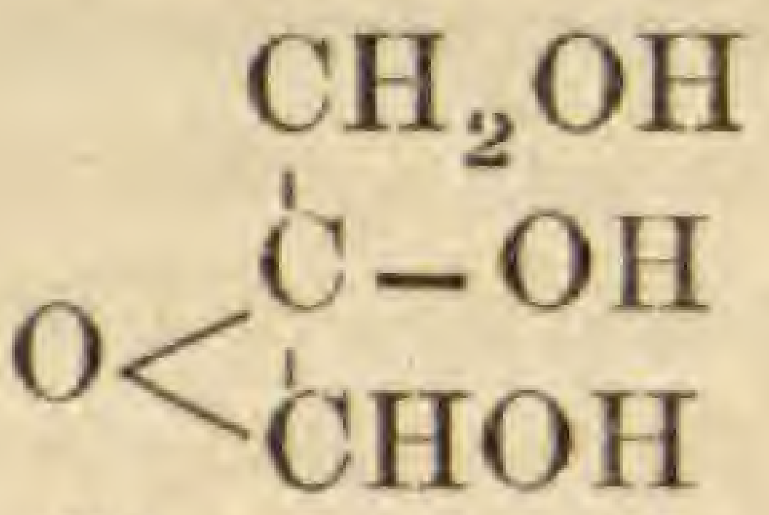




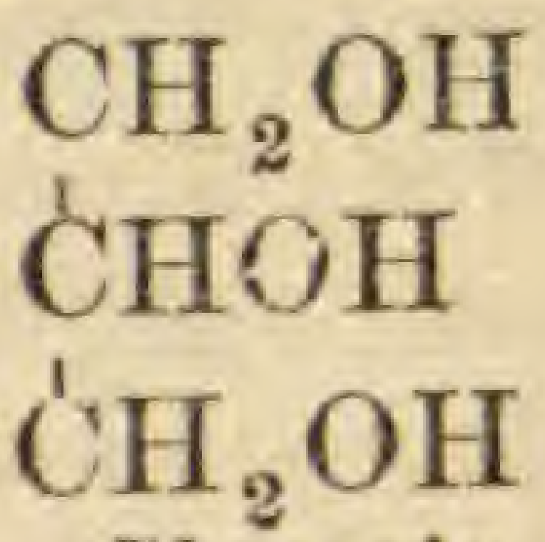
the author rejects the first because the acid does not give the iodoform reaction and cannot therefore contain a methyl group; and the third because it would lead to an improbable formula for acrylic acid. The second formula being accepted, the following formulas are derived for the bodies related to hydracrylic acid:



β iodopropionic acid,

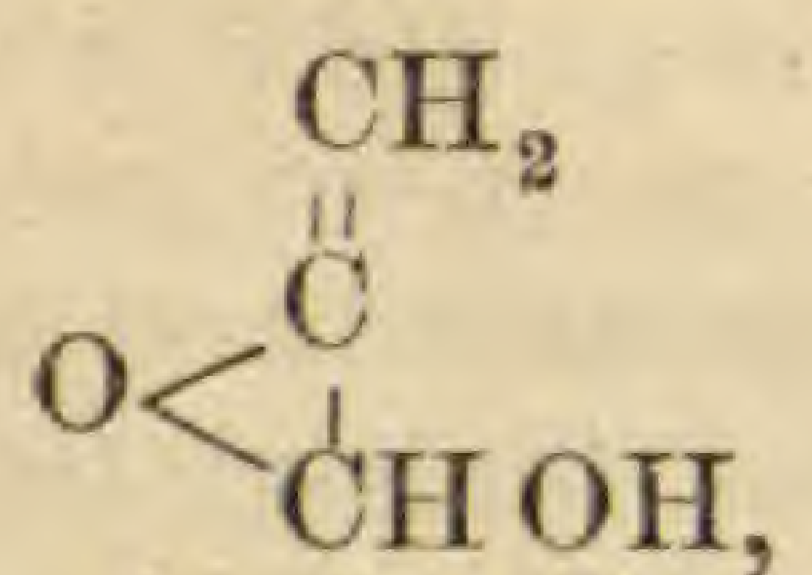


Glyceric acid.

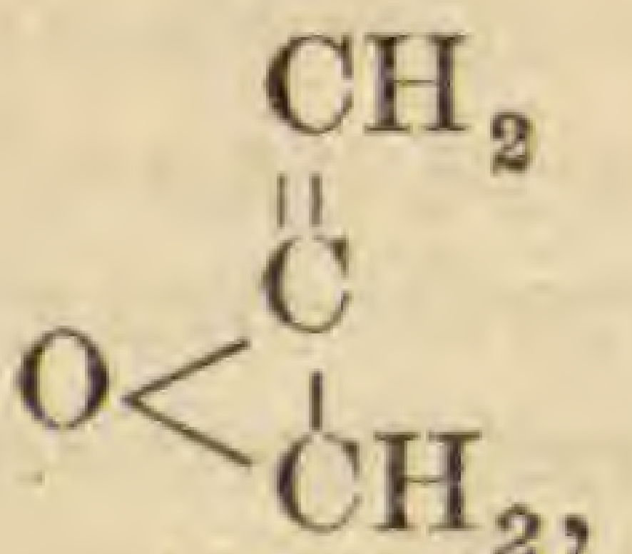


$$\begin{array}{l}CH_2OH\\ \vert\\ CHOH\\ \vert\\ CH_2OH\end{array}$$

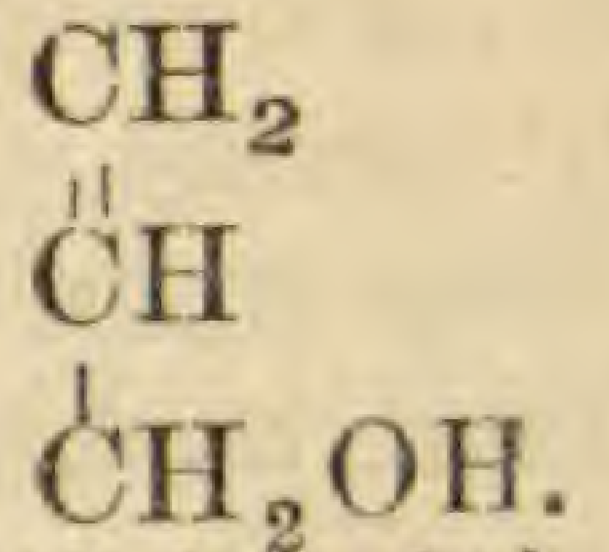
Glycerin.



Acrylic acid.



Acrolein.



$$\begin{array}{l}CH_2\\ \Vert\\ CH\\ \vert\\ CH_2OH.\end{array}$$

Allyl alcohol.

The author reserves to a subsequent paper the results of the investigation of the other constituent of the sarco-lactic acid.—*Ann. Ch. Pharm.*, clxvi, 3, Jan., 1873.—*Bull. Soc. Ch.*, II, xx, 22, July. G. F. B.

5. *On the Synthesis of a new Propionic acid.*—BERTHELOT showed several years ago that potassium hydrate absorbed carbonous oxide readily, producing potassium formate thus:

$$KOH+CO=CHO\ OK.$$

If now the alkali-alcoholates be employed, he conceived that the acids of the fatty series might be formed thus:

$$C_nH_{2n+1}\,OK+CO=\left\{\begin{array}{l}C_nH_{2n+1}\\ CO\,OK\end{array}\right..$$

His early experiments showed an absorption, but formate and not propionate—ethyl alcohol being employed—was obtained. This result was attributed to the presence of water in the alcoholate, and pure barium alcoholate—a substance in whose alcoholic solution water in the least trace, precipitates barium hydrate—was substituted. It slowly absorbed carbonous oxide, 8 c.c. of solution containing 1·5 grams barium oxide, absorbing 60 c.c. of the gas in 27 days, the resulting barium salt being soluble in the alcohol. Its analysis is peculiarly difficult, since it is destroyed by the least trace of water. The results gave the formula $C_3H_5Ba'O_2$. Hence the new body is isomeric with barium propionate, from which it is easily distinguished by its decomposition into alcohol and barium formate by the action of the water:

$$C_3H_5Ba'O_2+H_2O=C_2H_5OH+CHO\ OBa'.$$

The barium salt of common propionic acid is insoluble in alcohol. Berthelot gives it the name ethylformic acid and recognizes it as the type of a new class of acids isomeric with the fatty series and distinguished from these by being decomposed by water into alcohol and formic acid.—*Ann. Chem. Phys.*, IV, xxx, 139, Sept., 1873. G. F. B.

6. *On a new constituent of Urine.*—While seeking to determine the metamorphosis undergone by certain aromatic substances in the animal organism, BAUMSTARK obtained crystals of a new urinary constituent, having characteristic properties. It was first observed in the urine of a dog fed with benzoic acid, then in icteric urine and subsequently in normal urine. The urine is evaporated to a syrup, extracted while still warm copiously with absolute alcohol, filtered, the alcohol distilled off, the residue acidulated with hydrochloric acid and agitated with ether to remove hippuric acid, made alkaline with ammonia, treated with basic lead acetate, filtered, freed from lead by H_2S, evaporated to a syrup and allowed to stand. Besides urea, other crystals separate and remain undissolved on treatment with alcohol. Recrystallized from hot water, the substance appears in white prisms resembling hippuric acid, fusing at 250° and evolving white vapors in a tube, having an alkaline reaction and an odor of ethylamine. Analysis leads to the formula $C_3H_8N_2O$. It forms salts with acids, forms ethylsarcolactic acid when treated with nitrous acid, and evolves ethylamine and ammonia when boiled with barium hydrate. Hence, the author proposes for it the rational formula:

$$NH_2\text{---}CO\text{---}C_2H_4\text{---}NH_2.$$

—*Ber. Berl. Chem. Ges.*, vi, 883, July, 1873. G. F. B.

7. *On the Passage of gases through Colloid membranes of vegetable origin.*—M. A. BARTHÉLEMY performed the following experiments to prove that those of Graham on the dialysis of gases through caoutchouc could be verified on natural vegetable colloid films, especially on the cuticular surfaces of leaves, thus justifying the important part he makes the cuticle play in the absorption of carbonic acid by plants.

Everyone knows the *Begoniaceæ* with leaves spotted with white, which are cultivated in greenhouses. These white spots are, he maintains, only elevations of the epiderm upon a layer of nitrogen.

The leaves of certain varieties, very thin on the living plant, are reduced, on fading during the winter in darkness, to the condition of a pellicle endued with elasticity and representing almost nothing but the cuticular layers. It was these colloid membranes which served to repeat Graham's experiment. Except in a few modifications of detail, he followed strictly the course of that illustrious physicist.

First, to ascertain by the dialysis of air alone that the membrane is intact, presenting no rents, three experiments were made on the 16th, 17th and 18th of March. They gave the following results at the end of six hours :—

	16th.	17th.	18th.
Vol. of gas collected,	5·2 cm^3	5·5 cm^3	7·0 cm^3
Vol. of O absorbed by pyrogallate of potash,	1·9 "	2·3 "	2·2 "
Proportion of oxygen,	·36 "	·41 "	·31 "

Although the proportions of oxygen present a rather wide deviation owing to the difficulty of repeating the experiments under the same conditions of external pressure, temperature, and, especially of moisture, the conclusion may be drawn that oxygen passes more rapidly than nitrogen, and that air thus dialyzed contains on the average about 36 per cent of oxygen. This number is a little below that found by Graham with caoutchouc.

This verification made and this important result obtained, he next compared the velocities of the three gases which interest us most; for this purpose, after forming a current of carbonic acid above the membrane, he marked the point to which the mercury descended at the end of one hour; then substituting nitrogen or oxygen, he noted the time it took the mercury to descend again to the same level.

In four experiments made with different membranes, he obtained the following results:—

	1st.	2d.	3d.	4th.
CO^2	1^h	1^h	1^h	1^h
N	15^h	$13^h\ 40^m$	$15^h\ 30^m$	14^h
O	6^h	$6^h\ 20^m$	7^h	$5^h\ 40^m$

The experiments made under conditions of pressure, temperature, and moisture, which doubtless were not identical, yet agree sufficiently well with those of Graham, and allow us to conclude that the natural colloid surfaces of vegetables have for carbonic acid an *admissive power* which is thirteen to fifteen times as great as that of nitrogen, and six or seven times that of oxygen.

Some days after he repeated the experiment with carbonic acid, perfectly dry, and found for its velocity compared with nitrogen numbers varying from nine to eleven ; it seems then that dry carbonic acid passes less rapidly than when moist.

Replacing the vegetable film by caoutchouc, he obtained a similar result. The difference in the case of dry oxygen and nitrogen is less marked.

He remarks, in conclusion, that these experiments prove the dialysis of carbonic acid through the cuticle of leaves, just as much as those of Dutrochet on membranes and aqueous solutions prove endosmose by cellules, or the experiments on absorption made by

M. Dehérain with porous vessels, to which the academy accorded one of its highest rewards. In a word the *cuticular* respiration seems to be sufficiently proved by the presence of this membrane on all the organs, by the analogy of the physical and chemical constitution of this membrane with caoutchouc, by the experiments of Graham and the measures of the passage of gases through colloid membranes, and finally by the experiments of M. Boussingault, who attributes to the upper surfaces of leaves, destitute of stomata, a decomposing power greater than that of the lower surface covered with these minute apertures.—*Comptus Rendus*, lxxvii, 427, August, 1873. E. C. P.

8. *Relation between the atomic weight, the specific gravity and the hardness of the metallic elements.*—M. S. BOTTONE was led on theoretical grounds to admit that the natural measure of the hardness of any metallic element was the specific gravity divided by the atomic weight; and this conclusion seems verified by experiment. Taking as a measure of the hardness, the time required by a steel plunger with a uniform rotary motion to penetrate the metal to a certain depth, he found numbers, as the following table shows, which differ from theory only by amounts comparable with the errors of observation:

	Spec. Grav.	Atomic Wt.	Calc.	Expt.
Manganese	8·01	55·0	·1457	·1456
Cobalt	8·5	58·8	·1446	·1450
Nickel	8·28	58·8	·1408	·1410
Iron	7·7	56·0	·1375	·1375
Copper	8·66	63·4	·1364	·1360
Palladium	11·8	106·6	·1107	·1200
Platinum	21·5	197·4	·1090	·1107
Zinc	7·0	65·2	·1077	·1077
Indium	72·8	74·0	·0983	·0984
Gold	19·3	197·0	·0980	·0979
Silver	10·4	108·0	·0963	·0990
Aluminum	2·25	27·4	·0821	·0821
Cadmium	8·6	112·0	·0768	·0760
Magnesium	1·74	24·0	·0726	·0726
Tin	7·2	118·0	·0619	·0651
Thallium	11·86	204·2	·0574	·0565
Lead	11·38	207·0	·0550	·0570
Sodium	0·93	23·3	·0401	·0400
Calcium	1·58	40·0	·0394	·0405
Potassium	0·86	39·1	·0221	·0230
Diamond	3·5	12·0	·2917	·3010

—*Les Mondes*, xxxi, 720. E. C. P.

9. *On a periodicity of Cyclones and Rainfall in connection with the Sunspot periodicity.*—At the recent meeting of the British Association, Mr. CHAS. MELDRUM presented a table of the cyclones of the Indian Ocean, between the latitudes of 0° and 25°S. From 1847 to 1873, 237 such storms are recorded, and in their occurrence show a marked preponderance during the periods of maximum num-

ber of sun-spots. Three such maxima occurred in 1849, 1860 and 1872, and regarding each as extending over three years, the number of cyclones is 26, 39 and 36, while in the corresponding minima of 1856 and 1867, the number is only 13 and 21. 24 hurricanes were also recorded in Mauritius between 1731 and 1850, of which 17 occurred during maxima, and seven only during minima sun-spot periods.

The examination of 93 tables of rainfall renders probable a similar periodicity in this respect also.—*Nature*, Oct. 9th. E. C. P.

10. *Secondary Currents and their Applications.*—Mr. GASTON PLANTE has been engaged for some time in the study of the form of galvanic battery called a secondary couple. He immerses two long strips of lead, rolled in a helical form and separated by thick cloth, in dilute sulphuric acid, and connects them with a primary battery of two Bunsen cells. Decomposition takes places with the formation of peroxide of lead, and after a short time removing the primary, and connecting the terminals of the secondary battery, a powerful current passes for several minutes; the apparatus forming, in fact, a sort of condensor to store up the electricity generated in the primary battery.

In a memoir recently presented to the French Academy, he states that the action is greatly improved by the following method of preparing the plates. The primary battery is first connected to charge the plates; the current is then broken, and they are allowed to rest for some time, and then reconnected with poles reversed. The plates of lead thus undergo a change not only on the surface, but throughout their mass, by the formation and reduction of the peroxide. The liquid remains unchanged, for such couples have been used for years without replacing the acid or the lead; in fact, they seem to improve with time. When the current is broken, the deposits on the surface, either of oxidized or of reduced metal, acquire a crystalline texture and a strong adherence which helps protect the subjacent layers.

A couple thus prepared, with sheets of lead half a meter square, after being charged with two Bunsen cells, will heat to redness for twenty minutes a platinum wire half a millimeter in diameter and a wire a fifth of a millimeter in diameter for an hour, without any communication with the primary source, and even forty-eight hours after it has been charged.

A battery with a surface of one and a half square meters will in like manner heat a platinum wire to redness a month after it has been charged.

Although two Bunsen cells are required to prepare the plates, yet once prepared they may be charged by a very feeble primary current acting always in the same direction. Many applications are suggested for these batteries. For instance, a small battery will heat a platinum wire so that a gas burner may be lit a hundred times without recharging, and with a larger battery three or four thousand consecutive illuminations have been obtained. They may also be associated with electric bells so as to work with the same battery. Even more, if the primary current is too feeble to ring them, the secondary battery can by its accumulated work cause them to sound for a short time, thus forming a sort of electrical flywheel or accumulator of power.

A curious effect is produced by charging a secondary couple with a Gramme magneto-electric machine. The latter is then stopped by the hand, when, on removing the resistance, it starts under the influence of the secondary couple and begins to revolve in the *same* direction in which it was turned to charge the battery. This result, which is precisely the opposite of what we should at first expect, is simply explained as follows. When the Gramme machine is turned, it generates a current in a certain direction. If now a battery is introduced which will send a current through it in the same direction, the machine becomes an electro-magnetic engine and by Lenz law will turn backward or in the opposite direction from before. But the secondary couple reverses the current, and hence the machine turns in the same direction as at first.—*Les Mondes.* E. C. P.

11. *Sound and Music: A non-mathematical Treatise on the Physical Constitution of Musical Sounds and Harmony, including the chief acoustical discoveries of Professor Helmholtz;* by SEDLEY TAYLOR, M.A., late Fellow of Trinity College, Cambridge. London: Macmillan & Co. 1873, pp. xii, 219, 8vo.—As the author states in his preface, this treatise, "portions of which have been delivered in lectures at the South Kensington Museum, the Royal Academy of Music, and elsewhere, aims at placing before persons unacquainted with mathematics an intelligible and succinct account of that part of the theory of sound which constitutes the physical basis of the Art of Music."

In thus endeavoring to remove the difficulties which non-mathematical readers find in attempting to follow and comprehend the expositions of the complicated phenomena of sound and music, the author has not lost sight of the strict scientific method. Beginning with the simplest examples of periodic motion, by an easy and natural development of the subject, the reader is led on to the consideration of waves of various kinds, as resulting either from simple vibratory motions, or from several such combined; thence to the composition of complex sounds, and the causes of the characteristic qualities of the notes of the different musical instruments and the human voice, and finally to the subject of harmony, including the discussion of the varying characters of the different concords, and discords, and of their employment in music.

The successive topics are rendered more intelligible to the unscientific reader by a great variety of illustrations, many of which are peculiarly felicitous and elegant. In this respect, although little is added to the theory of acoustics, the book is fresh and original. The most unscientific reader cannot fail to be attracted by so simple and clear a presentation of an interesting subject, while the skilled acoustician may derive from it many valuable hints and suggestions. A. W. W.

12. *Objections to the views of Mr. Moon on the measure of work;* by R. J. Adcock. (Editorial Correspondence.)—In the October number of this Journal, page 301, I find an article taken from the Philosophical Magazine for Sept., 1873, written by Mr. Robert Moon, in which he brings some apparent objections to the definition and measure of work, as used by mathematicians and engineers, and in modern school text books,—for instance Professor Bartlett's Mechanics, Prof. Moseley's Engineering and Architecture,—which objections unanswered in your Journal might retard the advancement of science.

In his quotation from Prof. Maxwell, "along a path" is left out of the definition of work, which is not done in the standard works above mentioned, and is necessary to the idea of mechanical work. Then making the correction the definition stands: "To work is to overcome a resistance continually recurring along some path." And work is therefore measured, when the moving force or resistance is constant, by the force into the distance moved. Now Mr. Moon having, I suppose, the above definition and measure of work, draws the very absurd inference, that when a constant force F acts in a given direction upon a body free to move, during the time T, that because "the resistance which is being overcome at each epoch of time" is the same, that therefore the work done in equal intervals of time will be the same throughout the motion. He says this conclusion follows without giving any reason for it, except that after showing that the work done in this case in equal intervals is not the same, in the latter part of the paragraph (1), he says the definition "implies that the work done in equal intervals of time will be equal." Now the definition, instead of implying any such thing, says nothing about time. It shows that when the force is constant, that the work is equal for equal intervals of distance. The work of a constant force over a given distance is independent of the time of motion; the time depends upon the magnitude of the mass moved and upon its initial velocity, in the case of free motion, and may have any values.

Paragraphs (2) and (3) are correct, except that he calls V a variable quantity, after having assumed it as one of the arbitrary constants. (4) is objectionable for using the term work in a sense different from the received one, and for affirming that the reasonableness of a conclusion would be difficult to establish after having just given the proof of it.

To the elementary principle of *vis viva*, that twice the quantity of work=the living force,—stated more at length, twice the quantity of work expended upon a mass between two positions in space is equal to the difference of the *vis viva* at those two positions, whatever be the path between them, straight or curved, and whatever be the time of motion,—there can be no valid objection. Every objection which I have seen, when understood, is merely an example of the application of the principle.

Lenox, Warren County, Illinois, October 18th, 1873.

13. *Chemistry, Inorganic and Organic: with Experiments;* by CHARLES LOUDON BLOXAM, of King's College, London, &c. 225 Illustrations; reprinted from the second and revised English edition. Philadelphia (Henry C. Lea), 1873. 8vo, pp. 699.—The edition of Prof. Bloxam's Chemistry, noticed a year since (iv, 496), now appears to have been first issued in this country by Messrs. Lindsay & Blackiston, from the English types—from sheets in fact printed in London and sent over to this country—and was not *a reprint*, as was then supposed. The present issue, by Mr. Lea of Philadelphia, is an American reprint of the same English edition, and so far as we have compared the two there is no verbal difference between them, although the American edition has gained in bulk a little by difference in typography. The evident regret with which the author abandons the old chemical notation for the atomic system, the "beauty and harmony of which he thoroughly appreciates," and "the immense assistance it has afforded in research," he acknowledges, is a good example of the tenacity of grasp with which old ideas hold even the most intelligent minds—after years of familiarity. We have already expressed our high appreciation of Prof. Bloxam's valuable work.

II. GEOLOGY AND NATURAL HISTORY.

1. *Contributions from the Laboratory of the University of Pennsylvania.* No. 1. *Corundum, its alterations and associated minerals;* by F. A. GENTH. 56 pp. 8vo. (From the Proceedings of the Am. Phil. Soc., Sept. 19th, 1873.)—Dr. Genth presents in this memoir the results of a great amount of labor in the analysis and study of the rocks of the Corundum localities, especially those of North Carolina. He describes the geological position and relation of the chrysolite of the region, and shows that it is true chrysolite, and not a hydrous mineral allied to villarsite, as made out by Prof. C. U. Shepard; and that it is only sometimes hydrous as a result of alteration. He gives analyses by himself of spinel, smaragdite, zoisite, oligoclase, fibrolite, staurolite, damourite, ephesite and lesleyite, paragonite, jefferisite. chlorite of different kinds, pattersonite (shown to be near thuringite), chloritoid, margarite, besides descriptions and analyses of the new chlorite-like minerals *kerrite*, *maconite*, *willcoxite* and the margarite-like species *dudleyite*. He gives evidence for believing, from the relations of other species in and about corundum crystals, and the character of their own crystallizations, that the following species have been derived from the alteration of *corundum: spinel*, *diaspore*, *beauxite*, (opposing Hunt's view of the derivation of corundum from beauxite), *gibbsite* (probably), *opal*, *zoisite*, *tourmaline* (in all probability), *fibrolite*, *cyanite*, *damourite*, *staurolite* (probably), *pyrophyllite*, *ephesite* and *lesleyite* (which are shown to be mixtures containing a large percentage of free corundum, confirming Prof. Brush's results), *paragonite*, *euphyllite*, *jefferisite*, *chlorite*, *pattersonite*, *chloritoid*, *margarite*, *lazulite*. Dr. Genth concludes as follows:

That at the great period when the chromiferous chrysolite beds (in part subsequently altered into serpentine, etc.) were deposited, a large quantity of alumina was separated which formed beds of corundum;

That this corundum has subsequently been acted upon and thus been changed into various minerals, such as spinel, fibrolite, cyanite, and perhaps into some varieties of feldspar, also into tourmaline, damourite, chlorite and margarite;

That a part of the products of the alteration of corundum still exists in the form of large beds of mica—(damourite) and chlorite—slates or schists;

That another part has been further altered and converted into other minerals and rocks, such as pyrophyllite, paragonite, beauxite, lazulite, etc.

2. (1) *Geological Survey of Illinois, A. H. Worthen, Director.* Volume V, Geology and Palæontology: Geology by A. H. WORTHEN and JAMES SHAW; Palæontology by F. B. MEEK and A. H. WORTHEN. 619 pp. large 8vo, with 32 lithographic plates. Springfield (Illinois), 1873.

(2) *Report of the Geological Survey of Ohio.* Part II of Volume I, Palæontology. Descriptions of Invertebrate Fossils of the Silurian and Devonian Systems, by F. B. MEEK. Descriptions of Fossil Plants and Fossil Fishes, by J. S. NEWBERRY. 402 pp. large 8vo. Columbus, 1873.

These two volumes will be welcomed by the geologists of the world as among the most important contributions to Palæontology which have yet been made.

The Illinois Report is the fifth volume of the series, and the fourth in which a large part of the pages is devoted to the organic remains of the rocks of the State. This new volume makes the whole number of plates of fossils—and admirable plates they all are—*one hundred and thirty*—a very noble gift from the State to science, and the record of a very large amount of faithful labor and of thorough knowledge of the subject, as well as of artistic skill. This fifth volume, for the first 320 pages, is occupied with details with regard to the geology of several of the more northern counties of the State by Mr. Worthen and Mr. James Shaw, and many important facts are given respecting the lead mines, the various rock formations, the drift, building material, soil, prairies, etc. The fossils described are species from the Subcarboniferous limestones and the Coal measures. The chapter on these comprises descriptions of over one hundred and twenty-five species of Crinoids—figured from specimens mostly of wonderful perfection—adding largely to the number illustrated in the earlier volumes; also several Palæechinoids and Star fishes, and many Mollusks. The fidelity and science of Mr. Meek appear in all parts of the paleontology.

The General Geology of the State of Ohio having been described, the volume now issued is devoted to the Paleontology of the State, which subject is here only commenced. The State is especially rich in fossils of the Cincinnati group of the Lower Silurian, in fishes of the Devonian and Carboniferous, and in the remains of Carboniferous vegetation. Mr. Meek, who has done an immense amount of good work in American Palæontology, here describes from the Cincinnati group 33 species of Crinoids, nearly all new, and 7 of star fishes (genera *Stenaster* and *Protaster*), besides a large number of species of Brachiopods and other Mollusks, and several Trilobites; and also Mollusks and Trilobites of the Devonian. The species are all finely figured from drawings mostly by Mr. W. H. Holmes. Next follows the section by Prof. Newberry on the fossil fishes of the Devonian and Carboniferous, and on coal plants. A valuable review of the classification and distribution of American Palæozoic fishes is first given. The species of fishes described from the Corniferous limestone includes 11 of Selachians and 8 of Ganoids. There are other species also from the Hamilton, Chemung and Catskill groups, and also from the Subcarboniferous and Carboniferous beds. Twenty-one species were obtained from Linton, a Carboniferous locality. The plates represent well (from drawings by Prof. G. K. Gilbert) the head of the huge *Macropetalichthys*, the jaws and teeth of the great *Onychodus*, and of the still larger and more remarkable *Dinichthys*, the great teeth of several species of *Rhynchodus*, spines of various ancient sharks, and the plates of *Placoderms*, and the forms of many small Ganoids. The chapter on plants is especially interesting for the large number of kinds of fruits described, the figures of which occupy four plates.

Prof. Newberry states that twelve nearly perfect skeletons of the *Dicotyles compressus*, a hog-like extinct species related to the Mexican peccary, have recently been obtained near Columbus, and that a description of it with plates will appear in another volume.

3. *United States Geological Survey of the Territories*, F. V. Hayden, Geologist in charge. *Photographs of* 1873.—We have received an interesting selection from the photographic views taken by Prof. Hayden's Survey in Colorado this summer, and hasten to lay before the readers of the Journal some account of the operations of the survey in this department.

The photographic work was this year again in the charge of Mr. W. H. Jackson, who has approved in previous campaigns his skill as a workman, his enterprise and persistence as an explorer, and his good judgment in the selection of his subjects. To his party were joined, during most of the summer, the collectors in natural history. They began work near the end of May, about Long's Peak; the snow prevented them from ascending the mountain itself so early. Their views of the peak, however, and of the beautiful little Estes Park at its foot, were very successful. They then moved southward through the Front Range as far as Gray's Peak, getting the whole panorama on the way, and taking from Gray's itself a connected series of views around the horizon. The same was done again from Pike's Peak, to which the party next moved, visiting on their way Chicago Lake, Bear Creek, the Platte Cañon, and the remarkable tracts of fantastically worn sandstone known as Monument Park and the Garden of the Gods. From there, they traversed South Park, and, after again taking panoramic views from Mt. Lincoln, joined near Fairplay the party of the chiefs of the survey, and accompanied them to Weston Pass, Twin Lakes, and other points on the valley of the Arkansas, across the National Range and into the Elk Mts., and finally up the Arkansas and beyond its head waters to the Mount of the Holy Cross, returning thence to Denver and breaking up on the 5th of September. Panoramic views were taken from La Plata Mt. in the National Range, and from Whiterock Mt. in the Elk group.

The total number of views taken during the campaign is nearly 300, half of them being stereoscopic, half the remainder 4×7 inch plates, and the rest the large 9×14 inch plates. They fairly cover the region traversed, in its various aspects. The interests of science were especially considered in the selection of subjects, and it was designed that the panoramic views should combine with the drawings of Mr. Holmes, the artist of the survey (drawings, it is believed, rarely equalled for their comprehensiveness, minute accuracy, and artistic truth of expression), to make the reported facts thoroughly reliable, and to bring before the apprehension of lovers of Nature, whether for her beauty or her history, the grand scenery of the grandest part of the Rocky Mts. The high panoramas will need, in part, to be judged by their intent to display the structure of regions which few have visited or can expect to visit. The lens is far behind the eye in its power to appreciate the distances in such views, and to discover the far off and faint. And while there is plenty of sublimity in scenes where heights of 12, 13 and 14 thousand feet count by scores, and vast amphitheaters and deep gorges are on every hand, they are not precisely *picturesque*, in the proper sense; they are not manageable into pictures. Those who have seen both, give the preference in this respect to the Sierra Nevada over the Colorado mountains. Especially the great volcanic peaks of the western coast, raising their majestic isolated cones from a low base, are more powerfully impressive than ranges where lines of peaks and crests of immense but equal altitude ascend from bases already at 7 to 10 thousand feet; there are few summits in Colorado which are lifted more than 6000 feet above their immediate surroundings. The barrenness of these mountains, too, as regards both white snow and green vegetation, in the mass, detracts from their effectiveness. Almost everywhere, the snow lies in summer only in lines and patches, which, though of no small absolute dimensions, are petty as compared with the great mountain masses. The only marked exception, this summer (when the snow was much less, to be sure, than the average), was the eastern amphitheater of one of the great peaks of the Elk Mts., where there is an unbroken sheet a full mile wide, and covering half a mile of downward slope. This does not appear among the views taken; the survey were able to approach the mountain only from the rear. Even here, of course, is no glacier; the snow reaches the valley below only as water, after collecting in one of those intensely green lakes which dot the high slopes of these mountains, as of the Alps; the combined beauty and grandeur of the Swiss ice-rivers is altogether wanting. At the same time, the evidences of former glacial action on an immense scale are abundant and striking, and views of them are among the most valuable of Mr. Jackson's pictures. There is, for example, the picture (taken from 1300 feet above it) of the great glacier-trough leading down from the Holy Cross Mt., and filled for miles with *roches moutonnées* on the grandest scale: sheep-backs up to 50 feet high and hundreds of feet long, all rounded and smoothed, and crowding one another so closely as to be almost impassable. The nearer views, taken from amid these ridges themselves, and showing the fallen timber with which the spaces between them are filled, give a lively sense of the delights of travelling among them. One of the most striking pictures of the series is that of this Holy Cross Mt. itself, with its white cross 1500 feet long on its front; it was to gain this view that the party (as mentioned in our October number, above, p. 299) had to climb all day with 50 pounds of apparatus on each man's back, and then to spend the night near the summit, without food or shelter. Other important glacial views are those of the great moraines at the eastern base of the National Range, along the Arkansas Valley; the most remarkable of them, stretching out from the mouth of the regular and deeply penetrating valley of Clear Creek, are two or three miles long and 700 feet high, and from the opposite heights seem as regular as railway embankments. The Twin Lakes, a few miles farther up the valley, the lovely situation and beauty of which are well illustrated by a series of views, are themselves also interesting results of glacial action, nestled between vast moraines in front and vaster mountains behind; even the narrow bar that separates them is but a terminal moraine, dropped across their basin by a peak of the retreating glacier.

In the three more easterly ranges, there is great uniformity of material; almost everything is granite and gneiss; and the variety is that of eroded form. In the National Range, especially, there is not a trace of sedimentary rock through its whole extent of 80 miles. With the Elk Mts. the case is very different; and some of their striking and peculiar features are brought clearly to light by these views. They have a wonderful variety of coloring also, which unhappily photography is unable to reproduce. From the top of Italian Mt., for example (so named from its presenting in brilliancy the Italian colors, red, white, and green), nearly the whole structure of the group can be read in the contrasts of coloring: the light gray of the granitic and eruptive nucleus, with the numberless peaks of sandstone about it, the strata conspicuously dipping away in every direction, and in two shades of red, a lighter and a darker, the latter a rich maroon color. There are few more beautiful scenes than the Grand Teocalli, as seen from the mouth of the short valley (some three miles long, and a mile broad between high walls) which leads from it down to the East River: a vast pyramid, 2,700 feet high, of most regular form, in bare steps and courses of maroon red at the summit, and with the same color, blushing, as it were, with a most peculiar effect, through the thin grassy covering of its lawn slopes.

Besides these grander views, illustrative of the geography and geology of the region, there is the usual proportion, in the usual variety, of minor items of scenery, such as waterfalls, lakes, natural bridges, bits of ravine, and strange rock forms. Conspicuous among these last are the almost incredible shapes of eroded sandstone columns in Monument Park. W

4. *Synopsis of New Vertebrata from the Tertiary of Colorado, obtained during the summer of* 1873; by Prof. E. D. Cope. Extracted from the 7th Annual Report of the U. S. Geological Survey of the Territories, F. V. Hayden, U. S. Geologist in charge; dated Washington, October, 1873. [Received at New Haven about October 15th.] 19 pp. 8vo.—These few pages, from the forthcoming Report of Dr. Hayden, are to a large extent a list of the species of vertebrates made out from the collections of the summer, with references to Prof. Cope's "Paleontological Bulletins" Nos. 15, 16. They contain also descriptions of some other new mammals, including species of *Paramys*, *Canis*, *Mastodon*, *Symborodon* (allied to Rhinoceros), and of other genera; and also some Ophidia and Lacertilia.

No copies of the numbers of the Paleontological Bulletins of Prof. Cope referred to in the pamphlet have reached this city from the author.

5. *Precious Opal from a new Mexican locality.*—Signor D. Mariano Barcema, Secretary of the "Sociedad Mexicana de Historia Natural," gives, in the 39th number (second volume) of La Naturaleza, a publication issued by the Society, under date of May 8th, 1873, an account of opals from a new locality. The locality is at the Hacienda of Esperanza, 10 leagues northwest of San Juan del Rio, in the State of Queretaro. It was first found in 1855, but not announced or appreciated before 1870. The opals are described as of the first quality, and as of all varieties, milk opals, fire opals or girasols, "harlequins," and various kinds of the richest precious or Hungarian opals. The specimens sent the writer fully sustain Signor Barcema's descriptions. The "harlequins" are exceedingly beautiful, being a fire opal spangled within with brilliant green points, or like a most delicate mosaic, as Signor Barcema expresses it, of fire-red and metallic emerald. The precious opals vary from perfect pellucidity with green and fire-red flashes, through pale and deep reddish shades, to opaque white; and the last kind, with its no less brilliant green and red opalescence, is of remarkable beauty. One variety of the precious opal gives violet reflections; and another emerald with dark ultramarine.

These opals are described as occurring disseminated through a reddish quartziferous porphyritic rock; it looks like a tufaceous porphyritic rock. The ordinary reddish color of the opals is described as varying with the color of the containing rock. The fact is mentioned that the opals are more or less hygroscopic, and change in specific gravity with the moisture of the atmosphere.

J. D. D.

6. *Movements of the Glands of Drosera;* by A. W. BENNETT. A paper read at the Bradford meeting of the British Association, Sept. 20th.—A clear account of the facts, of late years familiar, thanks to Mr. Darwin, now confirmed by independent observations. Mr. Bennett observed not only the bending in of the glands upon the body of the insect, but that "the sides of the leaf had also slightly curved forward, so as to render the leaf itself more concave." With us, the leaves do much more than that. As well in *D. rotundifolia* as in *D. longifolia*, the end of the leaf folds over upon the base, or nearly, like a shut hand, thus fairly enclosing the captive. Plants showing this daily were growing, in wet moss, in our class-rooms through the summer. When we published Mrs. Treat's account of this infolding of the leaf, in this Journal, in November, 1871, and afterward in How Plants Behave, the discovery was thought to be new. But we find that the infolding of the leaf, as well as the intrusion of the glands, was discovered by Roth in 1779, and published by him in his Beyträge zur Botanik, in 1782, part 1, pp. 60–66. The only real addition to our knowledge—this old knowledge, recently reproduced—is that contained in the latter part of Mr. Bennett's communication, which is substantially to the effect that *Drosera* acts upon bits of raw meat just as upon a living insect, but is motionless toward inorganic bodies, and, in his experiments, to bits of wood and of worsted. In the report of Mr. Bennett's communication, given in Trimen's Journal of Botany, and elsewhere, no allusion is made to the history and record of all these discoveries. But as Dr. Sanderson, in a succeeding communication, referred to this last point as one which had been clearly made out by Mr. Darwin, it is as well to state that the following paragraph refers to him.

"Another and most practiced observer, whose observations are not yet published, declares that the leaves of the common Round-leaved Sundew act differently when different objects are placed upon them. For instance, if a particle of raw meat be substituted for the living fly, the bristles will close upon it in the same manner; but to a particle of chalk or wood they remain nearly indifferent." (How Plants Behave, p. 44.)

We have for several years been urging Mr. Darwin to publish the results of these and other (some of them still more curious) observations and experiments upon *Drosera* and *Dionæa*. A. G.

7. *Fly-catching in Sarracenia.*—Referring to our note on this topic in the August number, p. 149, we have, first, an oversight to correct. For "Mr. Hill of North Carolina," read Mr. B. F. Grady, Jr., of Clinton, North Carolina. Our correspondent in-

forms us that he published an account of his observations three years ago in the Carolina Farmer, published at Wilmington; and that this was copied into a Montgomery (Alabama) paper, but he is not aware that it attracted further attention. The author of the paragraph referred to, in the English translation of Le Maout and Decaisne's book, does not remember his authority for the statement there made. In a recent letter, Mr. Brady gives an account of observations repeated last summer upon the pitchers of *Sarracenia flava.* "These, brought into the house, and kept fresh by the immersion of the base in water, showed the saccharine secretion most abundantly about a quarter of an inch above the junction of the lid with the rim. . . . . Many flies settled on the lids and feasted on the saccharine narcotic. Evident signs of intoxication were manifested in each case, by their breaking loose repeatedly before tumbling into the gulfs."

Sarracenia Drummondii is the species which most closely resembles *S. flava* in the shape and structure of the pitcher. We now learn from a letter addressed by Dr. Chapman to Mr. Canby, that the former is well aware of a similar excretion in that species. "On the inside of the hood," he writes, "above its junction with the tube, there is a very faintly sweetish secretion, scarcely perceptible to the taste, which is very attractive to insects; and, as I do not detect any of this within the tube, I wonder how it happens that so many insects are entrapped, since they could easily fly away from the open hood." Mr. Brady's observations are here to the point; but wider confirmation is desirable, especially as to the narcotic character of the secretion, which needs abundant evidence. And the other species should now be scrutinized.

A. G.

8. *Engelmann; Notes on the Genus Yucca.* Extr. from *Trans. Academy of Science of St. Louis*, vol. iii. April, 1873.—This modest title comprises the principal results of Dr. Engelmann's long study of a difficult genus of plants. Pursuing his botanical investigations now for many years only in the intervals and spare moments of a busy and exacting professional life, Dr. Engelmann has made them tell most effectively and advantageously upon the science which numbers him as a distinguished votary, by taking up one subject at a time, and investigating it as thoroughly as possible. In this way he has mastered, in turn, our *Cuscutæ* (upon which his earliest essay was published in this Journal, thirty-one years ago, and his latest was a full monograph of all the known species throughout the world), our *Cactaceæ*, our Mistletoes, Euphorbias, *Junci*, *Callitriches*, etc., not to speak of several other genera or groups, or taking account of his sedulous and long-continued study of our Oaks and, above all, of our *Coniferæ.* Nor need we look to this as the close of the series, but rather see before him "fresh fields and pastures new," and wish for him more time to expatiate in them. Upon the principle, "to him that hath shall be given," he well deserves it, as having accomplished far more in these rescued moments than others who could mainly devote their days as well as nights to scientific work.

Almost without exception these monographs relate to difficult subjects, and such as require long-protracted investigation. This is also true of the present essay upon the genus *Yucca.* It is not a large one, only a dozen species being clearly made out; but those of long cultivation in Europe have been much confused, and recent ones described without flowers, while fruit is rarely formed out of their native stations, and dried specimens of any completeness are difficult to make, so that means of comparison are much restricted.

The true anthesis, as is now shown, is nocturnal, the flowers remaining half closed during the day. The anthers, with comparatively large and few grains of glutinous pollen, open rather earlier than the flower. The tips of the style, which were naturally taken for stigmas, are now shown to be functionless, the stigmatic surface being the moist and glutinous lining of a stylar tube, which extends downward nearly to the cells of the ovary and even communicates directly with them. As soon as it became evident that fertilization must depend upon nocturnal insects, it was found that they were most frequently and regularly visited by "white moths, which, usually in pairs, disported in the open flowers at dusk, and were found quietly ensconced in them when closed in day-time." Prof. Riley of St. Louis, the distinguished entomologist, was at this point associated with Dr. Engelmann in the investigation. The result has been given to the scientific world in his interesting memoir on *Pronuba yuccasella*, first read at the Dubuque meeting of the American Association for the Advancement of Science, in August, 1872, and now also published, as a sequel to Dr. Engelmann's monograph, in the Transactions of the St. Louis Academy.

"The rootstock of all the Yuccas is, under the name of *Amole*, an important article in a Mexican household, being everywhere used as a substitute for soap, as it is replete with mucilaginous and saponaceous matter, probably a substance analogous to the saponine of the *Saponaria* root. It is curious to learn that the negroes of the coast of South Carolina repeatedly destroyed Dr. Mellichamp's carefully observed clumps of Yuccas, in order to obtain the saponaceous rootstock." In Colorado Territory we found that *Yucca angustifolia* is as generally called "Soap-plant," as is the *Chlorogalum* in California.

While the nature of the fruit, whether capsular or baccate, is a tribal character in *Liliaceæ* generally, *Yucca* has both kinds; and Dr. Engelmann turns this character, with accompanying differences in the seeds, to good account in the systematic arrangement of the species. The common "Spanish Bayonet," *Y. aloifolia* of the Southern States, and some related Texan and Mexican species, represent the pulpy-fruited section; *Y. brevifolia*, which ranges across the Arizonian border of the United States, has a spongy indehiscent pod, probably at first more or less drupaceous; while the Bear-Grass, *Y. filamentosa*, and its allies bear a dry capsule. It may here be recorded that the name *Y. canaliculata* of Hooker must replace that of *Y. Treculiana* of Carrière, the latter being a name published without character, in 1858, the former described and figured in 1860, in the Botanical Magazine. The prince of Yuccas must be *Yucca baccata*, which, in its variety *australis*, forms "trees twenty-five to thirty feet high, and two or three feet in diameter, with ten or a dozen branches," or sometimes reaches to even fifty feet of elevation, according to the late Dr. Gregg, although the most northern form of it is almost stemless. Its pulpy fruits are "savory, like dates," are eaten fresh by both whites and Indians, and are cured by the latter for winter provisions. They also make a stew of the flower-buds and flowers, which Dr. Palmer found to be pleasant and nourishing. The seeds are said to be actively purgative. The fibers of the leaves are used for cordage, the trunks for palings, or are riven into slabs for the covering of huts, and the tender top of the stem is roasted and eaten.

Professor Riley's curious paper upon the mutual relations of Yuccas with *Pronuba*, a Tineideous moth that does the work of *pollination*, will be read with interest. A. G.

9. *On some remarkable Forms of Animal Life from the Great Deeps off the Norwegian Coast, partly from posthumous manuscripts of the late Professor Dr. Michael Sars;* by GEORGE OSSIAN SARS, quarto, with 6 copper-plates. Christiania, 1872.—This highly interesting and important memoir, which is written in English, contains very complete descriptions of a considerable number of the more remarkable deep-sea animals discovered by the author. The plates are excellent. The following species are described and figured: of Polyzoa, *Rhabdopleura mirabilis*, *Flustra abyssicola*; of Conchifera, *Yoldia obtusa*, *Pecchiolia abyssicola* (gen. nov.); of Cephalophora, *Dentalium agile*, *Triopa incisa*, *Goniëolis typica;* of Annelida, *Umbellisyllis fasciata* (gen. nov.), *Paramphinome pulchella* (gen. nov.); of Anthozoa, *Mopsea borealis*, *Fungicyathus fragilis* (gen. nov.); of Spongiæ, *Trichostemma hemisphæricum* (gen. nov.), *Cladorhiza abyssicola* (gen. nov.), *Hyalonema longissimum*.

The last named species has been found during the two past summers on our own coast, at moderate depths (see page 440), and *Cladorhiza abyssicola* was dredged in the deeper parts of the Gulf of St. Lawrence last year, by Mr. Whiteaves, who sent me a specimen for identification, agreeing in size and form with the larger one figured by Sars. By a most unfortunate error, Dr. Wyville Thomson* has applied this name to an entirely different genus of sponges, and for the true *Cladorhiza* he has constituted a new genus under the name of *Chondrocladia* (op. cit. pp. 187, 188, fig. 36), although he stated (p. 49) that he had examined the types of Sars' species.

---

* Depths of the Sea, by C. Wyville Thomson, 1873, p. 112. The species figured by Thomson (p. 187, fig. 45) as *Chondrocladia virgata* is stouter and less branched than *C. abyssicola*, and is probably a distinct species. It should, therefore, be called *Cladorhiza virgata*.

A species belonging, apparently, to the genus *Trichostemma* was also dredged by us during the past summer, off Cape Elizabeth, in 40–70 fathoms, adhering to stones; but it is larger, less regular in form, and more setose at the surface than the species described by Sars. A. E. V.

10. *Bidrag til Kundskaben om Norges Hydroider* (Vidensk.-Selsk. Forhandlinger, for 1873), with 4 "autographic plates;" by G. O. SARS.—This paper contains a complete list of the Norwegian Hydroids, with their geographical and bathymetrical distribution; descriptions and figures of a large number of new species and genera; and a review of all the deep-water species. Many of these species are found also on the coast of New England, and the work is therefore an important one for students of American marine zoology. The peculiarly executed figures are numerous and very characteristic, though not so finely wrought as most of those for which we are indebted to the skill of the author. Among the new species described are several that we have recently dredged on the New England coast. Of these the *Halecium gorgonoide* of Sars (p. 24, plate IV, figs 5–15) appears to be identical with *H. robustum*, described by us in December, 1872 (this Journal, vol. v, p. 9).

The *Acaulis primarius* Stimpson is well figured (plate v, figs. 14–20), and is represented as having a small and short but distinct stem. A fact that we had also ascertained several years ago*—but in our specimens, from the Bay of Fundy, the stem is longer and very slender. A. E. V.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On the Earthquake of October*, 1871, *and on a swarm of Locusts at Cordoba.* Letter from Dr. B. A. GOULD, to the Editors, dated Cordoba, September 8, 1873.—Since writing you a month ago, I have received additional data concerning the times at which the severe earthquake of July 6th and 7th took place in sundry places. These confirm beyond doubt the inference that the shocks of Sunday afternoon in the northern provinces, and of the subsequent night in the western ones and Chile, were perfectly distinct phenomena, although both of exceptional severity. The want of standards of local time makes it impossible to deduce any accurate data regarding the velocity of the wave. But from Valparaiso, which receives its time from the Observatory at Santiago, the moment of first shock is reported as 2^h 21^m 30^s. Sant. time. And from Mendoza, whither, as also to the other stations of the Transandine line, the time is transmitted weekly from this observatory, the moment is reported as 2^h 30^m, which when converted into Santiago time becomes 2^h 21^m 37^s, showing at least that the moment of occurrence at these two places could not have been very different. But from San Juan, the longitude of which differs probably by less than a minute from that of Mendoza, the time of the first shock is reported as 2^h 20^m A. M.

---

* Bulletin Essex Institute, vol. iii, p. 4, Jan., 1871.

I have recently been witness to one of the remarkable phenomena of this region, the passage of a swarm of locusts. On the 13th of August our attention was attracted and indeed forcibly diverted from all other objects by the myriads of large grasshoppers which filled the air, invaded the houses, and covered the ground, from which they rose like thick clouds of dust when disturbed by the approach of man or beast. Going out to observe the phenomenon more closely, I saw to the eastward what was apparently a long trail of dense black smoke, extending over 160° of the horizon, from which it extended to an altitude of about 5 degrees. The appearance differed in no respect from that of black smoke drifting from a large conflagration; but a strong field glass showed me that the servants were correct in assuring me that it was no smoke but a swarm of locusts. How wide this swarm was there was no means of judging, but from the position of the focus needed for resolving this animated nebula at its point of nearest approach, I estimated that none of the swarm passed within less than three or four miles of us. The insects were evidently transported by the wind, which blew from the north with a velocity of about ten miles an hour, and gave to the train of locusts all the wreathed and branched forms of drifting smoke. This was before 10 A. M.: how long they had been passing I know not, but the head of the column had passed far out of sight, and certainly twenty miles of its length were visible over the far-stretching pampa. They continued to pass in apparently undiminished number until the daylight failed. Meanwhile the stragglers, which had visited us in such profusion, disappeared; and the next day single specimens could with difficulty be found.

On the 1st of September the phenomenon was repeated, the insects returning from the south borne on a wind which moved at 5 or 6 miles an hour. They were descried at a distance of certainly not less than a dozen miles, moving directly upon us; but the wind hauled from S. to S.E. an hour later and saved us. The change of direction was very manifest, and the effect of the change of wind could be seen as it successively reached the different parts of the long procession. The Sierra, which extends N. and S. immediately west of Cordoba, the foothills rising at the distance of about 12 miles, barred their westward progress, and the train passed between us and the Sierra for many hours. I was able to fix the height of the swarm by sighting against the peaks, and ascertaining on the following day the distance at which they had passed. The altitude of the upper limit of the densest portion seems to have very slightly exceeded 7°, the distance of its near limit being about six miles. Thus the height of the dense nucleus seems to have been not less than 2000 ft., its width being here not more than six or seven miles, possibly less; the whole environed by a penumbra of copious stragglers. Yesterday and the day before, the north wind brought them back again for some hours of each day, but to-day the wind has returned to the south, and since I began this page they have come upon us in full force, literally darkening the sun, and at this moment of writing there is probably not a square inch of our grounds unoccupied by them. The sunlight on the floors presents a singular aspect, the crowded little shadows streaming rapidly across it and interrupting the greater part of the light.

2. *Remarks on the chemical analyses of samples of soil from Bermuda*, by his Excellency Major-General J. H. LEFROY, Governor and Commander-in-Chief. 46 pp. 8vo, 1873.—The analyses of soils of a coral island like Bermuda have a special interest. Major-General Lefroy adopts the conclusion of Professor Wyville Thomson, that the red soil, which occurs on some parts of the island, and contains very little lime, is a result of the solution and removal of the carbonate of lime of the coral rock and the consequent leaving behind of all insoluble matters which the seawater and organic sources may have contributed to it, with perhaps some extraneous additions. The average of the results of analyses of the red soil by Johnston and Manning afford organic substances, in 100 parts, 15·41, lime 5·95, magnesia 0·36, alumina 16·94, silica, or sand and insoluble clayey matters 36·60, oxide of iron 19·58, potash 0·14, soda, chiefly as common salt, 0·03, carbonic acid (combined with lime and magnesia) 4·06, sulphuric acid 0·02, phosphoric acid 0·70, chlorine (chiefly as common salt) 0·015. The white soil of the island contains 52 per cent or more of lime and 42 or so of carbonic and with 3·8 to 5 per cent. of organic matter and small proportions of other ingredients; and it is therefore mainly carbonate of lime.

3. *Report of the Director of the New York Meteorological Observatory, Department of Public Parks, City of New York, for the year ending December 31st*, 1872. 48 pp. 8vo. New York, 1873.—The question, Has the temperature of the Atlantic States undergone modification, considered in the Report of last year, receives further consideration in this Report, with a citation and approval of the conclusions of Profs. Loomis and Newton—that there is no evidence from meteorological observations of the last seventy years of any change. The Report discusses also and illustrates by diagrams the direction in which atmospheric fluctuations cross the United States, and closes with various meteorological tables.

4. *Munificent Gift to Science.*—Lafayette College, at Easton, Pennsylvania, has recently received gifts from Mr. Ario Pardee to the amount of nearly half a million of dollars. These gifts include a building for the scientific department, erected at an expense of $250,000. "Pardee Hall" was dedicated on the 21st of October. The orator of the occasion was R. W. Raymond, President of the American Institute of Mining Engineers. The hall has a front of 256 feet, and is built of Trenton brown stone, with trimmings of the light Ohio sandstone. It has laboratories for chemical, metallurgical, mineralogical, and other scientific purposes.

5. *Rocky Mountain Observatory.*—Mr. JAMES LICK of California, it is reported, is about to make a second great gift to Science.

He has offered to bestow upon the California Academy of Sciences an observatory, erected and equipped with the best and largest instruments, on some elevated point in the Sierra Nevada, at least 10,000 feet above the sea. In such a situation and well manned, it would work wonders in the way of astronomical discovery.

6. *Palladium.*—An ingot of this rare metal, valued at about $10,000, was exhibited at Vienna the past summer in the English department, having been extracted from about $5,000,000 platiniferous gold.—*Address of Dr. R. W. Raymond before the Am. Inst. of Mining Engineers.*

7. *Sulphur product of the World.*—In 1871 the Italian (Sicilian)
mines of sulphur produced .... 6,860,000 cwt.
The rest of the world in the same year produced .. 152,500 "
7,032.500
Equal in gross tons to 351,625

The quantity of sulphur produced from the roasting of pyrites is insignificant, this industry being occupied almost exclusively in the production of sulphuric acid.—*Ibd.*

8. *Report on the Fossil Plants of the Lower Carboniferous and Millstone Grit formations of Canada;* by J. W. Dawson. From the Reports of the Geological Survey of Canada. 48 pp. 8vo, with 10 plates.—This memoir extends greatly our knowledge of the Lower Carboniferous Flora. It also contains a list of the species of the Middle and Upper Coal Measures, and discusses the character of Sigillarioid and Lepidendroid stems.

OBITUARY.

August Breithaupt.—This venerable mineralogist died at Freiberg, Saxony, on the 22d of September, in the 83d year of his age.

His services as instructor in mineralogy commenced in 1813, with private lessons to students in the Royal Saxon Mining Academy. He was also at this time appointed Government Inspector of precious stones, and Administrator of the Mineralien-Niederloge. In 1817, on the death of Werner, he was called to complete the unfinished course of lectures in mineralogy in the academy, and in 1826, on the resignation of Mohs, he was appointed professor of mineralogy, a position he held at the time of his death, although relieved from active service several years since. For over half a century, Professor Breithaupt has been one of the most active investigators in mineralogy in Europe, describing a very large number of new species, and contributing a mass of observations of great value to science. He was the author of several mineralogical treatises, including a work on the paragenesis of minerals.

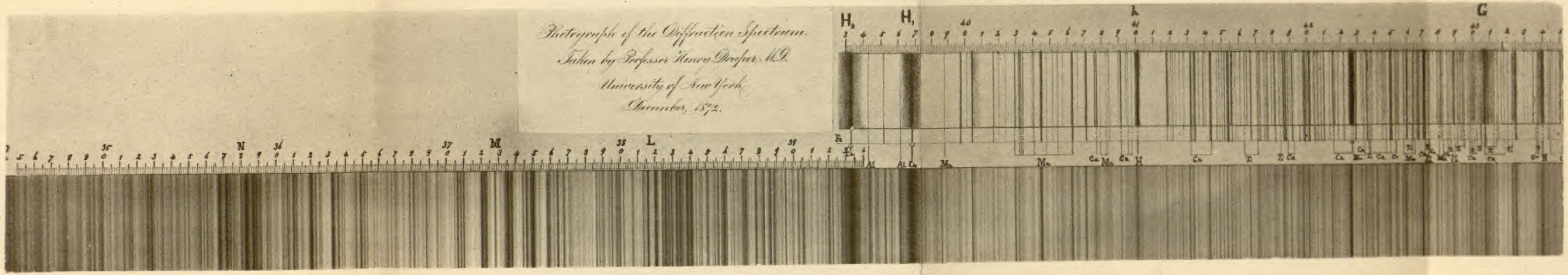
The grand collection of minerals in the Mining Academy, which he was chiefly instrumental in bringing together, remains as evidence of his untiring energy and disinterested devotion to the science of mineralogy and to the welfare of his beloved institution.

George C. Schæffer died, October 4th, at Washington, in his 59th year.

INDEX* TO VOLUME VI.

---

* The Index contains the general heads Botany, Geology, Mineralogy, Zoology, and under each the titles of Articles referring thereto are collected.



Photograph of the Diffraction Spectrum.
Taken by Professor Henry Draper, M.D.
University of New York.
December, 1872.