THE

AMERICAN GEOLOGIST.

A MONTHLY JOURNAL OF GEOLOGY

AND

ALLIED SCIENCES.

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The American Geologist, Prospectus for 1889.

The editors of *The American Geologist* announce the continuance of the periodical during the year 1889, under the same general plan as in the past. The leading purpose is to give expression to American thought on geological themes, and to offer a medium of ready communication for educational, biographical and bibliographical information, and geological news.

They hope the working geologists of the country will continue to favor it with their interest and co-operation, and will bear in mind the fact that no other journal on the continent devotes its entire means and energies to an adequate representation of the science which brings all other sciences under contribution. The editors hope *The Geologist* will become generally recognized as the organ of geological opinion and interests in America; and that briefer memoirs and items, especially those not designed for final publication, may be directed to its pages for presentation to the public.

It is the editors' intention, also, to continue and improve the treatment of geological themes connected with education. They have not yet been able to accomplish all which has been in intention from the beginning; but the purpose is to embrace under educational topics the discussion of questions relating to the place of Geology in Education; the exhibition of methods and devices for the presentation of geologic facts and doctrines, and the description and illustration of the scientific resources of leading Universities—especially those of the West, as being least known. In respect to geological biography, it is intended to offer brief memoirs accompanied by portraits, commemorative of deceased geologists who have done worthy service for science. In geological bibliography the editors still hope to supply information somewhat full and complete, together with critical notices and reviews of the most noteworthy publications.

The Geologist appeals for support to the intelligence of America; especially to those able to devote some time to geological reading; to those interested in the teaching of Geology and in the advancement of geological instruction in the schools. The editors hope the list of subscribers may be largely recruited with the beginning of the second year; and they beg each old subscriber to constitute himself an agent for the procurement of a new name.

With three hundred working geologists in the country, as there are, and many thousand intelligent readers of geological literature, the editors confidently anticipate a noble support for the only literary representative of geological learning and interests in the journalism of America.

The subscription price will be $3.50 per year in America, and $3.75 in foreign countries of the *Postal Union*. The general European agent is Mr. W. P. Collins, 157 Great Portland st., London W., England. Correspondence may be addressed to any of the editors, or to

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THE AMERICAN GEOLOGIST,
Minneapolis, Minn.

Roland D. Irving

THE

AMERICAN GEOLOGIST

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ROLAND DUER IRVING.

By President T. C. Chamberlin.

Professor Irving was born in the city of New York, on the 29th day of April, 1847. His father, the Rev. Pierre P. Irving, was a clergyman of the Episcopal church and a nephew of Washington Irving. His mother was a daughter of chief justice John Duer, of the supreme court of New York. Sprung thus from a family of literary talent on the one side and of judicial on the other, professor Irving inherited tastes and capabilities that especially fitted him for his subsequent work. His birth and early education in the metropolis of our country impressed upon him something of the breadth and complexity of its commercial, social and intellectual activities and gave to a mind naturally disposed to large and analytic conceptions a pronounced breadth and a discriminative habit. His youth was spent upon Staten Island, to which his father had removed in his second year. A lack of entire robustness of health, emphasized by frequent attacks of illness and a weakness of sight, interfered with systematic study and checked the indulgence of his passionate fondness of reading. His early training was therefore conducted mainly at home, his father and sisters being his chief instructors. It was only in his 12th year that he entered school. His dominant studies were classical, but he was fortunate in falling under the instruction of a teacher whose frequent rambles with his pupils fostered a love for natural history. Young Roland became especially interested in the collection of the rocks and minerals that were accessible upon the island. The identification and classification of these may be looked upon as the inititation of his subsequent scientific studies. In 1863 he entered the classical course of Columbia College. Forced by the condition of his eyes to suspend his studies in his sophomore year, he spent six months in England, the impress of which in certain choices of language and methods of thought remained with him throughout his life. On his return he was able to resume studies, though it was necessary that the greater part of the texts should be read to him. This probably strengthened a memory naturally retentive and drove him to meditative and independent thought, since he was measurably cut off from indulgence in simple acquisition. A full course in the School of Mines, of Columbia College, gave him the technical foundation for his future work.

During two of his summer vacations he found employment and practical experience in the coal mines of Wiconisco, Pennsylvania. Soon after graduation he was appointed superintendent of the smelting works at Greenville, New Jersey. Following this he was employed during parts of two years upon the Ohio geological survey. His career thus far had lain chiefly in the line of technical work. From this he was turned aside in 1870 by a call to the department of geology, mineralogy and metallurgy in the University of Wisconsin, and from that time onward his activities took two parallel lines, instruction and investigation. As an instructor his work was characterized by thoroughness, by a masterly command of the subjects he taught, by clearness of presentation and a graphic and humorous exposition, by perfect candor and sincerity, by earnestness, devotion and indefatigable industry—a rare combination of qualities, which made him not only a singularly effective instructor, but a worthy leader in all those moral and manly influences which characterize the true teacher.

Professor Irving's first independent geological investigation consisted of the demonstration that the Baraboo quartzites of central Wisconsin are very much older than the adjacent upper Cambrian sandstone (Dikelocephalus horizon,) which was at the time a battled question.* Shortly after he made similar investigations on the quartzites near Waterloo, Dodge Co., Wis.†

Upon the inauguration of the recent geological survey of Wisconsin, (1873,) professor Irving was appointed one of the three

*On the Age of the Quartzites, Schists and Conglomerates of Sauk Co., Wis. Am. Jour. Sci., vol. III, Art. XV, p. 93. The same in Trans. of Wis. Acad. of Sci. Arts and Letters, vol. II, pp. 107-119.

†Note on the Age of the Metamorphic Rocks of Portland, Dodge Co., Wis. Am. Jour. Sci., Vol. V, Art. XXXI, p. 282.

commissioned assistant geologists and began his well-known investigations in that connection. During the first year he was assigned to the study of the Penokee iron range. He was here compelled, at the outset of his official career, to encounter unwarranted expectations raised by previous flattering opinions respecting the richness of the iron deposits given by incautious and inexpert explorers. His perfectly candid and unreserved report brought the usual reward of frankness and sincerity in the face of opposing desire, at first a storm of protest and of adverse criticism, which even threatened the existence of the survey, later, a sullen acquiescence in the truth, and finally, an admiration for the correctness and the courage of the position taken and a diversion of enterprise from unprofitable into successful lines of exploitation. In the second and third years of the survey professor Irving's field embraced the Paleozoic and Archæan strata of central Wisconsin. In the last years he returned to the lake Superior field and laid the broader foundation upon which nearly all of his subsequent investigations were based. The results of his studies in this official relationship are recorded in the four volumes of the reports of the Wisconsin geological survey, (1873-1879). Meanwhile he had published several short articles in the American Journal of Science, the Trans. of the Wisconsin Academy, and elsewhere. Among these the more important are the "Age of the Copper-Bearing Rocks of Lake Superior and the Westward Continuation of the Lake Superior Synclinal."* "Some new points in the Elementary Stratification of the Primordial and Cambrian Rocks of south central Wisconsin."† "The Stratigraphy of the Huronian Series of northern Wisconsin, and on the Equivalency of the Huronian of the Marquette and Penokee Districts."‡

In 1880, professor Irving began those investigations upon the geology of the lake Superior region for the United States government which continued until the time of his death. The first of these consisted of a comprehensive study of the copper-bearing series, the results of which he gathered into a monograph which perhaps stands as the best single expression of his

*Am. Jour. Sci., vol. VIII, Art. VII, p. 46, 1874.

†Am. Jour. Sci., vol. IX, Art. VII, p. 440, 1875.

‡Am. Jonr. Sci. vol. XVII, Art. XLIX, p. 393, 1879.

work.§ This was the first approach to a unified and systematic discussion of this great formation occupying a tract of 40,000 square miles and embracing portions of Michigan, Wisconsin, Minnesota and Canada. Whatever differences of opinion may continue to exist concerning the interpretation of the debated phenomena, this must ever be recognized as a monument of industrious and able investigation and of candid and careful induction. Following these studies upon the copper-bearing series, professor Irving took up in a correspondingly comprehensive manner the investigation of the iron-bearing formations of the lake Superior region and their correlation with each other and with the original Huronian of Canada. Upon this work he was engaged at the time of his death. He had in preparation and nearing completion a monograph upon the Penokee-Gogebic range and had well in hand a large amount of material relating to the Marquette, Menominee and Vermilion lake series, as well as the original Huronian and Animike groups. His loss at this fruitful stage of his work, incalculable as it is, might have been still greater but for the fact that all his material passed into the hands of his co-laborer, professor Van Hise, who is intimately familiar with his unwritten as well as written views.

Some of Dr. Irving's leading conclusions from his later studies were set forth in his presidential address before the Wisconsin Academy of Science Arts and Letters, entitled "Divisibility of the Archæan in the North-west,"* and more especially in the following very notable papers: "Preliminary Paper on an Investigation of the Archæan Formations of the North-western States,"† "On the Classification of the Early Cambrian and Pre-Cambrian Formations. A Brief Dissussion of Principles; Illustrated by examples drawn mainly from the Lake Superior Region,"‡ "Origin of Ferruginous Schists and Iron Ores of the Lake Superior Region,"|| "Is there a Huronian Group?"¶ and the introduction to a forthcoming Bulletin of

§"Copper-Bearing Rocks of Lake Superior." Monograph V., U. S. Geol. Survey, 1883.

*Am. Jour. Sci., vol. XXIX, pp. 237-249, 1885.

†U. S. Geol. Survey, Fifth Annual Report, pp. 181-241, 1885.

‡U. S. Geol. Survey, Seventh Annual Report, 1886.

||Am. Jour. Sci., vol. XXXII, p. 255, 1886.

¶Am. Jour. Sci., vol. XXXIV, pp. 204-249, 1887.

the U. S. geological survey, "On the Greenstones of the Menominee and Marquette Regions," by Dr. G. H. Williams.

During these later years in which he was chiefly engaged upon monographic studies, he published numerous special papers, among which the more important were, "On the Nature of the Induration of the St. Peter's and Potsdam Sandstones, and of certain Archæan Quartzites in Wisconsin,"* "Paramorphic Origin of the Hornblende of the North-western States,"† "On Secondary Enlargements of Mineral Fragments in Certain Rocks,"‡ (jointly with professor C. R. Van Hise), and "The Junction between the Eastern Sandstone and the Keweenawan Series on Keweenaw Point,"§ (jointly with president Chamberlin).

Professor Irving's greatest contributions to science lay in the department of structural geology and genetic petrography. His investigations upon the great copper and iron-bearing series and the adjacent formations of the lake Superior region, constitute a contribution of the first order. The deep sympathy of the present writer with professor Irving's views on questions that have been subjects of divergence of opinion should perhaps restrain him from a full expression of his appreciation of the profound value of this work lest a color of personal partiality be thrown over this sketch, but it is not too much to assert that supporter and opponent alike recognize the ability which has characterized these investigations and the high order of value which must attach to them whatever interpretations may finally prevail.

In the line of petrographic genesis professor Irving made two very notable contributions, first, the demonstration of the prevalence and importance of the secondary growth of certain fragmental constituents of clastic rocks and the crystallographic co-ordination of the additions with the nuclear particles. The existence of such a second growth in quartz grains was an earlier discovery of others but was hit upon by him independently. Jointly with his co-laborer, professor Van Hise, he demonstrated a similar second growth of hornblende and other

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*Am. Jour. Sci., vol. xxv, p. 401, 1883.

†Am. Jour. Sci., vol. xxvi, p. 321, 1883.

‡U. S. Geol. Survey, Bulletin No. 8.

§U. S. Geol. Survey, Bulletin No. 23.

minerals and showed that such rebuilding was a prevalent process, constituting an important element in those changes heretofore designated metamorphic, thereby contributing an important factor in the elucidation of that mysterious process.

Perhaps the most important single determination by professor Irving, and one of his latest, was the demonstration of the origin of the iron ores of the lake Superior region. By a series of admirable investigations he traced step by step the transformation of the ores from original earthy carbonates of iron to their present forms, and made it altogether clear that they were primarily deposited as sediments in a manner closely similar to that of the iron ores of the Coal Measures. This discovery has given added significance to the association of these ores with carbonaceous shales, and has led to the recognition of the iron-bearing series as marking in some sense a pre-Cambrian carboniferous period.

The characteristics of professor Irving as a scientific investigator and writer are too well known to the readers of this magazine to need analysis here. Personally, to those who came within the circle of his intimate acquaintance, he possessed rare charms of character. Sincere, frank, conscientious in the highest degree, he was a warm and true friend. Possessed of a rollicking brusque humor, his intercourse was marked by a freshness that was a source of constant enjoyment and attraction to his intimate associates. No phrase better expresses it than picturesqueness. Modest and retiring, the number of his close friends was not large but their attachment to him was strong. The full strength of these attachments has only been realized in their breaking.

He leaves a wife, a daughter and two sons. The artistic skill of Mrs. Irving appears in some of the sketches and particularly in many of the microscopic illustrations of her husband's works.

THE GEOLOGICAL HISTORY OF THE OZARK UPLIFT.*

By G. C. Broadhead.

To the southern part of Missouri, the general term "Ozark Mountains" has for a long time been applied. This district

*Abstract read before American Association for the Advancement of Science; Cleveland meeting, August. 1888.

may include about 36,000 square miles within the state of Missouri, and is chiefly limited on the east by the Mississippi river and a line not very far west of that river, but excluding the most of St. Louis county and 3,000 square miles of the swamp district in the south-east. Its western limit is an approximate line passing south-west from Glasgow, via Marshall and Sedalia, thence near the line of the M. K. & T. R. R. to the Osage river, thence southwardly to Stockton, and south-westwardly to and beyond McDonald county. Its southern boundary is not far from the Arkansas river.

The Ozark plateau, near its eastern line, is 700 to 800 feet above the sea, and about the same elevation on the highlands near its northern line. The Archæan peaks of south-east Missouri rise 1,200 to 1,500 feet above the sea, while the unaltered sedimentary rocks surrounding them are but little over a 1,000 feet above the sea, increasing in elevation as we pass westward, until in Webster county they are 1,500 feet, in Wright county 1,700 feet and in Barry county over 1,500 feet above the sea. A little further west along the state line the elevation is 800 to 1,050 feet, reaching to over 1,100 feet in north-west Missouri, and in the south-west increasing still more in the direction of the Boston mountains.

A little beyond the western line of Missouri there begins a rise gradually increasing as we pass westward across Kansas, while on the east just across the Mississippi the general surface maintains a nearly uniform elevation but very little over 500 feet above the sea in southern Illinois.

The rock structure of this plateau includes the Magnesian limestone series of the Missouri geological survey, the equivalent of the calciferous sandrock of the New York system, or the Upper Cambrian as defined by C. D. Walcott.

Dr. Shumard's measurements have given:

	Pulaski.	Phelps.	Franklin.
First Saccharoidal sandstone, ...	....	30 ft.	175 ft.
Second Magnesian limestone,.............	....	150 ft.	300 ft.
Second sandstone,.........................	100 ft.	150 ft.	140 ft.
Third Magnesian limestone, ...	600 ft.	180 ft.	300 ft.

Prof. Swallow recognized 50 feet of sandstone on the Osage below the Third Magnesian limestone with 300 feet of a Fourth Magnesian limestone still below. In Madison county I have recognized over 200 feet of Magnesian limestone below the Third, and containing *Lingulella lamborni* Mk. From this occurrence I have referred these lower beds to the Potsdam group including also 20 feet of Ozark marble at the base, resting on a few feet to 90 feet of sandstone and conglomerate. The latter reposes on the Archæan rocks, granites and porphyries. The latter prevail in Iron, Madison and St. Francois counties, with occasional peaks in Reynolds, Washington and Wayne. The granite occupies the lower hills and valleys, the porphyry rises into peaks a few hundred feet high to nearly 700 feet above the valleys. The evidence is that the sandstones and magnesian limestones (Potsdam and Calciferous) were deposited in Archæan valleys of erosion, for they generally repose nearly horizontally, or with slight inclination, upon the Archæan.

The only exception is, that the Ozark marble beds are not always horizontal. The following section of rocks was taken by Dr. Shumard in Ste. Genevieve, and will serve to show what strata occur along the eastern margin:

Lower Carboniferous	800	feet.
Chouteau group	120	"
Devonian	50	"
Upper Silurian	250	"
Hudson River group	160	"
Trenton group	250	"
First Magnesian limestone	150	"
First sandstone	80	"
Second Magnesian limestone	250	"
Second sandstone	150	"
Third Magnesian limestone	200	"

On the northern side of the Missouri river we find that the Second Magnesian limestone is the lowest rock, near the western line of St. Charles county, and continues to be so as far as ten miles west of Jefferson City. The Upper Silurian is not recognized along the same line, and the Devonian does not exceed 100 feet in thickness, and thins out in the eastern part of Boone county. The Trenton thins out in the eastern part of Callaway county; and as we go west and south-west the Magnesian limestone series of the Calciferous is only separated from the Coal Measures by the Lower Carboniferous.

The Magnesian limestone series are the rocks seen along the streams and on the hills throughout the Ozarks, generally the

Third limestone forming the bluffs with Second sandstone, or Second Magnesian limestone occupying the higher lands.

In Wright county, Dr. Shumard, observed rocks of the Chouteau group on the higher knobs—relics of former extensive deposits.

The First sandstone is chiefly found on hills near the margin of the Ozark plateau.

Prof. Worthen speaks of a mountain ridge 500 to 600 feet above the level of the river at Cairo, crossing the southern part of Illinois from near Bailey's landing to Shawneetown, soon disappearing beneath the Coal Measures. In Schoolcraft's *Travels in the Mississippi Valley*, 1821, this range of hills is laid down and called Oshawano (Shawnee) mountains.

The Devonian is tilted up at Bald Bluff and Bake Oven, Jackson county, Ill., 25°.* The Trenton limestone is elevated 70 feet and forms a reef of rocks at Grand Chain, in the river, with a high bluff on the Illinois side, and still higher on the Missouri side.* There is also a remarkable dislocation and downthrow at Salt Lick, Monroe county,* crossing the Mississippi river at Plattin rock and upturning the Saccharoidal sandstone to view.

Another, well defined axis crosses the Mississippi river between this and the mouth of the Merrimac river, and is well displayed near Columbia, St. Clair county, Ill., where the Coal Measures rest on the upturned Lower Carboniferous. Prof. Worthen speaks of a well defined anticlinal at the latter place. On the west side of the river the Trenton is thrown up to view. The strike of these axes produced passes along a monoclinal in the direction of Sulphur Springs, St. Louis county, to near Augusta, St. Charles county, which may be considered part of the eastern boundry of the Ozark uplift. A northward extension from Augusta shows an uplift of Trenton limestone on Dardenne creek, and of the Devonian near the west line of St. Charles county, on Peruque creek, with a lesser elevation on Cuivre river, in Lincoln county.

The Cap-au-grês axis crosses the Mississippi river bringing up to view the Second Magnesian limestone just above the mouth of Sandy creek with the Saccharoidal sandstone above,

*Worthen.

while south of Sandy creek the Burlington limestone is elevated at an angle of 80°, and not far down the bluffs the St. Louis limestone is seen reposing horizontally.

The Cap-au-grés axis crosses the Illinois river six miles above its mouth. In Missouri it passes north-west and is recognized along its line by a series of sink holes, and is soon lost beneath more recent rocks.

Another axis seems to branch off from this, coming to view near Auburn, in Lincoln county, thence near Prairieville, Pike county, and Frankfort and Jones siding, showing the Lower Trenton near Freeman's and Trabue's lick on Salt river, Ralls county, and is last seen in a slight rising of the Chouteau beds near Newark, Knox county.

The Lower Carboniferous (Keokuk group) appears on the east fork of Chariton in Randolph county, indicating a slight uplift, for the adjacent and neighboring rocks are all of the age of the Lower Coal Measures.

A few miles north of Cameron, in DeKalb county, there is a slight disturbance of the Upper Coal Measures cracking and tilting the strata, and subsequent filling of the cracks with calcareous vein matter.

The Mississippi channel is apparently along or near the axis of a monoclinal fold; the Missouri river evidently so, from St. Charles county to Cooper, its channel being directly on the strike of the monoclinal and thus limiting the northern extension of the Ozark plateau. On the Missouri bluffs from Augusta to within a few miles of St. Charles there is a downthrow of 1,000 to 1,200 feet, leaving the St. Louis limestone nearly horizontal at St. Charles; but as we pass westwardly the Keokuk group ascends in the bluffs, then the Burlington, then the Chouteau, then the Trenton, Black River and Birdseye groups, until finally the Magnesian limestone series with 133 feet of Saccharoidal sandstone; and as we approach Augusta the Second Magnesian limestone is apparently nearly horizontal.

Along the Missouri, from St. Charles to Boone, the strata are nearly horizontal, the Second Magnesian limestone capped with First sandstone forming the escarpments along the river. At Hermann the Second sandstone appears at the base of the bluff, and while the First sandstone is generally the cap rock on the south side of the river, we find the Trenton group occupying the summit on the north side. Passing northward from the river we find that in 12 miles these strata with the overlying Trenton and Devonian have disappeared and are replaced with those of the lower Carboniferous. The general surface being about the same elevation on the south side would indicate a dip northward. We thus know we are on the confines of the Ozark uplift.

A few miles below Glasgow an anticlinal brings the Chouteau limestone to view, while the strata a few miles below and a few miles above belong to upper members of the Lower Carboniferous, indicating an upthrow of probably 200 feet.

Near Glasgow the Lower Coal Measures are at the base of the bluffs and continue so for a long distance up stream. At Miami, Saline county, nearly 100 feet of Lower Carboniferous beds appear in the bluffs, while on the north side the Lower Coal Measures are the lowest strata.

At Sedalia the surface rocks are Lower Carboniferous (near the base) and on Muddy creek, west, we find the First Magnesian limestone soon replaced by the upper members of the Lower Carboniferous and the Coal Measures. South of Sedalia are only found the Magnesian limestone series and in the northeast part of Cedar county they are the surface rocks while the Second Magnesian limestone is the lowest seen at Dunnegan's Mill, east of Stockton. On Cedar creek, west, the Keokuk is the bed rock. We therefore know that Marshall, Sedalia and Stockton must lie near the break of the great monoclinal on the west. All along this line the Coal Measures are only a few miles west, separated by the intervening Keokuk outcrops from the Chouteau or the Magnesian limestones lying eastward. Westwardly the Coal Measures extend into Kansas and then dip beneath the Permian and the latter beneath the Cretaceous as we ascend towards the mountains.

The southern foot of the Ozark uplift is probably near the Arkansas river. The Ozark plateau probably dates the begining of its uplift in the early Carboniferous, or while the Chouteau beds were being deposited, and continued during the Burlington period; and these rocks in many places have been deposited directly upon the Magnesian limestones but were soon eroded. This is shown by occasional local beds around the margin of the great uplift.

The effort nearly ceased after the Burlington era except at a few points where the succeeding Keokuk and subsequent Coal Measures are slightly disturbed; then all was quiet.

This great plateau seems to have been uplifted by forces acting at different places upon a broad or flat surface forming a massive anticlinal, and breaking off into a monoclinal around the margin.

The upthrust was quaquaversal.

We do know that several axes like unto anticlinals have passed out on the east and north and have thence been traced for some distance away. If they had worked together, they have acted as a massive geanticlinal. On the west we observe rocks dipping to the west but no evidence of any remarkable upthrust of the Lower Carboniferous, but there may have been more active energy. On the north there is evidence of upturnings in Howard, Saline, Cole, Callaway, Randolph, St. Charles, Lincoln, Pike, Knox and St. Louis.

It thus seems that the uplifting began just before the close of the Lower Carboniferous period and continued until after its close, and there may have still lingered a slight force into the succeeding Upper Carboniferous. This was nearly contemporaneous with the close of the Appalachian revolution.

While this extensive area was being uplifted deposites were gradually forming east, north and west, first sandstones, then successions of clay beds; then Coal plant marshes, dry land with luxuriant trees, the bark of which went to form the coal. The sea would roll in and overwhelm the laid down mass; sea shells and crinoids were innumerable, soon to die and be broken and ground together; life after life and deposit after deposit. Thus were the Coal Measure limestones formed. Sands and clay beds would also accumulate and be slightly uplifted so as to form the soil to grow another forest to form coal. So the process would go on, and when complete it would be slightly elevated in north-west Missouri, and the sea-trough, a little west of Missouri, be prepared for the ensuing Permian.

Along the Mississippi river, from St. Louis to Commerce, the lower exposed rocks are Trenton, Upper Silurian and Lower Carboniferous, with the First sandstone at one place. Eastwardly, in Illinois, these are soon covered by the Coal Measures, while on the west, and only a few miles away, the surface rocks are the Lower Magnesian limestones, indicating a rapid rising on the west; the same remarks will apply to the northern flank along the Missouri river, excepting that the base rock in sight is generally the Second Magnesian limestone as far west as Boone county.

Around the western margin the Lower Carboniferous generally rests upon the Magnesian limestone series, while only a few miles on the west, are the Coal Measures.

Around the northern and western margin of the plateau, we find, through Warren, Montgomery, Callaway, Boone, Page, Cole, Morgan, Pettis, Moniteau, Cooper, Benton, Cedar and Jasper, occasional isolated deposites of coal chiefly impure varieties of cannel or bituminous. These so-called "pockets" are almost invariably dipping at a certain angle, whereas the coal beds of the state in their proper place are nearly or apparently horizontal. These pockets are rarely of any great extent horizontally, but may be 5, 10, 30 or nearly 100 feet thick, and often of no greater dimension in any other direction. Cannel and bituminous are often found in the same pocket. Organic remains are extremely rare, but we more often find with the coal small deposites of pyrite or sphalerite, and sometimes even galena. Many of these deposites occur in side valleys tributary to larger ones and about directly against Lower Carboniferous or Magnesian limestone strata. These beds often are found high up in the hills adjacent, while the coal reposes at the foot, but in no case do they overlie the coal.

Certain of these pockets occur at the lead mines of Webb City and Joplin, and it would seem that their disturbance was in a measure coincident with the formation of the ores of these mining districts. These facts showing the Ozarks to be at a greater elevation above the sea than the country east, north and just west, would indicate their age. The rocks are all older than those in the districts east, north, west and south, although the latter occupy a lower level above the sea. Facts also indicate a gradual rising up of the whole plateau at a period subsequent to the deposite of the Carboniferous strata.

THE GLACIAL ORIGIN OF CLIFFS.

By W. M. Davis.

The trap-ridges in the Triassic areas of Massachusetts, Connecticut, New Jersey and Pennsylvania are much alike in the chief features of their physical history from their formation down to the glacial period; but when the ice came the ridges south of the moraine escaped the heavy rubbing that the more northern ones suffered, and it appears that a consequence of this recent difierence still remains in the contrast between the generally bold front and steep, rocky talus of the glaciated ridges and the more rounded, tree-covered slopes of the others. As far as my observation goes in the four states named above, the contrast is distinct. It is particularly well marked between the ridges of Massachusetts and Connecticut and those of middle New Jersey and eastern Pennsylvania. About Meriden, Connecticut, for example, the faces of the cliffs are high and almost or quite vertical, and the talus slopes below them are often bare of soil and support no plants, save lichens, for hundreds of feet together: the sharp-edged stones lie loosely at the angle of maximum slope and move easily under a climber's foot. The protection against sliding afforded by an occasional small tree is indicated in the grayer color just below it, caused by greater growth of lichens. On the other hand, in New Jersy, at the southern end of the Watchung mountains, in the neighborhood of Bound Brook, the ridge is heavily timbered, and while the outcrop cliff and its talus are indeed distinctly perceptible, they are both of gentle expression. It seems as if this difference may be because the talus of the northern ridges has not yet in postglacial time reached the normal condition of balance between supply and loss, that must have obtained there in preglacial time and that still prevails in the nonglaciated area.

The strong cliffs and steep talus slopes of the northern ridges can hardly be ascribed to any peculiarity of their preglacial history. Like the southern ridges, they are the outcropping edges of sheets of dense trap lying in most cases conformably between beds of much softer sandstones and shales. Since they were given their present monoclinal attitude, they have been reduced by pre-Cretaceous and Cretaceous erosion nearly to a base-level surface. Shown in vertical cross-section as bl, fig. 1;

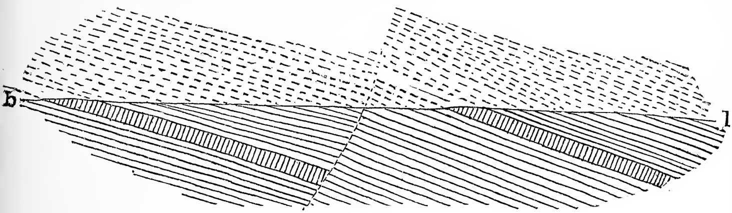


Fig. 1.

and this ancient low-land has been in post-Cretaceous time bodily elevated and greatly eroded, the softer bedded rocks having been thereby reduced nearly to another lowland on a second base-level, BL, fig 2, seen in the low country between the present

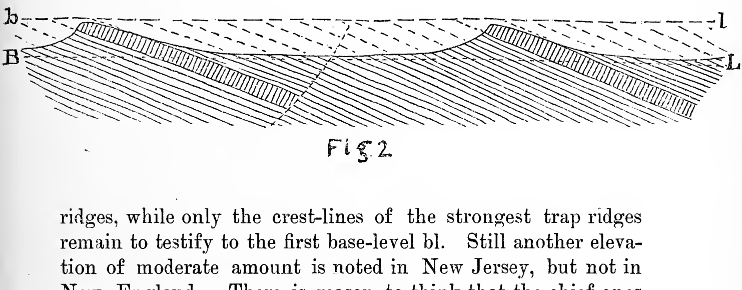


Fig 2.

ridges, while only the crest-lines of the strongest trap ridges remain to testify to the first base-level bl. Still another elevation of moderate amount is noted in New Jersey, but not in New England. There is reason to think that the chief ones of these processes were practically contemporaneous from Massachusetts to Pennsylvania, and the rocks throughout are so much alike that we should expect the topographic profile of the two districts to be closely similar; and indeed so it is, except in the detail of cliff and talus.

We may briefly consider the general development of the talus before questioning whether the New England ridges owe their present form to glaciation. The talus is a special form taken temporarily by the waste of the land on its way to the sea.

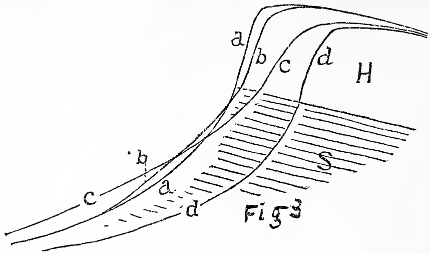
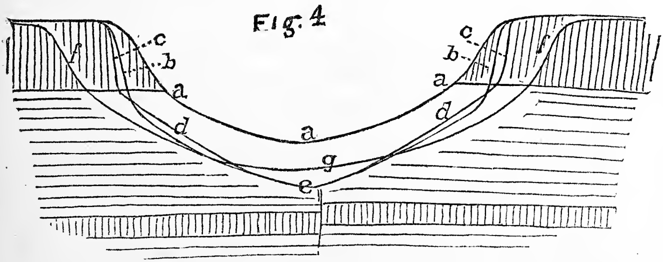


Fig 3

When the rapid weathering of a soft bed, S, fig. 3, undermines the outcrop of a hard bed, H, the fragments from the cliff-face of the latter fall down the slope and form a protective covering or talus which retards the further wasting away of the soft bed beneath it. An approximate adjustment of form will be attained when the supply of stony blocks from the cliff about equals the loss by weathering from the talus. If the supply be for a time faster than the waste, the outline, a a, will change to b b, or to c c, until the supply is reduced by the gentler slope and smaller face of the weathered and partly buried cliff and comes to equal the loss from the talus, which has been increased by reason of the greater surface exposed to weathering. This adjustment undoubtedly prevails in the non-glaciated part of the country. Complete adjustment however is not reached. The loss must be always a little in excess, for the mass as a whole is slowly wasting away. As the waste progresses, the cliff that was steep and bold in the youth of the region, falls back and weakens in its middle life and fades away in its old age.

Although the conditions that determine whether b b or c c will be the form selected by the balance of natural processes, during early maturity , the occurrence of a strong transporting agent at the foot of the slope may be named first. A sea-shore cliff has little talus; the waves carry the cliff-waste away as fast about as it falls. A river may locally be as effective but these agents do not enter our problem, unless perhaps in the case of the Palisades, and even there the Hudson is so quiet as to exert little control. Climate is also an important condition in determining the form and size assumed by the talus. In a wet climate transportation is so active that the talus is reduced to a minimum of volume and coarsest texture; in a dry climate, transportation is reduced to its lowest terms, and the waste from the mountain slopes accumulates in maximum of volume and finest texture as is seen in our arid western regions, or in Persia where Blanford has described it as a controlling feature of the Piedmont country. But between New England and New Jersey, we cannot look for existing differences of climate of value sufficient to account for the differences of topography here discussed. Let us turn instead to secular variations of climate, such as brought a sheet of ice over the northern ridges.

Heavy glaciation, long enduring, would scrape away the loose material of a talus and undercut the soft beds beneath the hard layer. When the ice melts away, the profile would be like d d, fig. 3, in which the cliff is very strong and the talus is practically wanting; then for a time the wasting of the cliff-face would be at its highest rate, both from its s eepness and from the great hight of the face exposed; and the supply of material for a new talus would be rapid. A new adjustment to sub-aerial conditions of supply and loss would be approached at a quick rate at first, but slower and slower as it is neared; the glaciated trap-ridges seem to be about half way advanced in this progress. The lower Connecticut valley affords excellent examples of these uncompleted taluses, surmounted with cliffs of a strength that most New Englanders do not expect to find so near at home. The notch in the Hanging Hills, in which the Meriden reservoir has been constructed, between West Peak and Notch Mountain, fig. 4, is enclosed by superb cliffs, c c, over



loose rocky slopes, d d. The cliffs are freshly scarred where blocks have lately fallen; the talus is steep and barren, and many large blocks lie at its foot. The location of the notch is such as to protect it from any exceptionally rapid erosion under ordinary conditions, it being a divide between streams to the north and south and not a water-gap; but it is closely in the direction of glacial movement, and a strong stream of ice must have been turned through this passage between the high enclosing hills.

Let the preglacial profile be a a; Glacial erosion must have been particularly severe in such a trough, and after the preglacial waste had been scoured out, the bed rock must have been attacked and ground out to a depth of many feet, changing the profile from aaa to bcb. The notch was thus deepened and widened, and when the ice was at last melted out of it, a clean U-shaped trench was revealed. Since then the small amount of weathering on glaciated surfaces assures us that there has not been nearly enough time for the talus to attain a form of adjustment; the first rapid weathering by which the cliffs retreat from b to c has furnished the beginning of a waste-heap in the talus, d, below; but there is yet needed a long period before a new form of equilibrium, fgf, will be reached, such as characterizes the non-glaciated ridges.

We may conclude therefore that we owe not only our lakes, our waterfalls and our gorges, but also our refreshed and emboldened cliffs to the glacial period. Post-glacial time must have been brief, because so little advance has been made towards the more mature forms of all these features. Only the smallest lakes have been filled; only the weakest barriers have been cut away. The waterfalls have worn but a little distance up stream, and the gorges still retain nearly vertical walls. The cliffs of the New England trap-ridges show equally little progress towards the more conservative forms of middle life.

September, 1888.

THE DIABASIC SCHISTS CONTAINING THE JASPILYTE BEDS OF NORTH-EASTERN MINNESOTA.

By Horace V. Winchell.

Several divergent theories have been presented and ably supported regarding the nature of the rocks associated with the jasper and iron ore beds of the Vermilion lake region in Minnesota. The jaspilyte and the enclosing rocks have both been considered sedimentary;* the jaspilyte has been called eruptive and the green schists in which it lies sedimentary;† the jaspilyte has been regarded fragmental and the schists eruptive.‡ A few considerations on the subject prompted by recent explorations and developments in this region may be of interest.

In the western part of the iron region the ore is nearly all in the sesqui-oxide state, and it has been supposed to be such throughout the range. The schists which enclose the ore and jasper beds (jaspilyte), are frequently iron stained to such a degree as to render it impossible to form an opinion as to their original nature and appearance. Dr. Wadsworth refers to them as "baked" by the intrusive action of the eruptive jaspilyte. They are very generally soft and schistose. In places there is a banded structure nearly or quite coincident with the schistosity. This has been accepted as proof of aqueous deposition.

Going east along the iron range the green schists are seen to be less strongly impregnated with iron rust and less schistose. There is also seen in them a coarse conglomeritic structure in which the boulders all seem to be of the same material as the schist itself, but contain calcite amygdules around their periphery and to a certain extent in the boulder-mass. The iron ore is no longer hematite only, but is intimately associated with magnetite.

Around Ely, in the vicinity of the Chandler mine, on the shores of Long lake, north of the mine and a mile inland south of the mine and lake, this coarse conglomerate is seen to have an immense development. East of Ely the iron ore becomes more and more magnetitic, until, in township 63-9, west of Snowbank lake, are found large lenticular masses of jasper and *magnetite* included in the green schistose conglomerate.

In this township the green schist also assumes new characters. It is seen to rise in hills or ridges 250 feet or more, stretching for three or four miles toward the east-north-east. In it is

*A. Winchell, 15th Annual Report Geol. and Nat. Hist. Sur., Minn. p. 193.

†M. E. Wadsworth, Bul. Mus. Comp. Zool., Geol. Series I.

‡N. H. Winchell, 15th Annual Report, Geol. and Nat. Hist. Sur., Minn. p. 221.

still seen the well marked, coarse conglomeritic structure which can be seen in it north of Tower in the Stuntz Island conglomerate, and which is seen at intervals in the line of strike all the way to Ely.

The boulder-forms in this green rock become smaller and smaller until they are only an inch or a fraction of an inch in length. The entire rock for acres around is in many places destitute of any covering of drift or vegetation, and is seen to be composed of these elongated pebbles of greenstone. In many places even here there are traces of sedimentary action in the arrangement of this basic material.

Toward the north side of this greenstone-conglomerate ridge, in township 63-9, the rock becomes more massive. The schistose and conglomeritic structures fade out, and the rock instead of being fine-grained and soft, or almost amorphous, becomes firm, tough and finely crystalline. The crystals grow larger and the rock coarser and more massive until it forms hills and ridges of moderately coarse diabase.

In the midst of this massive, basic, eruptive rock are found the large lenticular deposits of jasper and magnetite mentioned above. The contact between the jaspilyte and the diabase is everywhere abrupt and perfectly distinct. Masses of jaspilyte from the size of a pea to deposits a hundred feet thick and a quarter of a mile long are seen at innumerable places in sections 5, 6, 7 and 8, 63-9. Many samples from this place show the nature of the diabase and the manner of contact. The diabase is usually quite fine and slightly schistose at the immediate contact; but a few feet or even inches away it becomes coarse and massive. Threads of the basic rock often penetrate into or cross entirely the jaspilyte masses.

The strata of jasper and magnetite are here, as elsewhere, excessively folded and contorted, but they appear to stand as a rule in vertical arrangement just as the jasper and hematite rock does at Vermilion lake. The jasper contains a larger proportion of dark-colored bands than farther west.

The massive form and basic nature of this green rock are not the only evidences of its eruptive origin. The rock on the north and east sides of it, (for the diabase swings around so as to strike north and south, east of Snowbank lake,) is, or was, mica schist. Where this comes into proximity with the diabasic rock it has been hardened and rendered massive and porphyritic. It gradually resumes its original character as we recede from the greenstone ridge.

That this diabase is of an old date is proved by later eruptive greenstones which intersect it in the form of dykes. These are composed of fresher looking rock, and though they are occasionally faulted, have evidently not undergone such epochs of pressure and disturbance as the greenstone which they cut.

Following the diabase again north-westwardly across the strike it becomes schistose and less like an eruptive rock. Grains of free silica may be seen here and there and signs of sedimentary arrangement are more numerous. These changes go on until the rock is found to be siliceous and even flinty, and has unmistakable sedimentary bands, or is a smooth, soft argillyte of a gray or nearly black color.

The above very condensed account is intended to bring into notice two points regarding the origin and the mutual relations of the jaspilyte and diabasic schists. *First*, the jaspilyte is contained in a basic eruptive rock which is frequently conglomeritic and generally schistose; but which is at times perfectly massive and crystalline. *Second*, this basic rock has in many places undeniable evidences of aqueous arrangement, and grades conformably into siliceous stratified rocks which are purely fragmental.

To explain how a basic, eruptive rock can thus change by insensible gradations into a siliceous fragmental one is not a difficult matter.

Suppose a region, as in north-eastern Minnesota, which for a long period was the seat of basic volcanic eruptions. The Sandwich islands and the island of Java furnish examples of similar regions existing at the present time. In the shallow ocean there would be formed islands by the volcanic accumulations, and others by elevations of the earth's crust. These exposed districts would be subject to erosion and would furnish acidic sediments and siliceous deposits. From the craters eruptions would take place and sheets of lava would flow down the sides of the volcanoes into the sea or over the land as the case might be. At the same time volcanic dust and ashes would be thrown up to a great height and carried perhaps for miles before they were deposited in the surrounding waters. Accompanying these phenomena would be volcanic bombs and ejections of basic matter such as those mentioned by Dr. Johnson-Lavis in the AMERICAN GEOLOGIST for December, 1888, p. 424.

These would be thrown to great distances and would appear in the sediments where they finally found a resting place as boulders in a conglomerate of material similar in the composition of its matrix to the boulders themselves.

The eruptive material would be subjected to the action of the waters in which it fell. Some of it would be immediately deposited as a basic sediment. Other portions would be mingled with siliceous grains derived from the wearing away of other adjacent shores. During intervals of volcanic inactivity siliceous sediments only would be formed on top of the basic deposits already made. Sometimes the fragmental and eruptive materials would be mixed in about equal proportions; and again one or the other would predominate and the resulting rock would be acidic or basic.

These various inter-gradations and commixtures of different materials are all represented in the rocks of the region referred to. Although this belt of diabasic schist is immensely thick and extends for miles it is no greater than volanic deposits are known to be in other places on the globe. Of course it is understood that the distance across the strike represents only the depth or twice the depth, or thickness, of the deposits and not the lateral extent of the overflows; for the rocks of the region have been folded and pressed together, the horizontal strata turned to verticality and the prevailing schistosity thus produced in the greenstones.

Minneapolis, December, 1888.

NOTE ON THE GEOLOGY OF MT. STEPHEN, BRITISH COLUMBIA.

BY R. G. MCCONNELL.

I have just returned from an extended exploration in the north, and find that during my absence several papers have been written by Dr. Rominger and Mr. Walcott on the Cambrian fauna of Mt. Stephen. Dr. Rominger, on authority no doubt, states in his first paper, published in the *Proc. Acad. of Nat. Sciences*, of Philadelphia, that the locality from which the fossils he describes were obtained was accidentally discovered by Mr. Klotz. It is difficult to see on what this claim is based, seeing that Mr. Koltz' share consisted in sending his cook to make a collection after the beds were found and pointed out to him, and after the collections from that and other places, now in the museum of the geological survey of Canada were obtained. The presence of fossils in Mt. Stephen was first made know in 1884 by Mr. L. Lambe, of this office, who found them loose in the *talus* at the base of the mountain. Afterwards, in 1886, while working in the neighborhood my attention was drawn by Mr. Klotz, I think, to a "curiosity" which one of the men working on the railway had in his possession. This, on examination, proved to be a trilobite, and learning on enquiry that it came from the slopes of Mt. Stephen, I found without difficulty the beds from which it had fallen.

Mr. Walcott complains in his paper published in *American Journal of Science*, September, 1888, of a lack of stratigraphical knowledge of the district, and as Dr. Rominger, after a personal examination, admits his inability to supply this, although it is possible his researches might have been attended with better results if he had taken the trouble to make himself acquainted with what had already been done, a few remarks on the geology of the mountain may not be without interest.

The stratigraphy of Mt. Stephen, in its general features at least, is exceedingly simple, although no detailed measurements of individual beds have yet been made. It will hardly be understood, however, without a brief reference to the various formations found in the district. The series of beds which I have called the Bow River group, forms the basal member of the section as exposed along the line of the Canadian Pacific railway, and consists mainly of a great development of dark-colored, greenish and reddish argillites, associated more especially in its upper part with some schists, sandstones, quartzites and conglomerates. The base is no where visible but the part exposed has an estimated thickness of over 10,000 feet. Following this is the Castle Mountain group, a formation which agrees very closely in age and composition with the Pogonip limestone of Clarence King's Middle Nevada section. It consists mostly of massive crystalline dolomites, alternating with fine grained, evenly bedded dolomites, ordinary limestones, and calcareous shales. In some places the dolomites and limestones are replaced in part, or altogether, by a great series of greenish calc-schists and greenish and reddish shales and slates. The Castle Mountain group is found at intervals across the whole width of the range, but it is otherwise with the succeeding formations. In the eastern part the section is very imperfect, as both the Silurians, as well as all the formations between the Carboniferous and the Middle Cretaceous, so far as known, are wanting. In this section the Castle Mountain group is overlaid by the intermediate limestone of Devonian age, and this by the Banff limestone of Devono-Carboniferous age, above which and forming the top of the section come the shales, quartzites and conglomerates of the Cretaceous. In the wertern part of the range the Castle Mountain group graduates upwards into a series of black shales holding graptolites which professor Lapworth has assigned to the Utica-Trenton fauna, above which comes a limestone holding Halysites catenulatus. This succession is expressed in the following section:

Zone of Halysites catenulatus	Halysites beds.
Zone of Graptolites (Utica-Trenton)	Graptolitic shales.
Zone of Asaphus	Castle Mountain group.
Fauna described by Dr. Rominger,	
Zone of Paradoxides	Bow River group.
Zone of Olenellus	

Total thickness 23,000 feet.

In Mt. Stephen and its eastern neighbor, Cathedral mountain, only the two lower formations are present. In the latter mountain the beds of the Bow River group were composed principally of quartzites, with some slates and schists, alternating above with the limestones of the Castle Mountain group and have been carried up by an anticlinal to a hight of over 3,000 feet, and are well exposed all along the lower slopes of the mountain. The upper cliff-part of the mountain shows the limestones, shales and dolomites of the Castle Mountain group, to the steep weathering of which the peculiar configuration from which the mountain derives its name is due. The beds of the Bow River group can be traced westwards to Mt. Stephen, but here, although the easterly dip is still maintained, they suddenly disappear, and the whole mountain from base to summit is composed of beds belonging to the succeeding formation. The cause of this disappearance is due to a steep downthrow fault with a displacement of over 3,000 feet, which passes between Mt. Stephen and Cathedral mountain, and on the opposite side of the valley cuts through the eastern shoulder of Mt. Field. The beds of the Bow River group brought down to the surface by this fault, are arched up again a few hundred feet, by a second anticlinal, and are then exposed for some distance along the base of Mt. Stephen, but soon afterwards dip to the west and disappear for good about a mile east of Field. They are overlain and followed round the anticlinal by the dolomites, limestone and shales of the Castle Mountain group of which the upper and greater portion of the mountain consists.‡

No fossils have been detected so far in the lower part of the Bow River series, but specimens of *Olenellus gilberti* were found about 2,000 feet below the top of the formation by Dr. Dawson in 1884. The next fossiliferous zone in ascending order occurs near the junction of the Bow River and Castle Mountain groups, at which point specimens of Paradoxides and other fossils were found. Between three and four thousand feet farther up occurs the fauna described by Dr. Rominger. Higher up in the same formation, but some distance farther west, specimens of an Asaphus were found, above which come the graptolitic shales referred by professor Lapworth to the Utica-Trenton.

Office of the Geological Survey of Canada, Dec. 1, 1888.

SOME GEOLOGICAL PROBLEMS IN MUSCATINE COUNTY, IOWA, WITH SPECIAL REFERENCE TO THE RECTIFICATION OF THE SUPPOSED KINDERHOOK NEAR THE MOUTH OF PINE CREEK.*

By S. Calvin.

More than thirty years ago† Prof. James Hall, then state geologist of Iowa, made a geological reconnaissance along the

‡A section through mount Stephen and Cathedral mountain may be found in Part D, Annual report, Geol. Survey of Canada, 1886.

*Published simultaneously in the bulletin of the laboratories of natural history of the State of Iowa, vol. I, No. 1.

†In the years 1855 and 1856.

Mississippi river, from Lansing to Keokuk, for the purpose of obtaining a general knowledge of the geological structure of the eastern part of Iowa. The same ground had previously been traversed, at least in part, by the geologists D. D. Owen and B. F. Shumard, and the work of Hall, while correcting some mistakes, tended in the main to confirm and establish the conclusions of the earlier geologists. Considering the undeveloped condition of the country, the vastness of the field attempted to be covered in a short time by the surveys of Owen and Hall, and the scantiness of the materials for observation as compared with those now available in our quarries, railway cuttings and other artificial excavations, we cannot but admire the skill and success with which the several geological problems were worked out. Mistakes of course were made, mistakes were under the circumstances unavoidable. While Hall, by reason of better facilities for study, was able to rectify some of the errors of his predecessors, he was himself occasionally led into error, and one of these errors has been the cause of some confusion among geologists. The desire to correct this error must stand responsible for the addition of this paper to the already overburdened literature of geology.

In the days of the geological reconnaissance referred to, the present town of Buffalo in Scott county, Iowa, was known as New Buffalo. New Buffalo figures in all these earlier reports, for near the village occurs an interesting fossiliferous limestone, exposed along the river or in the sides of the ravines; and the reports of Owen and Shumard* and Hall† are in accord in referring this limestone to the age of the Hamilton group of New York.

The Hamilton limestone of Buffalo with its peculiar association of fossils, disappears beneath the level of the river at ordinary stages a short distance below Montpelier in Muscatine county. The last seen of it in that immediate region, it forms a low ledge or reef, exposed at low water, and running out into the Mississippi river a hundred yards or more at a point almost directly in front of the present residence of Mr. G. W. Robinson. If, however, we follow the bank of the Mississippi, we

*Owen's Geological Survey of Wisconsin, Iowa and Minnesota, Philadelphia, 1852.

†Report on the Geological Survey of Iowa, by James Hall, 1858.

shall find, a short distance above the mouth of Pine creek, an exposure of yellowish sandstone with interstratified shaly beds. The position of this sandstone leaves no doubt as to its relations to the Hamilton limestone. Although along the river the contact is not seen, the sandstone is evidently superimposed on the limestone.

The relation of the sandstone, coupled as it is with an entire change of lithological characters, led Hall to refer it to the Chemung period,* and a fossil spirifer that occurs abundantly in the form of internal casts in one of the layers, is described as a new species under the name of *Spirifer capax*† and occupies a conspicuous place among the figures of species supposed to represent the Chemung fauna of Iowa.

A yellowish sandstone resting upon greenish shales occurs in the bluffs along the river at Burlington. This sandstone contains casts of brachiopods in abundance, but it does not contain a single specimen of *Spirifera capax.* Nevertheless Hall regards the Burlington sandstone as the equivalent of the spirifer-bearing sandstone of Muscatine county, and refers it likewise to the age of the Chemung group of New York.‡

Thus matters stood until Meek and Worthen, in a paper on the Goniatite limestone of Rockford, Indiana,§ proposed the name *Kinderhook group* to include, not only the Goniatite beds in question, but the yellow sandstone at Burlington and all the equivalent strata of the Mississippi valley that had previously been referred to the age of the Chemung. Furthermore a study of the Kinderhook fauna at Burlington, near the town of Kinderhook in Illinois, at Rockford, Indiana, and at other localities where the formation is typically developed, showed that the Kinderhook group is not only not Chemung, that it is not Devonian at all, but that it is related to the strata above it rather than to those below it, and must therefore be transferred to the Carboniferous series. Accordingly Meek and Worthen in their reports on the geology of Illonis,‖ have placed the Kinder-

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*Hall's Geology of Iowa, vol I, Part I, p. 89.

†Id., vol. I, Part II, p. 520, Plate VII, figs. 7 a-d.

‡Hall's Geology of Iowa, vol. I, part I, p. 89 *et. seq.*

§Am. Jour. Science, vol. XXXII, No. 95, Sept. 1861.

‖Geological Survey of Illinois, vols. I–VII. See particularly vol. I, pp. 44 and 118.

hook group, including the yellow sandstone at Burlington, at the base of the Sub-carboniferous. The conclusions of Meek and Worthen are justified by the total absence of Devonian species from the beds of the Kinderhook. Even such wide-spread Devonian genera as Atrypa, Strophodonta, Acervularia etc., are conspiciously absent. On the other hand the crinoids and fishes, as well as the Productidæ among the brachiopods, all impart to the Kinderhook fauna an unmistakable Carboniferous *facies.*

Dr. C. A. White follows Meek and Worthen in referring the sandstones at Burlington to the Carboniferous instead of the Devonian.* Without quoting authorities farther it may be assumed that all competent geologists are now in accord as to the correctness of the position in the geological series that later and more careful study has assigned to these sandstones.

Up to the present time no one so far as I know has called in question the propriety of assigning the yellow sandstones above the mouth of Pine creek in Muscatine county to the same horizon as the yellow sandstones at Burlington. Hall's statement as to their equivalency has been accepted as final, and when the sandstones of Burlington were transferred from the Chemung period to the Sub-carboniferous, by common consent the spirifer-bearing sandstones of Muscatine county were supposed to be similarly transferred. White speaks of the Kinderhook beds as striking the Mississippi river an Muscatine,† S. A. Miller refers *Spirifera capax*‡ Hall to the Kinderhook group. Hall in a recent publication§ speaks of *S. capax* as from the "Lower Carboniferous, mouth of Pine creek, Iowa." Calvin influenced by the general concurrence of opinion states that "the Kinderhook is seen resting on the Hamilton in Muscatine county."|| Other writers, similarly influenced have been led to support the view that the sandstones at Burlington and the sandstones near the mouth of Pine creek belong essentially to the same geological horizon.

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*White's Geology of Iowa, 1870, vol. I, p. 189.

†White's Geology of Iowa, 1870, vol. I, p. 189.

‡American Palæozoic Fossils, S. A. Miller, 1887, p. 129.

§Report of State Geologist for the year 1882, Albany, N. Y., Plate 52, figs. 15, 16, and description of plate.

||Notes on the Geological Formations of Iowa, p. 7. Prepared for distribution at the World's Industrial Exposition at New Orleans, 1885.

During the past ten years the writer has made repeated excursions to the region near the mouth of Pine creek, atracted first by unusual facilities offered for collecting beautifully preserved casts of the so-called *Spirifera capax*, and afterward by the desire to study anew the stratigraphical phenomena of the region. A very casual study of the facts now available in determining the geological problems of the region in question, is sufficient to demonstrate that the spirifer-bearing sandstone at Pine creek is not the stratigraphical equivalent of the Kinderhook sandstone at Burlington. The two sandstones do not belong to the same period, nor do they even belong to the same age. The writer has handled more than a thousand specimens of *Spirifera capax*, the specimens occurring in the form of casts in the supposed Kinderhook sandstone. Impressions of the external surface of the shell are often very perfectly preserved, revealing every detail of surface marking. From the study of such an array of material showing every phase and character of the species there can be but one conclusion, and that is that *Spirifera capax* is simply the cast of *Spirifera parryana* Hall, a species more or less common in the limestones at Buffalo—limestones that Hall and Owen and Shumard, with the full concurrence of all geologists who have examined the region, referred to the horizon of the Hamilton group of New York. *Spirifera capax* is therefore a synonym of *Spirifera parryana.**

Associated with the casts of *Spirifera parryana* (*S. capax*), in the sandstones about Pine creek, occur the casts of such typical Devonian species as *Atrypa reticularis* Lin; *Spirifera aspera* Hall; *Strophodonta demissa* Conrad; *Orthis impressa* or *Orthis iowensis* Hall; and many other well known brachiopods. There is not a single Kinderhook species in the entire beds so far as observed, nor is there a species that could by any stretch or reasonable allowance be regarded as a representative of any of the Carboniferous or Sub-carboniferous groups. On the contrary all the species are identical with species occurring in the Hamilton limestones at Buffalo, Pine creek Mills, Han-

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*The two species are described and illustrated in the same publication, Hall's Geology of Iowa, vol. 1, part 2. *S. parryana* however is entitled to precedence since it is characterized on page 509 and Plate IV, while the description and figures of *S. capax* are not given until we reach page 520 and Plate VII.

son's Quarry, Atalissa and all other points where limestone containing *Spirifera parryana* is exposed.

The yellow sandstones above the mouth of Pine creek therefore are of the same age as the limestones near Buffalo. They are not even Chemung unless the limestones are also Chemung; much less are they *Lower Carboniferous* or Kinderhook.

Owen gives a recognizable figure of *Spirifera parryana* as it occurs with the shell preserved in the Hamilton limestones along Pine creek, and another figure of a cast of the same species as it occurs in the overlying sandstones.* Both forms are described as *Spirifera euruteines*, but it is interesting to note that the specific identity of the two forms is distinctly recognized, and that furthermore the beds containing them are referred to the same period.

No Kinderhook or Sub-carboniferous of any kind has been observed by the writer in the region about Pine creek in Muscatine county. A very complete section of the rocks of the region may be studied in the bed and banks of Robinson's creek, a small stream emptying into the Mississippi a short distance below Montpelier. Near the mouth of the creek is the ledge of limestone already mentioned as exposed at low water, and extending out into the river for more than a hundred yards. This limestone is the same as that found at Hanson's quarry, Pine Creek mills and many other points, and is characterized by the presence among others of the following fossil species: *Spirifera parryana*, *S. aspera, Atrypa reticularis*, and *Athyris vittata*. Following up the channel of Robinson's creek we find,—1, beds of arenaceous shale with some thin beds of limestone, containing branching polyzoa, *Atrypa reticularis*, *Strophodonta demissa*, very large forms, and *Orthis iowensis*;† —2, argillaceous shale only a few feet in thickness and containing no fossils;—3, layers of sandstone among which is a bed about 14 inches in thickness containing casts of *Spirifera parryana*, (*S. capax*) with which are associated either in the same bed or in adjacent beds both above and below, casts of *Atrypa reticularis, Strophodonta demissa*, *Orthis iowensis*, and *Spiri-*

*Owen's Geological Survey of Wisconsin, Iowa and Minnesota, Table III, figs. 2 and 6.

†No opportunity has yet been found to measure the thickness of the several members of the section.

fera aspera;—4, a considerable thickness of sandstones containing no fossils as far as observed;—5, arenaceous beds containing casts or impressions of corals related to *Cladopora*, and impressions of what seem to be immense masses of *Stromatopora*;—6, a bed of fragmentary materials interstratified with irregularly interrupted flexuous beds of shale and sandstone, varying greatly in thickness and spread over the uneven and apparently eroded surface of the underlying sandstone;—7, flexuous beds of shale, with a bed of impure coal from two to three feet in thickness;—8, evenly bedded friable sandstone varying in color from yellow to gray, and containing in some of its layers numerous impressions of *Calamites*, *Sigillaria* and *Lepidodendon*. Casts of the stems of Lepidodendon, apparently of the species recognized by Owen as *L. aculeatum* Sternberg,* were observed more than nine inches in diameter.

The beds 1–5 are of Devonian age and must all be referred to the same period as the limestones at Buffalo and Pine creek Mills. Beds 6, 7 and 8 are of much later origin; they belong to the Carboniferous period and were probably contemporaneous with the upper Coal Measures of southwestern Iowa.

Practically the same succession of strata as seen in Robinson's creek, may be observed in what is know as the railroad quarry at Montpelier. An immense quantity of stone was taken out by the railway company and used as riprapping to protect the embankment from the wash of the river. The magnitude of the work performed here may be inferred from the fact that the riprapping extends, sometimes for miles continuously, as far as Muscatine, a distance of sixteen miles. The beds worked were Devonian sandstone, the equivalents of 3, 4 and 5 of the section on Robinson's creek. The spirifer-bearing layer is here about two feet in thickness; it is harder than at the localities on Robinson's creek or on the river above the mouth of Pine creek, and it would seem to have furnished a very large proportion of the material used in riprapping. At the upper end of the quarry, coal-measure shales and sandstones are seen resting unconformably on the Devonian sandstones. The lower beds are very flexuous and distorted. A well marked layer at any point may thin out and disappear in a distance

*Owen's Geological Survey of Wisconsin, Iowa and Minnesota, Table VI, figs. 1 and 2.

of twenty feet. The conglomerate bed, number 6 on Robinson's creek, is here well marked, the fragmentary materials being interstratified with irregularly contorted beds of shale and sandstone disposed at all imaginable angles and frequently thinning out within a few feet. At one point observed in the face of the bluff the conglomerate bed had a thickness of eight or ten feet, while only a short distance to the left the same layer had thinned to eight or ten inches. In the face of the bluffs at a height of about fifteen feet, occurs a layer of impure coal about ten inches in thickness, and above the coal are regular, horizontal, even-bedded layers of sandstones representing number 8 on Robinson's creek. Below the coal seam all the strata are confused, contorted, irregular; above the coal seam the layers are even, regular and horizontal.

There are two distinct sandstones belonging to different ages, in the region about Pine creek and Montpelier in Muscatine county, Iowa. One belongs to the Middle Devonian, the other to the Lower Carboniferous. To avoid confusion I have used at different times in this article the term *Spirifer-bearing sandstone* to denote the earlier of the two. We may speak of them hereafter respectively as *Devonian* and *Carboniferous* sandstones.

The Carboniferous sandstone is extensively developed throughout the region from Buffalo to Muscatine. An exposure of nearly a hundred feet in thickness may be seen at Wild Cat den, a mile and a half above Pine Creek mills. At Wyoming Hill, a short distance below Fairport, it is well exposed and furnished numerous remains of Coal-Measure plants. In the lower part of the city of Muscatine it is again seen in the high bluff, lying as usual above a layer of rather impure coal. At one locality on Pine creek, above Wild Cat den, this sandstone is somewhat more indurated than usual, and is quarried to supply the local demand for building stone.

The coal seam which appears everywhere to accompany the Carboniferous shales and sandstones of the region, varies in thickness from eight or ten inches to two or three feet. For the most part the coal is of inferior quality, being more or less shaly, and containing large quantities of pyrites of iron. At a few localities, however, notably near Buffalo, the coal has been profitably worked.

The Devonian sandstone, as developed at and near Montpelier, seems not to have a very wide geographical distribution. The conditions favoring its deposition were evidently local. In the particular locality affected by them, these conditions, whatever they may have been, operated disastrously on most of the Devonian fauna. During a part of the time, however, *Spirifera parryana* found the conditions unusually favorable. The great number of casts of this species occurring in the spirifer-bearing layer would indicate that the sea-bottom was fairly crowded for a time with large, healthy, vigorous individuals; and that the species occupied the region to the almost total exclusion of everything else. *Spirifera aspera*, the constant associate of *S. parryana* in the underlying limestones is almost entirely absent, only two or three *S. aspera* being seen among many hundred *S. parryana*. Even *Atrypa reticularis*, that most ubiquitous of all Devonian brachiopods, apparently capable of living anywhere and under any circumstances, was represented by a comparatively few widely scattered individuals. The *Orthis iowensis* attained a larger size than usual, but the number of individuals was small. *Athyris vittata* which is one of the most abundant shells in the subjacent limestones, is unrepresented in collections from the sandstone. In the fossiliferous portion of the sandstone individuals of *Strophodonta demissa* are about as numerous as in the limestone.

It is only in one layer, and that not very thick, that *Spirifera parryana* occurs. Some of the species mentioned persisted after *S. parryana* abandoned the struggle. They range a foot or two above the spirifer bed, but brachiopod life soon ceased, and the sandstone through several feet of its thickness shows no traces of fossils.

There is but a single fish tooth in the collections from the sandstone, and it is apparently identical with an undetermined species occuring in the Hamilton limestones at Solon and Iowa City.

The most significant facts recorded in the Devonian and Carboniferous strata of Muscatine county have been recognized by all geologist who have personally examined the region. These facts are detailed with scientific minuteness in the reports on the geology of Iowa and Illinois. Briefly stated, we have evidence that at the close of the Hamilton period, after the limestone and sandstone strata had been finished the sea retired southward and westward, and Muscatine county became a part of the growing continent. The strata of the Kinderhook, Burlington, Keokuk and St. Louis epochs were successively deposited in the gradually retreating sea, and at successessively greater and greater distances from Muscatine county. All this while the agents of erosion were at work in what is now the region of Pine creek and Montpelier. There is absolutely no evidence that the region ever received any Sub-carboniferous deposits. The epochs of the Lower and Upper Coal-Measures seem successively to have followed the St. Louis epoch in Iowa, and the Iowa coal basin proper, occupies an area to the south and west of the region occupied by the St. Louis group. While, however, the Carboniferous shales and sandstones about Buffalo and Montpelier are of the same age as what is known as the Middle or Upper Coal-Measures, I do not believe that any very direct connection exists between them and our Iowa coal field. The connection seems more direct with the Illinois coal field. After a period of subaërial exposure, represented by the strata of the Sub-carboniferous and probably by a considerable portion of the Coal-Measures, the region about Pine creek that had been left bare at the close of the Devonian, was, by subsidence, carried down beneath a sea that gradually encroached upon it from the southeast and caused the Illinois coal field along the Mississippi above and below Davenport, to overlap eroded strata, not only of the Devonian, but of the Upper Silurian age.

Channels and ravines had been cut in the older strata during the long interval they were above the sea level, and in these channels and ravines the encroaching sea deposited strata of the Carboniferous age. The Carboniferous deposits may have overtopped the ridges and highlands, but the relation of their upper limit to the present strata cannot be ascertained. Subsequent erosion, the chief agent being probably the great ice sheet of the glacial period, has stripped off the larger part of these Carboniferous beds in their northwestern extension, leaving but fragments of the strata as outlying patches in areas that were in some manner peculiarly sheltered. It will be remembered that some of the strata were originally deposited in ravines walled in by relatively hard beds of Silurian or Devonian age, and it is in such ravines that the outlying patches chiefly occur. The conditions would be most favorable for the protection of the soft sandstone strata, at least from the agents that operated during the glacial period, when the ravine occupied by the strata was comparatively narrow and had a direction at right angles to the flow of the ice sheet. The largest masses and most extensive area of outlying Coal-Measures occur along the Mississippi, between Buffalo and Muscatine. Between these points the river runs from east to west. Was there an old Mississippi occupying the same channel practically in pre-Carboniferous times? Were these great masses of shales and sandstones laid down in a valley of erosion, and have they been preserved from denudation because the valley had a direction at right angles to the ice flow when glacial conditions and glacial erasion were at their culmination? These questions may be answered affirmatively or negatively by some one who has time and facilities for working out the problem.*

A sentence or two in the fifth volume of the Geological Survey of Illinois, page 223, would seem to have some bearing on the question under discussion. The authors of the chapter on the Geology of Rock Island county, Messrs. Worthen and Shaw, say: "There are also some brown beds near Andalusia that contain numerous *Gasteropods* and *Orthoceratites*, and a few miles below, these are overlaid by from eight to ten feet of a brown magnesian limestone that contains casts of a large *Spirifer* like *S. parryanus* and *Strophomena demissa.* These brown beds are directly overlaid near the mouth of Stonecoal creek by the sandstones and shales of the coal-measures."

Near Andalusia then it would seem that we have essentially the same geological phenomena as in the region about the mouth of Pine creek, with this difference, that the sandstone containing casts of *Spirifera parryana* (*S. capax* Hall,) is represented by a magnesian limestone. A magnesian limestone as all know, does not preserve calcareous structures, and so in the Devonian dolomite near Andalusia, as in the Niagara and other dolomitic limestones of the northwest, the fossil brachio-

*For particulars relating to the distribution of outliers of the Carboniferous age, the reader is referred to Hall's Geology of Iowa, vol. I, part 1, pp. 120-133; White's Geology of owa, pp. 228-9; Geological Survey of Illinois, vol. v, pp. 228-232.

pods are, for the most part, preserved only as internal casts of the shell.

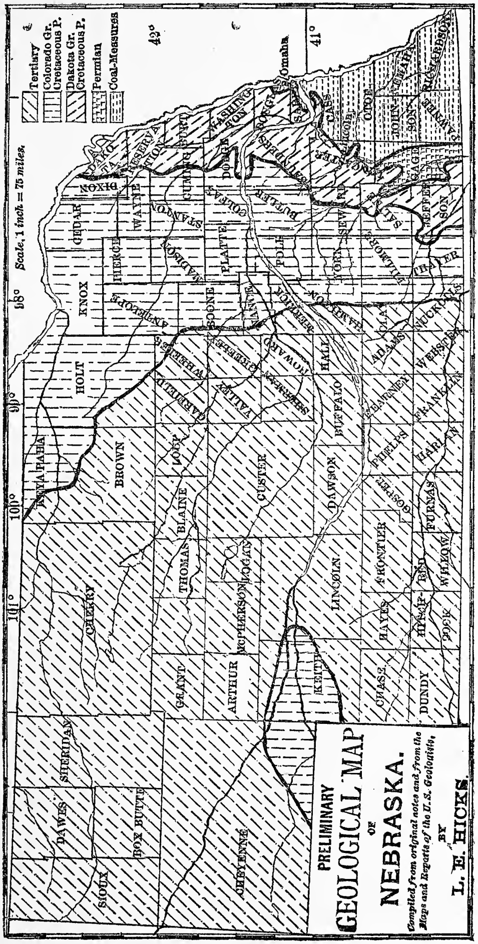
The fact that a dolomitic bed near Andalusia passes into a bed of sandstone farther west in the region of Pine creek, Iowa, would be in perfect accord with what I have already pointed out in the American Geologist for January, 1888, vol. I, page 30—namely, that the great dolomitic masses of strata representing the Niagara, Galena and Lower Magnesian limestones of Iowa, were formed off shores, and that further seaward, or at least further to the south and west, where they are generally concealed by newer strata, the place of the dolomites was taken by sandstones and shales.*

SOILS OF NEBRASKA AS RELATED TO GEOLOGICAL FORMATIONS.

By L. E. Hicks.

The soil upon which the farmer and fruit grower depends for the success of his labors is a thin stratum spread over the surface of the earth, varying from a few inches to two or three feet in thickness, and composed of two elements, *humus* and mineral matter. The first element is organic, derived chiefly from plants, but partly from animals, and has undergone partial decay. It is the essential element of fertility. But notwithstanding its prime importance it is, in point of origin, secondary and dependent upon the mineral matter. This possessed some degree of fertility in itself, and so produced a crop of plants whose decay enriched the place of their growth, and began that course of production and accumulation of *humus* which has resulted in the elaboration of the deep black soils which rejoice the heart of the Nebraska farmer. The mineral element of our soils varies greatly in composition, and these variations bring to view at once the relation of soils to the underlying rocks. It might be supposed that so thin and superficial a stratum as the soil, a stratum, too, which derives its most characteristic element from organisms growing freely in the air, would be independent of the rocks beneath. The bed rocks are often

*Notes on the Formations passed through in boring the Deep Well at Washington, Iowa, by Professor S. Calvin, American Geologist, vol. I, p. 28 *et. seq*. Published January 1888.


PRELIMINARY
GEOLOGICAL MAP
OF
NEBRASKA.
Compiled from original notes and from the Maps and Reports of the U.S. Geologists,
BY
L. E. HICKS.
Tertiary
Colorado Gr. Cretaceous P.
Dakota Gr. Cretaceous P.
Permian
Coal-Measures
Scale, 1 inch = 75 miles.
98°
99°
100°
101°
42°
41°
Omaha
DAWES
SIOUX
SHERIDAN
BOX BUTTE
CHEYENNE
CHERRY
KEYA PAHA
BROWN
HOLT
KNOX
CEDAR
DIXON
DAKOTA
WAYNE
PIERCE
ANTELOPE
MADISON
STANTON
CUMING
BURT
WASHINGTON
DOUGLAS
SARPY
DODGE
SAUNDERS
COLFAX
PLATTE
BOONE
BUTLER
POLK
YORK
SEWARD
CASS
OTOE
JOHNSON
PAWNEE
RICHARDSON
GAGE
JEFFERSON
SALINE
FILLMORE
THAYER
NUCKOLLS
CLAY
ADAMS
WEBSTER
FRANKLIN
KEARNEY
HALL
HAMILTON
MERRICK
HOWARD
GREELEY
WHEELER
GARFIELD
VALLEY
SHERMAN
BUFFALO
DAWSON
CUSTER
LOUP
BLAINE
THOMAS
LOGAN
McPHERSON
ARTHUR
GRANT
KEITH
LINCOLN
FRONTIER
GOSPER
PHELPS
HARLAN
FURNAS
RED WILLOW
HAYES
CHASE
DUNDY

buried deep under many feet of clays, sands, and gravels, so that their relation to the soil seems to be extremely remote. But these clays, sands, and gravels, which constitute the subsoil, are derived from the bed rocks, either those of the immediate vicinity, or the bed rocks of some region not very remote. All the mineral matter of soils and subsoils is derived from the bed rocks by decomposition and disintegration. I have already shown that the *humus* is dependent upon the mineral matter. Hence, the whole mass of the soil with all of its constituent elements is derived from the rocks. If all the loose material above the bed rocks were scraped off from the state of Nebraska, not many centuries would elapse until a new soil would be formed. If then we wish to understand the nature and origin of our soils, we must study the bed rocks. To facilitate this investigation I present herewith a Preliminary Geological Map of Nebraska upon which the geological distribution of the bed rocks is represented. This map has cost me much labor in the field, but I do not claim for it anything more than approximate accuracy. It is such a map as a geologist would construct to illustrate a preliminary reconnoissance, not such as would accompany the final report of a geological survey.

By reference to this map you will see that the oldest formation in the state is in the southeast. Underlying the counties of Richardson, Pawnee, Johnson, Nehama, Otoe, and Cass, and parts of Lancaster, Sarpy, and Douglas, the bed rocks are limestones, shales, and sandstones, with a few thin seams of coal. These rocks belong to the series of the Coal Measures of the Carbonic system. The coal in them is too thin and poor in quality to be of much commercial importance; still it is mined for local use in several counties. About 1,300 tons were taken out in 1887. Of the three kinds of rocks in the Coal Measures the sandstone is least important, both as to quantity, value as a building stone, and effect upon the soil. A few thick layers of it occur along the Missouri river, but it plays no important part in the industries or wealth of the counties underlaid by the Coal Measures. The shales are more abundant than either the limestones or the sandstones, constituting more than half of the entire thickness of the Coal Measures. They are of no value except as the basis of soils and of brick and fire clays. The clays produced by the decomposition of shales are often of superior quality. As the basis of soils these coal measure shales are good or bad according to the other elements mixed with them. Shales alone will weather down to a soil which is heavy and difficult to till. But if mixed sufficiently with sand and lime a rich loam will be the result. The shales of the Coal Measures are often calcareous enough to furnish the lime necessary for a good soil, and if not, the presence of limestones in the same formation yields a happy combination. The sandy element, which is needed to combine with the disintegrated shales in order to make a light, tillable soil, is furnished by the glacial drift and loess; two formations which lie upon the bed rocks in Eastern Nebraska. These are the newest of the Nebraska deposits (except the alluvium which is still forming along the streams) as the Coal Measures are the oldest, and they will be described in the proper place.

The limestones of the Coal Measures are the most important of the series in point of their economic value for lime and building stone, as well as their influence on the soil. The decay of limestones always tends to enrich the soil—a fact so obvious as to challenge the attention of the most careless observer. Limestones weather and decay much more rapidly than is generally supposed. The carbonic acid of the air and water attacks them with great vigor. Frosts crack their surfaces and the roots of plants enter and enlarge the fissures by their growth. Little by little the rock is broken down or dissolved, yielding its nutritive elements to the soil.

I have stated that the oldest rocks in Nebraska are in the south-eastern corner. Going westward from the Missouri river one constantly encounters newer rocks lapping over on the older ones. Passing from Pawnee to Gage county we pass from the Coal Measures to the Permian, the last series of the Carbonic system. The rocks of this series are very similar to those of the Coal Measures, the distinction between the two being based upon a difference in the fossils and the absence of coal. Hence in the area underlaid by Permian rocks the same soils may be found (so far as they depend upon the subjacent rocks) as in the counties where the rocks belong to the Coal Measures. The Permian occupies about two-thirds of Gage county and small portions of Saline and Lancaster counties.

After the Permian epoch there was a long interval during which no rock-forming sediments were deposited in the region now known as Nebraska. During the Carbonic period the sea prevailed over this region and in it were deposited the mud, sand, and lime which have hardened into the shales, sandstones, and limestones of the Coal Measures and Permian. Then the sea retired, and during the Triassic and Jurassic periods while thick strata were formed in other parts of the continent, Nebraska was dry land. The streams of water upon its surface cut deep valleys during this interval. Then as the land slowly sank again the sea once more invaded this region. In the valleys formed by running water, which were approximately in the same lines with the valleys now in existence, the incoming sea formed deep bays along its eastern shore. In these bays and all over the region covered by the incoming sea, was deposited a series of sands, clays, shaly sandstones, hard sandstones, quartzite, lignite, conglomerate, and shale, which now forms the Dakota group of the Cretacic system. This is found in Dakota, Burt, Cuming, Dodge, Washington, Douglas, Sarpy, Saunders, Lancaster, Seward, Saline, Jefferson, and Gage counties, as the reader will see by reference to the map. Some of these counties are almost wholly occupied by the Dakota group, others are just touched by this formation.

Of the varions kinds of rock above mentioned as occurring in the Dakota group, the sands, sandstones, and clays are most abundant, and exert the greatest influence upon the soil. The clays are valuable for brick and pottery. Where they form continuous strata of considerable extent, with a level surface, the water is retained, causing boggy or swamp land. By themselves these clays impart too great heaviness and tenacity to the soil, but with a suitable proportion of sand intermixed a good loam is formed. An abundance of sand and sandstone is everywhere present in the Dakota group to temper the clays. In some places the sandstone predominates so much as to form sandy knolls with a thin and poor soil or none at all. But these bald knobs are not numerous, and are never of great extent. The glacial drift and loess cover the country occupied by the Dakota group so generally that it is only on the high points projecting into the valleys that the sandstone foundation is in sight, making thin land.

West of the Dakota group comes the Colorado group of the

Cretacic system, extending through the east central portions of the state. Its eastern boundary is the Dakota group as already indicated. Its western boundary runs from the north-west corner of Brown county in a south-easterly direction to Boone county, thence almost due south to the Kansas line, near the point in Nuckolls county where the Republican river leaves Nebraska. Besides this great central belt of the Colorado group there is another area in Cheyenne, Keith, Lincoln, and Perkins counties along Lodge Pole creek and the South and North Platte. The rocks of the Colorado group are limestones, shales, and clays, which exert the same influences upon the soil as already ascribed to such rocks occurring in the Carbonic system. A characteristic difference, however, between the Carbonic limestones and those of the Colorado group is that the latter are extremely soft and friable, thus the more readily breaking up and yielding their nutritive elements to the soil. So well marked and general is this characteristic that these strata of the Colorado group are generally known as "rotten limestones." They are full of shells of the genera *Inoceramus* and *Ostrea*. Some of the outcrops look like dumping grounds of an oyster market, as if the shells had been thrown down by the wagon load and partially cemented together by the solution and redeposition of the calcareous matter. This process of solution and redeposition has in some places produced large masses of crystals of calcite. In northern Nekraska the limestone of the Colorado group is quite chalky, so that it is known as "chalk rock." Fine sections of it may be seen in the hills bordering the Missouri river in Cedar and Knox counties. In western Nebraska the limestone of the Colorado group is firmer in texture than in the central belt, but still readily yielding to the action of the elements, and thus enriching the soil.

The Cretacic rocks both of the Colorado and Dakota groups were deposited in seawater. Marine fossils occur in them from top to bottom. After the close of the Cretacic period much of Nebraska was dry land, but a fresh water lake covered all the western and central counties. In this lake, which varied in its extent from time to time, were deposited the rocks of the Tertiary era the most widely distributed of all the geological formations of Nebraska. It is indicated on the map by oblique strokes from the right above to the left below. The rocks of the Tertiary include nearly all the kinds previously mentioned. Limestone of the ordinary kind, rotten limestone, ordinary sandstone and calcareous sandstone, indurated clays and soft clays, conglomerate, lignite, and quartzite, are all found in the Tertiary. Loose sands also occur in great abundance, and as they are driven to and fro by the wind form the belts of "sand hills" which mar the beauty and productiveness of many townships. Marl of fine quantity for fertilizing, and thick beds of peat, are also found in the Tertiary.

The so-called "bad lands," or *mauvaises terres*, of the Tertiary are formed by erosion in the indurated clays and marls which yield to running water readily enough to form deep gullies in the line of the current, and yet have the requisite firmness and tenacity to stand up in steep walls against the weather. These bad lands constitute a temporary stage of the evolution of stable land surfaces in soft strata. So long as the little streamlets have a rapid fall they gouge out deep gullies with steep walls. Each side channel entering the little valley forms a tributary canon, which again forms its tributaries, until an intricate maze of principal and tributary canons is produced. In the process of formation while erosion is in rapid progress no vegetation can obtain a permanent hold in any of the gullies. But as the system enlarges and the tributary canons run into each other, the central stem of the tree-like system widens out and ceases to become deeper because the natural drainage level has been reached. Grasses, weeds, shrubs, and trees take root. The steep walls are washed down to gentle slopes which presently take on the grateful green of the valley. Thus the whole region which the water had cut into barren, forbidding, and impassable gullies, may be transformed into fertile valleys. The process is too slow, however, to make it advisable to locate claims in the bad lands. Like all geological processes, it requires ages to work these changes. The whole continent is gradually approximating a condition of stability as regards erosion but that condition will not be reached until the whole surface is reduced much nearer to the level of the sea than it is at present.

The bad lands and sand hills, however, form but a small part of the country occupied by the Tertiary. Some of the best grazing and arable land in Nebraska may be found in the bed of the old Tertiary lake, and it owes its fertility directly to the sediments deposited there. Much of that sediment is indistinguishable from the loess of eastern Nebraska, one of the best foundations in the world for a fertile soil, as shown more fully below. Both are fresh water formations, much resembling the dried mud of existing lakes and rivers, whose fertilizing qualities are exemplified in bottom lands, in the beds of lakes reclaimed by drainage and in the effects of the overflowing waters of the Nile upon the lands of Egypt.

This completes the enumeration of the bed rocks of Nebraska, as they are delineated upon the accompanying may. There are two additional formations not represented on the map, but mentioned in this paper because of their great and direct influence upon the soil. These are the glacial drift and the loess, both of which belong to the Pleistocene or latest period of geological history. They are not shown upon the map, for two reasons. In the first place, their extent in Nebraska, especially that of the loess, is not thoroughly known. In the second place, they overspread several of the older formations so completely that if they were represented on the map the underlying formations would be hidden. It would require a separate map to exhibit these Pleistocene deposits, or two maps in addition, since the loess partially overlies the drift, and requires a map by itself. The glacial drift is composed of sand, gravel and clay. It was carried down from the north or north-east, and spread over the eastern part of Nebraska by the agency of ice, or of ice and water combined. The clay of this drift sometimes forms a "gumbo" soil as, indeed, the clay of any geological age may do, if not mixed with sand and lime.

But in general the glacial drift has about the right proportions of sand, gravel, clay, and lime (from the limestone pebbles and bowlders) to form an excellent soil and subsoil. A soil formed from and resting upon glacial drift is usually loamy, easy to till, with good drainage, and not soon injured by drought. The loess has nearly the same general distribution as the glacial drift—*i. e.*, it may be found over much the same territory, though neither drift nor loess covers every square mile of the general region in which they are found, and one may be wanting where the other is present. Whenever in Nebraska at least, both are present the loess is above the drift, and forms the surface of the country, thus exerting a more direct influence upon the soil than any other formation. This influence depends upon the chemical and physical properties of the loess. In its chemical composition the loess contains all the essential elements required in the growth of plants, in so far as that growth depends upon the mineral kingdom. Hence when the organic matter of the humus is added to loess (some organic matter being already contained in the loess itself) the happiest combination for a fertile soil is secured. The physical properties of the loess are of even greater importance than its chemical composition. It is permeable to moisture, and therefore insures good drainage to the soils formed and underlaid by it. At the same time, water does not run through it so rapidly, or pass away so completely, as in sand or gravel. Every cubic foot of it retains a large amount of moisture, and, since it has a thickness of more than a hundred feet in many places, the aggregate amount of moisture retained by it is enormous. As the surface dries in the heat and drought of summer this retained moisture is brought up to nourish the growing crop. In the rainy season a fresh stock of moisture is laid up. This storage of moisture is much facilitated by the loosening of the surface in the operations of tillage. The loess is capable of assuming almost the hardness of stone, a fact which accounts for the excellent natural roads in Nebraska. By the trampling of animals, the sun's heat, and the beating of storms, the natural surface of the prairie became hard and nearly impermeable, causing the rain-fall to pass off in sudden floods. The breaking up of this hard stratum by cultivation causes the retention of a much larger percentage of the rain-fall, and indirectly increases the rain-fall itself.

The loess is a deposit of sediment in a fresh water lake which covered eastern Nebraska during a very late period of geological history. I have already spoken of another fresh water lake in western and central Nebraska, in which the Tertiary rocks were laid down. It is difficult to distinguish between the late Tertiary strata and the loess—a fact not at all comforting to the field geologist, but quite the contrary to the farmer in western Nebraska. In many counties formed of Tertiary strata the upper member is a fine loamy clay or marl, in every respect similar to the loess—so similar, indeed, that some geologists have described it as loess. Whatever it is in the geological classification matters not to the practical farmer, as he reaps bountiful harvests from it.

Alkali lands are caused by standing water. A tract thoroughly drained will never be permanently alkaline. Underdraining is better than surface draining, because it tends to draw the moisture downward from the surface. The opposite result occurs where standing water evaporates. Not only are the alkalies in the water precipitated as the evaporation proceeds, but more alkali is brought up from beneath by the ascending moisture. Drainage and tree-planting will cure nearly all the alkali patches in Nebraska.

EDITORIAL COMMENT.

THE EXHAUSTION OF ANTHRACITE COAL.

In 1880 Mr. P. W. Sheafer, of Pottsville, Penn., made estimates of the amount of anthracite coal remaining in the three fields of Pennsylvania,* viz.

	Area, square miles,	Acreage.
First, or Southern coal-field	146	93,440
Second, or Middle coal-field	126	80,640
Third, or Northern coal field	198	126,720
Total	470	300,800

	Yards.	Tonnage.
First, average total thickness of beds	25	11,306,240,000
Second, average total thickness of beds	15	5,854,464,000
Third, average total thickness of beds	15	9,199,872,000
Total tonnage		26,360,576,000
Amount to be mined, one-third		8,786,858,666
Total shipments to January 1st, 1888		628,612,720
Adding for local sales and amount used at mines as per Geol. Rep. (1887, est'd 6 per cent.)		53,119,40
Total production to January 1st 1888		681,732,129
Present available supply, workable		8, 107,125,537

At present rate of production would last 202 years.
With maximum rate of production from 1890 (50,000,000 tons), would last 162 years.

From which he conludes:

The total amount of coal still to be mined is 26,360,576,000 tons. The total waste, as experience has shown, is equal to two-thirds of the coal deposit, and reaches the appalling amount of 17,573,717,334 tons, leaving

*American Association for the Advancement of Science. Proceedings, 1880.

us only 8,786,858,666 tons to send to market. In all our calculations of anthracite we have counted the area as if in a level plain, and made no allowance for the undulations which must necessarily increase the amount of coal. But as many of the flexures are abrupt and broken, making much faulty and refuse coal, it will cover any over-estimate of area or of thickness we have made in our calculations. Our tables show that 360,-017,817 tons have been sent to market in the 59 years from 1820 to 1878 inclusive. Our consumption now amounts to 20,000,000 tons annually. The increase of production for the past ten years has been 187,112,857 tons. At this rate we shall reach our probable maximum output of 50,-000,000 tons in the year 1900, and will finally exhaust the supply in 186 years.

Recent re-estimates made by the editor of the *Mining and Engineering Journal* vary considerably from these results. These estimates fix the amount of coal in the ground as 9,000,-000,000 tons, two-thirds of which is waste, leaving 3,000,000,-000 tons as the total amount of available coal to be mined. With the present lavish methods of mining, and with the present increasing amount of coal marketed, this would be exhausted in seventy-five years. This causes Mr. Sheafer to reconsider his former calculation and he comes to the conclusion that the time he formerly allowed for the exhaustion of the anthracite coal deposits was too great, and that the aunual output is increasing at a rate hardly expected by any statistician ten years ago. He distributes the present available tonnage as follows:

	Tons.		Tons.
1st. Southern field	4,000,000,000	Workable (⅓)	1,333,000,000
2nd. Middle field	1,800,000,000	"	600,000,000
3d. Northern field	3,200,000,000	"	1,066,000,000

The present rate of shipment is:

First field, percenta shipment,	30 per cent	12,000,000
Second field "	18 " "	7,200,000
Third field, "	52 " "	20,800,000
	100	40,000,000

At these ratios of shipment, the Wyoming region would exhaust itself in 51 years, leaving the other regions to supply the demand with workable coal after that time.

	Tons.
Southern field	721,000,000
Middle field	232,800,000

Assuming each field to double its proportion and ship as follows: Southern field, 65 per cent, Middle field, 35 per cent, in 16⅔ years more, or 67 ⅔ years hence, the Middle field would be totally exhausted, leaving the Southern field with less than 300,000,000 tons of coal to mine, that would last 7½ years longer, or a total exhaustion in 75 years.

Mr. Sheafer calls attention to some improved methods of mining. "The large shipments of our railroad companies seem to be for the purpose of securing the most tonnage possible, and lead to the working of mines for large production more than careful mining. Those who own lands are exercising more care in mining, so as to seecure a continuance of the supply. But when we have large coal beds, say from 20 to 40 feet in thickness, as in the Mahanoy district and part of the Wyoming region, how can we secure half of the coal if we must support the surface? Neither timber nor even iron props will answer the purpose. Any bed of coal less than ten feet in thickness can be mined so as to secure three-fourths of the coal. In bituminous beds you can rob the pillars and let the surface fall and no harm results. The same is true in smaller anthracite beds. But when you have to mine the Mammoth bed, you cannot confine the great pressure of the surface to a small area. The heavy sandstone rock which covers it, when disturbed by the removal of a pillar, brings on a pressure that affects the whole mine. * * * * There has been recently adopted a plan at the workings of the Kohinoor colliery, in the Shenandoah district in Schuylkill county, that, I think, will enable us to secure three-fourths of the coal in the mine. At this point the Mammoth bed is 40 feet thick and lies nearly horizontal. To support the surface and the town upon it, will naturally require great pillars of coal, at least half of the mine. The plan devised, and now being worked, is to bore through the superincumbent strata, 400 feet thick, eight-inch holes to the top of the coal bed. Cast-iron troughs 10x12 inches wide, with continuous bands of scrapers moving in them, or what is now called a "scraper line," connect with the immense culm banks at the breaker, some 1,600 feet distant. The scraper line delivers continuously a large amount of culm at the mouth of the hole. This meets there a stream of water, and a mixture of about three-fourths water and one-fourth culm constantly drops into the river below and there distributes itself, permeating every nook and corner of the cavities. The deposit becomes so hard as to require a pick to remove it. It entirely fills the chamber even to the roof, and supports the pillars, but leaving them accessible to the miner for removal when the large spaces surrounding them are entirely filled. Of course we must direct the currents of water and culm, limiting the culm by dams or batteries, and allow the water to flow back to the main sumpt of the mine, where it is pumped out to be again used in carrying more culm to its original abiding place. Filling with culm alone would not answer the purpose; it would form a cone of loose dirt and of no strength; but if deposited as above described it becomes a nearly solid mass, an abundant support to the surface or strata above the vein. The material is cheap, abundant and conveinent. We can now realize, after a year's trial, that we secure three-fourth of all our coal where this method has been adopted. I hope our further experience will yield even better results."

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Synopsis of Rosenbusch's New Scheme for the Classification of Massive Rocks. By W. S. Bayley. This is a separate issue of 24 pages of Prof. Bayley's three contributions on the subject to the American Naturalist. This condensed view of Rosenbusch's classification is timely, and Prof. Bayley's pamphlet, if accessible, will be a great convenience to the increasing number of petrographic investigators who may not as yet have provided themselves with the second edition of the original work.

Proceedings and Transactions of the Nova Scotian Institute of Natural Science, of Halifax, Nova Scotia. Vol. vii, Part ii, 1887-88. This part contains three important geological papers by Rev. D. Honeyman, D. C. L., on "Glacial Geology of Nova Scotia;" "Carboniferous Flora with attached Spirorbes," and "Nova Scotian Superficial Geology, Systematized and Illustrated." Mr. Honeyman concludes that the facts as observed by him conflict equally with Sir J. W. Dawson's theory of absence of glacier agency, and Thomas Belt's opinion that the Nova Scotian Drift is a "local phenomenon." The same Part contains a third paper on "The Carboniferous of Cape Breton, with Introductory Remarks," by E. Gilpin, Jr., F. G. S., F. R. S. C.

Peter Redpath Museum, McGill University, Montreal. Specimens of Eozoon Canadense and their Geological and other Relations. Montreal, September, 1888. By Sir J. William Dawson, L. L. D., F. R. S., F. G. S., &c. This memoir, of 107 pages, is the result of an attempt to catalogue and describe the original specimens on which the name *Eozoon* was based, together with those later acquisitions which have thrown further light on its structure. The collections made by Sir W. E. Logan are now for the greater part in the Museum of the Geological Survey at Ottawa. Those accumulated by the author of these notes, as well as duplicates presented by Sir W. E. Logan, are in the Peter Redpath Museum. Large and valuable collections, more especially of microscopic preparations, were also in the possession of Dr. W. B. Carpenter at the time of his death.

Many have supposed that the attacks made on the assumed organic nature of *Eozoon* by King and Rowney and by Möbius and others had settled the question adversely, but Sir W. Dawson comes forward with a mass of evidence old and new, on which he bases his faith with undisturbed security. In his summary of arguments in support of the animal nature of *Eozoon canadense*, he embraces the following statements: 1. It occurs in masses in limestone rocks just as *Stromatoporæ* occur in the palæozoic limestone. 2. In small or limited individuals it assumes a regular rounded, cylindrical or more frequently broadly turbinate, form. 3. Microscopically it presents a regular lamination, the laminæ being confluent at intervals so as to form a net-work in the transverse section. The laminæ have tub erculated surfaces or casts of such surfaces, giving an acervuline appearance to those laminæ which are supposed to be the casts of chambers. 4. The original calcareous laminæ are traversed by systems of branching canals, now filled with various mineral substances. 5. In some specimens large vertical tubes or oscula may be seen to penetrate the mass. 6. On the sides of such tubes, and on the external surface the laminæ subdivide and become confluent, thus forming a species of porous epidermal layer or theca. 7. Fragments of *Eozoon* are found forming layers in the limestone, showing that it was being broken up when the limestones were in process of deposition. 8. The great extent and regularity of the limestones show that they were of marine origin, and they contain graphite, apatite and obscure organic (?) fragments other than *Eozoon*. 9. The mineralization is identical with that of Silurian and other fossils. 10. Sometimes the calcareous filling of the canals and chamberlets can be distinguished as different from the calcite of the original wall. 11. The specimens have been folded and faulted with the containing limestones, showing that they are not products of any subsequent segregation. 12. Similarly they are crossed by the veins of chrysotile which traverse the limestones and are of later origin. 13. All the forms and structures are such as might be expected of a gigantic generalized rhizopod of primitive times. 14. Many of the objections raised have been based on insufficient or imperfect specimens, or on want of the necessary experience in the study of the more ancient fossils in various states of preservation.

Functionally *Eozoon* was a collector of calcareous matter from the sea. Its role was the same as that of the stromatoporoids and calcareous sponges, smaller foraminifers and corals of the later times. Zoologically Eozoön presents some resemblances to stromatoporoids, but the position of these is in dispute. They are evidently divisible into different groups, and *Eozoon* may represent one of them. *Eozoon* is probably more akin to the calcareous-shelled rhizopods than any other modern group. "The modern *Polytrema* which encrusts shells and dead corals in the warmer seas seems to me to present more resemblance to *Eozoon* than any other organism I know."

The Gold Fields of Victoria. Reports of the mining registrars for the quarter ending 30th June, 1888. Compiled and arranged by the Secretary for mines. (C. W. Langtree.) Melbourne. 4to. pp. 92. From this document it appears that the yield of gold for the quarter was 150,193 ounces. The ground actually worked upon was 324½ square miles. The mining population was 25,679, of whom 12,795 were employed in quartz-mining, and 12,884 in alluvial mining. The Chinese miners number 3,980. The total of dividends paid was £117,214. The deepest shaft was 2,409 feet. The total value of the machinery employed was £1,815,731. The mining interests of the colony appear to be chiefly confined to gold, and their condition is prosperous.

PROF. C. L. HERRICK HAS RECENTLY issued the third part of the bulletin of the laboratory of Denison University at Granville, Ohio. The principal part of the volume is occupied with a paper on the results of Prof Herrick's investigations on the Waverly group of Ohio. The fossils are described and a very large number of them are well figured.

Prof. Herrick divides the Waverly into three parts and characterizes them palæontologically as follows:

No. I, contains 25 species with a decidedly Devonian habit (often closely related to Hamilton species) and only 2 or 3 species of Carboniferous habit.

No. II, contains 12 species of Devonian affinity (often Chemung) and 9 of Carboniferous habit.

No. III, contains no species showing Devonian relationship and 7 that indicate a Carboniferous habit.

As the outcome of his study he is evidently inclined to place the Waverly group lower in the scale than has hitherto been done by geologists. Of the second group he says: "Most of the strata may have been deposited while the Catskill was forming at the east but the fauna was essentially of Chemung character."

It would require more space than we have at present at command to express fully the work of Prof. Herrick, but we may say that he has made a valuable contribution to the solution of the vexed question of the true place of the Waverly in the geological column.

Another article of geological interest in the volume, is by Mr. Aug. Foerste on some palæozoic fossils. The chief species noted are *Microdiscus punctatus* from the St. Johns' group, N. B., a new Lichas from the Cincinnati group which he proposes to name *L. halli*; the so-called *Sphereochus romingeri*, of Hall, which so far as the Ohio specimens are concerned, he says, is identical with the European *S. mirus;* and several new species of trilobites and corals from Australia.

Die Steinkohlen, ihre Eigenschaften, Vorkommen, Entstehung und nationaloekonomische Bedeutung. Von Franz Toula, Wien, 1888, 12mo, pp. 1-208, pl. I-VI. The Society for the Propagation of Scientific Knowledge, in Vienna, has published under the above title, a work which, for its concise and comprehensive treatment of the general subject, as well as its special adaptation to the needs of working field geologists, is worthy of notice. The opening chapters are devoted to a discussion of the different kinds of coal, their properties and characteristics, and the results of numerous chemical analyses. Following this, the author treats of the geology of the palæozoic coals and their geographical distribution, illustrated by many sections and maps, with tables of their production in the various countries, together with a very brief history of their exploitation in those countries. In a somewhat extended discussion the physical conditions under which the different coals were formed are considered, as well as some of the problems as to the age of the eastern and southern coals. The latter he regards as of true Carboniferous age, the change in the plant life from a palæozoic to a mesozoic facies being credited to a change of climate caused probably by glaciation, occurring in the latter half of the Carboniferous epoch. The synopses of the great families of the coal plants, described in un-technical language, with brief characterizations of many of the principal genera and species, is a feature of the work which geologists in the field will duly appreciate in such a hand book. In the systematic classification of the coal flora the author proves himself familiar with the work of the leading European authorities on palæozoic plants, and he adapts it to the most recent results obtained by Stur, Weiss, Williamson, Renault and Grand Eury in the course of their palæobotanical investigations. This is illustrated by six quadruple plates of the most widely distributed coal plants, engraved with unusual excellence, and giving special prominence to the nervation and detail. The form convenient for the pocket, in which the book is published, suggests the utility of an English translation in a similar edition.

Notes on the geology of western Texas. By PROF. ROBERT T. HILL. (Reprint from the Texas Geological and Scientific Bulletin; Austin, Oct., 1888.) Professor Hill reports on two trips made by him over "the vast prairie and mountainous areas of western Texas which seem to be the geological *terra incognita* of the United States." Along the line of the Texas Pacific Railway he finds a rich field "for competent scientific investigators." Equally important was the trip from Texarkana westward to Henrietta, and thence north-west over the plains and up the valley of the Canadian to Tucumcarri mountain in New Mexico. "The surface of the Llano Estacado," he says, "is an early quaternary loam, and a direct continuation of the great plains of Kansas and Nebraska, while the white-matrixed conglomerate which appears so clearly as the surface of the valley dividing the north and south plains is a later quaternary deposit. This all implies: *first*, a great basin of aqueous sedimentation in early quaternary time of the region now occupied by the Llano Estacado; *Second*, a subsequent elevation to a hight, but in no way approaching its present altitude; *Third*, a subsequent semi-submergence, during which time the sediments (tierra blanca of the Mexicans) of the trans-Pecos mountain valleys, and of the wonderful sub-plains or valleys now occupied by the Pecos, Rio Grande and Canadian were cut; *fourth*, a later, rapid and enormous uplifting of the region to the present altitude, the course of which is recorded in the extrusions of eruptive masses of 'malapais' or recent volcanic rocks. In fact these plains, and the geology of the whole region bring to the eastward many miles our knowledge of the wonderful phenomena of Mount Taylor and the Zuni plateau, west of the upper Rio Grande, and give us the connecting link between the marvelous quaternary phenomena of the lower cotton belt and of the great plains."

The detailed results will be given in Prof. Hill's forthcoming report on the geology of south-western Arkansas.

On the origin of primary quartz in basalt. By JOSEPH P. IDDINGS, of the U. S. Geol. Sur. (From Am. Jour. Sci., Sept., 1888). This paper describes certain specimens of basalt which exhibit a remarkable number of porphyritic grains of quartz, recently collected in New Mexico, in the vicinity of the Rio Grande Canon.

These quartzes are plainly not the product of alteration nor infiltration, for the rocks are fresh, and on the surface of the olivines but slight change is visible. Each grain is closely surrounded by a shell of augite crystals intimately connected with the enclosing rock mass. The quartz is pure and free from inclusions of gas, fluid or glass. Each grain is a single individual with uniform optical orientation throughout. They are not made up of an aggregate of small grains, the form which secondary quartz usually assumes. The grains are rounded or subangular. They are not like the quartzes of granites, gneisses and sandstones which are more or less permeated with inclusions of gas and fluid, but are like the porphyritic quartz grains of volcanic rhyolytes.

The author mentions several other similar chemical occurrences that seem paradoxical under ordinary physical conditions of crystallization, such as an iron olivine in a rhyolyte with 75 per cent of silica and less than 2 per cent of iron oxide. He concludes that when such anomalous coincidences are found the surrounding physical conditions which attended the solidification of the magma must have been exceptional. The exceptional physical conditions may have preceded the final solidification, and been of such a character as to demand the secretion and crystallization of the anomalous mineral forms, and indeed seem to have been so in the case of the quartzes, and to have ceased. This is evinced by the resorption of the angles and edges of the crystals into the general basic magma, resulting in the rounding of the grains.

After enumerating the various physical conditions and agents which are likely to vary within the crust of the earth, such as temperature, pressure, viscosity, water vapor, eutectic substances, and their combined as well as their separate action on the magma, he applies them to a hypothetical case in the production of known quartz-bearing basalt; and suggests that through the agency of absorbed water, acting under favorable conditions of pressure and temperature, a partial consolidation of the deep-seated magma may be effected in the production of extremely acid and basic silicate minerals in unstable solidification, the dissociating action of heat or of super-heated steam being sufficient to nullify the ordinary chemical affinities but not able to suspend the tendency to isolation and crystallization. On the removal of the exceptional physical conditions, the unstable solidification may be broken up and the crystals partially or wholly resorbed again into the general magma; or if final solidification supervened they may be embraced as indigenous though abnormal crystals in the resulting rock. The paper is a very interesting and valuable one to the petrographic student.

Microscopical Physiography of the Rock-making Minerals: an Aid to the microscopical Study of Rocks. By H. ROSENBUSCH. Translated and abridged for use in Schools and Colleges, by Joseph Iddings. Illustrated by 121 woodcuts and 26 plates of photomicrographs. New York, John Wiley & Sons, 1888.

Every well executed effort to introduce to American students and investigators the recent views and methods of European, and especially of German petrographers, deserves a cordial reception. For such reason, we are glad to welcome the translations, complete and partial, which have been made of Hussak's *Gesteinbildende Mineralien*, and of Rosenbusch's Classification of Massive Rocks, condensed in a translation by Professor Bayley. It would still further aid American petrographic studies if we could see in an English dress such other works as Des Cloizeaux' *Manuel de mineralogie*, Von Lasaulx' *Einfuhung*, Roth's *Allgemeine und chemische Geologie* (1879-1887) and Kalkowsky's *Elemente der Lithologie.*

Mr. Iddings' translation has been a work of considerable magnitude and delicacy. The effort at abridgment has also involved much responsibility. Such enterprises embody no temptations to selfishness or ambition. The abridgement consists chiefly in the omission of historical and literary portions—in part also, of portions explanatory of the diverse views and expedients of investigators. It involves the omission of many citations of authorities. To a limited extent it consists in the condensation into a brief statement, of matter more expanded in the original. The effects of these various methods of abridgement are various. Sometimes the omitted matter sustains no connection of dependence with matter retained—being merely accretionary, and hence separable without violence. Such are the "Historical Introduction" and other historical paragraphs, the description of the microscopes of Fuess—even his new microscope—and of Voigt and Hochgesang, since the action and appliances of the Nachet microscope cover about all the ground. Such also are some of the various appliances for getting stauroscopic effects, and for accomplishing various other ends. Sometimes the omissions are amplifications which in the original shed additional light on difficult points. Sometimes also they are intermediate steps in a verbal or algebraic argument; and here the difficulties of comprehension are evidently increased. Learners need amplification rather than ellipses. This is somewhat felt, for example, in the condensation of the mathematical discussion of the theory of the behavior of doubly refracting plates in parallel polarized light.

As a final result of abridgement we have in this translation 333 pages, and 121 cuts in the text. The original contains 664 pages of the same size (includidg 88 pages of titles) with 171 cuts in the text. The beautiful Newtonian scale of colors is also wanting from the translation. On the contrary, the twenty-six plates of "microgrammes" are reproduced without visible deterioration. The abridgement was planned probably, in the interest of the American student, "omitting" as the translator says, "what seemed to be refinements beyond the needs of the average student." For the greater part, this is the result; but in some cases the omissions increase the learner's difficulties. Simplicity sustains no direct ratio to brevity.

So far as the work of translation is concerned, the author's success is deserving of great commendation. Sometimes we find the long and knotty sentences of the original broken up—English and Gallic fashion—to the great advantage of clearness. Generally, the sentences have undergone such transpositions and reconstructions as set the meaning forth in good idiomatic English. Occasionally however, obscurities and inaccuracies of the original are too faithfully reproduced. An example occurs on page 85, in the paragraph next to the last, in the expression "when the principal axis is parallel and perpendicular to the direction of the rays." Evidently, this is a geometric impossibility. The author and translator intend to say "when the principal axis is parallel and when it is perpendicular to the direction of the rays." So on page 49, the translator, following the author, says: "the short or inclined diagonal of the end faces of the nicol prism which has a rhombic form." Evidently, they mean "have rhombic forms." A similar solecism occurs at the top of page 61, where the translator says: "The actual appearance, however, is different for an optically uniaxial and biaxial substance"—as if such substances were normal occurrences. Here however, the translator has deviated from the author's "verschieden bei den optisch einaxigen und den optisch zweiaxigen substanzen." So sometimes, the translator has overlooked the presence of a German idiom, and imported an obscurity. This happens in his translation of "beide," which he renders "both," where the meaning would better appear if rendered "the two." Examples occur, p. 39, 14th line from the top, p. 62, 5th line from the top, and p. 82, 3d line from the top. In general, however, the meaning of the original is brought out with admirable lucidity, surpassing that achieved by the author. Again and again, this feature elicits our commendation. Occasional typographical errors are noticed, but these are mostly obvious, though in some cases, the learner would not readily detect them, and in all cases they are regrettable.

A work like this is onerous if a mere literal translation; but where condensation is also sought, the labor quite surpasses that of translation. This great work of Rosenbusch—*Mineralien* and *Gesteine*—embodies a vast amount of industry and abstract thought. It is to be hoped that both author and translator of this volume will find adequate reward for an undertaking so desirable in its results and so satisfactory in its achievement.

RECENT PUBLICATIONS.

1. *State and Government reports.*

Reports on the geology of Bath and Fleming counties. By W. M. Linney. Roy. 8 vo 85 pp. Colored geological map. *Geological survey of Kentucky.*

The present condition of knowledge of the geology of Texas. 95 pp. By Robert T. Hill. *Bulletin No. 45, U. S. Geol. Sur.*

Analyses of waters of the Yellowstone National park. 84 pp. By Gooch and Whitfield. *Bulletin No. 47, U. S. Geol. Sur.*

3. *Papers in scientific journals.*

Canadian Record of Science, vol. iii, No. 4. On some Canadian rocks containing scapolite, with a few notes on rocks associated with the apatite deposits. FRANK D. ADAMS and ANDREW C. LAWSON. Eozoön canadense, SIR J. WILLIAM DAWSON. On the Eozoön and paleozoic rocks of the Atlantic coast of Canada in comparison with those of western Europe and the interior of America. SIR J. WILLIAM DAWSON. The St. Lawrence basin and the great lakes, J. W. SPENCER. The study of mineralogy. T. STERRY HUNT. Mineralogical evolution, T. STERRY HUNT.

Am. Jour. Sci., November No. Mineralogical notes, by Penfield and Sperry; (1). Beryl; (2) Phenacite; (3) Monazite; (4) Sussezite; (5) Twin crystals of quartz with inclined axes; (6) Oligoclase with abnormal optical properties; (7) Barium Feldspar (the cassinite of Dr.Lea); (8) Pure magnesia, mica, Phlogopite. Mineralogical notes, by W. E. Hidden; Xenotine from several places. *December No.* A brief history of Taconic ideas, by J. D. Dana. Puget group of Washington territory, by C. A. White. Sulphantimonites from Colorado, by L. G. Eakins. New Thorium Mineral, Auerlite, by Hidden and Mackintosh.

American Naturalist, August No. The Dikes of the Hudson River highlands. J. F. Kemp. Dr. N. O. Holst's studies in Glacial Geology, Josua Lindahl.

4. *Excerpts and individual publications.*

Notes on the Sub-Carboniferous series at Sedalia, Mo., by F. A. Sampson. Description of two new species of Carboniferous trilobites. By A. W. Vogdes. From the Trans. N. Y. Acad. Sci. June 4, 1888.

The language of paleolithic man. By Daniel G. Brinton, M. D. Read before Am. Phil. Soc. Oct. 5, 1888.

Report on bones of Mastodon or Elephas found in association with human relics in the village of Attica, Wyoming Co., N. Y. By J. M. Clark. 7 pp. 8 vo. one plate.

On Perlitic Felsites, and on the origin of some Epidosites. By Frank Rutley. *Quar. Jour. Geol. Soc. for November 1888.*

5. *Foreign publications.*

Neue Beobachtungen ueber die Quartaerbildungen der Magdeburger Börde, von R. D. Salisbury and F. Wahnschaffe. Separat-Abdruck a. d. *Zeit. d. d. geol. Gesell.* Bd. XL. Heft 2. 1888.

Recent observations on the glaciation of British Columbia and adjacent regions. Geo. M. Dawson. Ext. from the *Geol. Mag.* Decade III, VOL. v, p. 347; Aug. 1888.

Ueber den Dolerit von Londorf. von A Streng in Giessen, mit Tafel v. Separat-Abdruck a. d. *Neuen Jahrbuch fur Mineralogie* etc. 1888 Bd II.

CORRESPONDENCE.

While in England, and through the kindness of Prof. W. C. Williamson, of Owens College, Manchester, I had the pleasure and privilege of examining, in company with Dr. Stur of Vienna, and Mr. Seward of Cambridge the immense and critical collection of microscopic sections on which rest the statements which for the past twenty years Prof Williamson has put forward regarding the nature of the lepidodendrids and sigillarids. As is well known to all students of this department of science, Prof. W. has maintained almost single-handed against others the partly vascular nature of the stem of these great trees of the Coal Measures. Mr. Carruthers, of the British museum has been the most prominent leader on the opposite side.

No one can, I think, rise from an examination of the beautiful series of slides which the industry of the professor has accumulated in the course of a long life's work without feeling that the structure of these old trees was what he has affirmed it to be. I was previously familiar with the engraved figures in the proceedings of the Royal Society of London, but there always lurks a certain, or rather an uncertain, amount of doubt in regard to the "personal equation" of the observer. By an almost unconscious omission, and an equally unconscious amount of commission, a drawing often becomes a diagram and ceases to be truthful. It represents, not what the microscope shows, but what the observer saw, and these, as every microscopist knows only too well, are two distinct things. But after a careful examination of Prof. Williamson's material, no doubt can remain in the mind of the observer, that the existence of a true woody cylinder in both these genera is fully established. Abundance of teal fibre and of medullary rays may be seen in the sections of their stems which the professor has made. Many other points of which I have not the time to write just now, are also established by his work. We need no longer, therefore, hesitate to conceive of these giants of the palæozoic forests as huge exogenous cryptogams containing in themselves the essential structure of the Lycopodium and that of the dicotyledonous trunk of the present day.

Soon afterwards I had also the pleasure of visiting Mr. R. Kidston of Sterling, another enthusiastic worker in the same field, whose beautiful collection of the same kind only confirms in the strongest and clearest manner what Prof. Williamson has published. Mr. K's results have been laid before the scientific world in a series of papers published in the transactions of the Royal Society of Edinburgh, and in the Quarterly Journal of the Geological Society of London. It is only fair to add that fortune has favored the workers on the other side in a singular manner by affording them specimens of the coal plants in a state of preservation that renders them well adapted for the purpose of microscopic research. No similar specimens have, so far as I am aware, been yet discovered on this side of the Atlantic. Silicified and calcified fossil trunks of Lepidodendron and Sigillaria lend themselves easily to the work of the lapidary and the microscopist, and though these are rare even in Europe yet they have been found in quantity sufficient for the purpose. The pyritized remains of which such specimens usually consist in this country, though confirming the results above stated as far as their evidence goes, yet fall far short of the complete demonstration afforded by the transparent sections of Europe.

A chair of palæobotany has been established in the University of Cambridge, England, and will be shortly filled by the appointment of Mr. Albert C. Seward, B. A., F. G. S., of St. Johns' College, to the professorship. It is a subject for congratulation that this important and interesting, though new science, will now be represented at one of the old universities of England, and with the advantage of the long established Woodwardian museum by its side.

Akron, O. E. W. Claypole.

The need of an elementary work on petrography.—The writer after considerable study on the subject, is convinced that a suitable elementary work on the difficult science of microscopic petrography remains to be written. The several works available to the student, purporting to be elementary and suited to the necessities of the learner, are indeed, expositions opening the science in logical gradations of thought. They are entirely adequate viewed as memoirs addressed by experts to experts. The method and style are those of learned discussions in elaborate treatises, and journals of special scope. It does not seem to be appreciated that the style and method of learned exposition are not the best style and method for elementary instruction. To make an abstruse subject intelligible to a beginner requires fundamentally different handling from that employed in addressing a learned society or an expert coterie. Too often the treatises called elementary are mere compilations from scientific periodicals or books, without any apparent consciousness of the fact that what is good for the learned may be very unsuitable for the learner.

The underlying motive in these elementary treatises seems to be the belief that every step must be logically taken, and that no foresight of the outcome must be permitted. Authors expect the student to labor through a body of abstract definitions, statements and doctrines, before affording glimpses of the phenomena which they underlie. Such work can be done by bright students. The work can be accomplished by any good student, provided he have a competent instructor to whom he may turn in case of insurmountable difficulty. But the writer holds it to be a first principle in the preparation of a book for learners, that it should be made a self-sufficient illumination and guide, and that it should render its subject easily accessible, stimulating and attractive. In fact, it should be adequate for *Selbststudirende.*

In the field of petrographic instruction it might be well to devote an introductory course to an exemplification of the phenomena, without much if any, attempt to impart the science. The first and most natural thing is to show the student the *facts* the explanations of which he will receive later. Let detailed directions be given as to methods of manipulation. Let a large range of observations be provided, embracing every class of phenomena applied in the theoretical exposition which is to follow. Let attention be directed to every feature of the phenomena which may possess critical significance. Let observations be multiplied. Let the pupil even learn the characteristic behavior of the leading minerals before he is prepared to understand why they behave thus and so. The acquisition of such a mere empirical acquaintance with optical characteristics would not be scientific study; but it would form a foundation for scientific study. It is even true that the well informed expert tends somewhat to lose sight of some of the principles involved in the phenomena which he witnesses, and by familiarity and long acquaintanceship with different minerals declare at sight that this is leucite, this is olivine, this is rhombic amphibole, and that is monoclinic pyroxene. It is not suggested that critical observations be undertaken; nor that research could be carried on without a sound insight into crystallographic and optical principles. The writer contemplates the acquisition of a stock of observed facts to which appeal may be made in subsequent illustration of theories. As our manuals are constructed, the student is first introduced to a study of explanations and then to a knowledge of the things explained. The natural process is inverted.

In connection with the empirical course might well be associated the work of preparing thin sections. After practice in sections made in aimless directions—more particularly in rocks—the pupil should have plain and detailed directions in the section-making of minerals in predetermined directions. By this time, if the pupil is not already acquainted with descriptive crystallography, he ought to acquire the rudiments of the subject. He will thus learn, in due time, that the optical phenomena afforded by a species of mineral depend on the direction in which it is cut. Much profit would be gained if the manipulation did not proceed beyond sections of uniaxial minerals. These will illustrate most of the fundamental phenomena.

The student now is in possession of a stock of facts, and he may justly be summoned to an exposition of underlying principles. With a recollection of observed phenomena vividly in mind, the theoretical discussions will be vastly more intelligible than when they treat of a mass of indications which have never been matters of observation by the pupil. In the study of optical principles it will place the learner at a disadvantage if he is put off with some abbreviated and generalized presentation. The magnitude of the science is no less when condensed into a few pages than when expanded into a general treatment. All therefore, which is not supplied by the book-help must be worried out by the thought and perplexity of the learner. Difficulties greater than necessary drive the student toward abandonment of theory and repose in virtual empiricism.

After familiarizing the learner with a wide range of phenomena, and after supplying him with ample theoretical explanation, the book help should afford detailed indications of the manipulations necessary in entering on the investigation of an unknown mineral—say one detected in a crystalline rock. The analytical chemists have set the proper example in the formation of guidance-tables. Rosenbush has supplied a general table of the kind required. But each subdivision of it ought to be subjected to further analysis. In fact, the method might be carried to the actual determination of all the common mineral species. The tables of Hussak might here be made available.

But the book-help might do more. It might well select for illustration some actual case of such character that the pupil could secure a duplicate of it, and carry the investigation through by an application of the analytical table or tables. Authors of works on determinative botany have set us the example of this sort of aid at such a stage of study.

It is at once apparent that a proper compilation of aids for *Selbststudirende* furnishes occasion for models such as have never been constructed, to illustrate ellipsoids of elasticity, bisectrices, and other doctrines. It is even more apparent, that a demand exists for purchasable thin sections of minerals cut in definite directions. These might be accompanied by full printed explanations of phenomena presented in light of various kinds, in rays parallel or convergent, and in different positions of the nicols. These however, might be omitted if suitable book-helps were to be had. An undertaking of this kind is commended to those who have means and time for makiag thin sections. The writer does not ignore the value of Julien's numerous sections; but we find them, with their accompaning descriptions, rather intended to illustrate to experts the nature of different rocks and minerals, than to explain to the learner how and why the appearances presented justify the conclusions announced.

To the writer it seems that the petrographer who will give the public an elementary book conceived along the lines above indicated, will do American students a very great service. But American students are in no need of another work revealing an ambition to construct a fabric of mere solid logic, and a fear that due simplicity will be mistaken for limited knowledge.

A work like Rosenbusch's *Mineralien*, presenting a thorough and complete digest of the doctrines of optical investigation possesses inestimable value. But it is rather a "manual" or "handbook" for consultation by investigators than an elementary guide for learners. It is not a book based on true pedagogic philosophy. Its general plan and frame-work are those of a full systematic treatise, without due cognizance of the historic laws of the acquisition of knowledge. The guiding principle of its method is logic rather than psychology. To the subject-matter the justice done is ample; to the student, scant. Similar statements may be made respecting E. S. Dana's able treatment of the optical properties of minerals. Mr. Hawes' admirable exposition, besides lacking the true method, is too brief for the necessities of the learner. We yet need a learner's guide to microscopic petrography. A. WINCHELL.

Ann Arbor, Dec. 17, 1888.

Further notes on "a green quartzite from Nebraska."—I trust that a few additional notes, which have been suggested by Dr. Hicks's remarks on the "green quartzite," in the November number of the Geologist will not be out of place.

Mr. Bailey's observations accord with my own, as regards the limit of the drift. See the map on page 393, Proceedings of A. A. A. S., vol. XXXIII [1884]. In the same connection it is interesting to notice that Gen. G. K. Warren who had traversed the region a little further north stated at the Chicago meeting of the A. A. A. S. [1868] that the Missouri marked the limit of the drift in that latitude, and accounted for it in a way quite similar to that independently arrived at by myself in the paper before mentioned; viz.: That the course of the Missouri was determined by the escape of waters southward around the edge of the ice. Between a few miles south of the mouth of White river and the mouth of the Niobrara, I have found no trace of drift more than three or four miles west of the Missouri, although I have examined at four separate points. A prominent reason for this close correspondence between the river and the edge of the drift is found further in the fact that a high table land, more or less capped with this same "green quartzite," abuts upon the river through most of this distance. Above the White river and below the mouth of the Niobrara, the limits of the drift leaves the immediate vicinity of the Missouri, as the adjoining land becomes less elevated. The bearing of this on the origin of the drift in those regions is significant.

The first point where I met with this "green quartzite" was upon the top of the Bijou hills, where it forms a capping 12 to 15 feet in thickness. West of the Missouri it caps similar buttes, including the conspicuous Medicine butte, and 40 feet below the upper stratum there is another thinner but similar. The rock is fine grained sand sometimes obliquely stratified, irregularly thin-bedded, solidified for the most part into very compact vitreous stone. It often contains worn pebbles some of them resembling pitch-stone. By weathering it becomes whiter, and then resembles mortar.

I have observed it in the following localities, which are beyond the eastern boundary, so far as I have yet seen it published. It is found widely exposed on a butte eight miles east of Greenwood, Yankton Reservation. Many blocks of it lie together, as though nearly in situ, about two miles south-east of Niobrara, Neb., also a similar collection upon a butte, in Nebraska, five or six miles south-west of Yankton. A quarry of it occurs near Jackson's, half way between Niobrara and Creighton. A sandstone resembling it, but softer, is found about 100 feet below the summit of the hills at Wessington Springs, Jerauld Co, Dak. The quartzite stratum is quite easily recognized, and though thin, is quite persistent.

I have taken the following notes on its altitude, Bijou hills, 2,000 feet above the sea; opposite the mouth of Pratt creek, 1,950; east of Greenwood, 1,675; 10 miles west of Niobrara 1,650; south-east of Niobrara, 1,525; near Jackson's, 1,675; south-west of Yankton, 1,500; Wessington Springs, 1,850. These are all barometric, and several only approximate estimates, but enough to indicate considerable dip to the east.

I have not observed fossils sufficient to identify the formation, but from stratigraphical relations there is little doubt that it is later Teritary. Dr. Hayden referred the strata in Bijou hills to Pliogene [Loupfork]. Although not speaking particularly of the quartzite, he mentions "yellowish-white grit" and "gray sand with a greenish tinge." His experience with the field along the Niobrara and Loup Fork gives this opinion much weight. (See Prelim. Rep. Expl. in Neb. & Dak. 1855-57. p. 78.)

Tabor, Iowv, Dec. 8, 1888. J. E. Todd.

Some remarks on professor Henry S. Williams' Report of the Sub-Committee on the Upper Palæozoic (Devonic), in The American Geologist, for October, p. 226. Professor H. S. Williams says: "In the final report, (1842, for the 3d district, p. 13,) Lardner Vanuxem proposed the name

Erie division' (of the New York system) for the series of deposits called Upper Silurian by Conrad, but added to them the Chemung group."

First—"Vanuxem proposed the name Erie division." In his final report (1842, for the 3d district, pp. 12 and 13,) Vanuxem says: "The views of Dr. Emmons were cordially embraced and adopted."...."adopting the terms *Champlain*, *Ontario* and *Erie*." Dr. Emmons in the final report (1842, for the 2nd district, p. 100,) says: "Following out the plan of the nomenclature for the rocks of New York (using *national names*,) I have considered that, for purposes of study, they might be arranged in four groups as follows: Champlain group, at the base of the Transition system; Ontario division....the Helderberg series; and lastly the Erie group." The names of *group*, *division* and *series*, being all used indifferently and in the same paragraph. There is no possible doubt that Dr. Emmons is the author of the *national names* of "Taconic system," "New York system," "Champlain, Ontario, Helderberg and Erie divisions."

Second—Conrad added the Chemung and Portage groups to the Catskill group, and referred the whole to the Old Red sandstone or Devonian system, in his fifth annual report, pp. 41 and 42, 1841.

Those two quotations and dates are at variance with professor Williams' expressed opinions.

Farther on professor Williams says: "In 1846, (Paleontology of New York, Vol. i, p. xvii,) professor Hall first announced the opinion that 'from a paleontological point of view the deposits down to the Oriskany should be included in the Devonian.' Thus the term Devonian became established in the nomenclature of American geology." *First*, the Paleontology of New York, Vol. i, did not appear in 1846, but in 1847. *Second*, at p. xvii, there is no such paragraph as the one quoted by professor Williams; and no such paragraph exists anywhere in the volume. *Third*, the term Devonian comprising the deposits down to the Oriskany was established by de Verneuil in 1846, during a visit to Schoharie, and the collection of John Gebhard in that village, ("Note sur le parallelisme des roches des dépots paléozoiques de l'Amérique septentrionale, etc." Seance du 19 avril 1847, p. 677, in *Bulletin*, *Soc. geol. France*, tome iv, 2d series).

There is no question that de Verneuil, established with its proper meaning the term Devonian in the nomenclature of American geology.

Professor Williams refers to the name *Erian* as proposed in 1871, by Mr. J. W. Dawson, "as equivalent to Devonian." It is simply the term *Erie* division of Dr. Emmons, with the termination *an* for homophony.

JULES MARCOU.

Cambridge, Mass., 8 Nov., 1888.

PERSONAL AND SCIENTIFIC NEWS.

MR. B. SHIMEK, A CONTRIBUTOR TO THE GEOLOGIST, on the subject of the fauna of the Loess, and formerly an instructor in the Iowa City high school, has been appointed to the position of instructor in zoology in the state university of Nebraska.

Dr. C. Rominger devoted some weeks during the past autumn to the study of the geology along both shores of lake Champlain. He is now occupied in the search for ores of zinc in southern Misssouri.

The Committee of Organization of the American Geological Society have called the first meeting for Thursday, December 27, 1888 at 9 a. m. in the botanical lecture room of Cornell University at Ithaca, N. Y.

The Geological Survey of Texas has been organized by the appointment of E. T. Dumble as state geologist, and professor W. H. Streeruwitz and W. F. Cummins as assistants. The parties have already entered the field. Mr. J. H. Hernden was appointed chemist to the survey, with Messrs. Smith and R. B. Hadley assistants.

Number I, volume I, of the bulletins from the laboratories of Natural Science in the State University of Iowa, is now in press and will soon be ready for distribution. It will contain articles on geology and palaeontology by S. Calvin; on Saprophytic fungi by T. H. McBride; on parasitic fungi by A. S. Hitchcock; on Iowa mollusca by B. Shimek, and on local coleoptera by H. F. Wickham.

Coal Mines in China. The output and consumption of coal from the Tong colliery, Kaiping, amounted in 1887, to nearly 200,000 tons, and is expected to reach 270,000 tons for 1888. This colliery is in the province of Chi-li, about 90 miles from Tientsin. The railway connecting Kaiping with Tientsin is now completed. Extensions are planned toward the north and the south, and Kaiping coal will before long be delivered from Pekin to the regions beyond the Great Wall.

Coal Mines of British Columbia. In another quarter of the world new developments in coal production are attaining great magnitude. During September the foreign shipments from the Nanaimo and Comox coal mines amounted to 43,908 tons. For customs purposes this is valued at $4 a ton. The greater portion was shipped to San Francisco.

The town of Florence, between Pueblo and Canon City, Colorado, is enjoying a "boom" on account of the recent discovery of coal oil of excellent quality and in paying quantities in its immediate vicinity. About twenty wells have been bored apparently within a space not exceeding two or three hundred acres, and those that are pumping yield on an average about 70 barrels a day. According to Prof. Newberry the wells are bored in a dark Carbonaceous shale of the age of the middle Cretaceous. This shale is found over a comparatively large area, and the oil production of the region therefore is capable of practically indefinite extension.

THE PLACER MINES ABOUT DOWNIEVILLE, on the Yuba river, had the reputation in 1851 '52, of being among the richest in California. Not only the "flats" along the banks, but the bed of the river and of each small tributary were mined, and every foot of bed-rock was searched over for the precious metal. After a lapse of more than thirty years we find companies of Chinese washing over the old gravels and obtaining from American waste sufficient to satisfy all the conceptions of Chinese wealth. A white man whom we found washing over old gravels in the solitude of Slug Canon, reported that from April to July he had obtained, in gold, an average of four dollars a day. When the gravels were first worked it was not unusual to take out an average of $150 to $200 a day for each man employed.

THE ASSOCIATION OF WESTERN NATURALISTS held its first regular annual meeting October 24th and 25th, at Champaign, Illinois. About thirty members were present, embracing representatives from Michigan, Ohio, Indiana, Wisconsin, Illinois Iowa. Papers on methods of observation, and methods of teaching in geology were presented by T. C. Chamberlin, President of the State University of Wisconsin, and S. Calvin of the University of Iowa. T. C. Chamberlin was elected president of the Association for the next year. Madison, Wisconsin, was chosen as the next place of meeting.

DR. TREUB, DIRECTOR OF THE GOVERNMENT BOTANICAL GARDENS, in Java, has recently visited the volcanic island, of Krakatoa, and finds it covered with verdure from shore line to summit. The significance of this fact will be appreciated when it is remembered that during the terrific explosions of the volcano a few years ago the heat generated was sufficient to destroy all the vegetation on this island and all the adjacent islands for a radius of several miles. The plants that first established themselves on the old cinder heaps and restored the beauty of waving foliage to the once desolate island, are, curiously enough, ferns. The ferns however, seem to have been preceded by cyanoppyceous algæ, which spread as a thin film over the surface of the moist rocks and cinders, and furnished the necessary conditions under which fern spores might germinate and the prothallus stage be safely passed. Without the algæ it is doubtful whether the ferns could have gained a foothold. Phænogamous plants are gradually getting possession of stations along the shore, and they will in time, in part at least, displace the ferns. Geologists will be reminded by all this of the manner in which the palæozoic continents received their flora. Ferns and their allies were the first occupants, and for a long time there was nothing but the fern-like forms. Was some low, creeping alga of which traces have not yet been detected, a necessary precursor of the palæozoic ferns?

The large collection of fossil fishes, made by Dr. Clark, of Berea, O., to which we recently called attention in these pages (see American Geologist for July 1888, p. 62) has been purchased by Dr. Newberry. America is to be congratulated on the fact that so large and valuable a mass of perfectly new material in palæontology has not been bought out of the country and taken to Europe as has already happened with many fine cellections in the past. It is a thing greatly to be regretted that in so many instances the men who understand the value of such collections have not the means to buy them, while those who have the means do not understand their value. Some of the finest have been sold out of the country in years past and can now only be seen on the other side. This is the case with the fine archæological collection of Messrs. Squier and Davis now in the Blackmore Museum at Salisbury, England.

We understand that the same or a similar destination would ere long have awaited the fossils of Dr. Clark had they not been secured by Dr. Newberry.

Just before selling the collection Dr. Clark was fortunate enough to find several specimens which appear to throw a new light on the structure of Dinichthys and perhaps of some other kindred forms. Doubtless Dr. Newberry will in due time announce his conclusions in regard to them and it would be premature to say more than that these last finds seem to place several of the large plates of the armour in new and unexpected relations. At least it is exceedingly difficult to understand how these plates could have been found in the position in which they occurred if they were situated as shown in the published plates.

AN UNJUST ATTACK.

(REPLY TO ARTICLES CONCERNING THE AMERICAN COMMITTEE OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS BY PROF. J. D. DANA AND MAJ. J. W. POWELL, IN THE *American Journal of Science* FOR DECEMBER, 1888.*)

In the December number of the American Journal of Science, 1888, appear, by a singular coincidence, two articles bearing on the report of the American Committee International Congress of Geologists, both of them calculated to produce an impression upon the mind of the reader unfavorable in proportion to his ignorance of the real facts of the case. As one of these articles is written by the chief editor of the journal, the tutelar, and the other by major Powell, the official representative of U. S. geology, a reply to them becomes necessary.

Firstly, it is unfortunate that in this article of Prof. J. D. Dana there is not a single statement which of itself would convey a just idea of that with which it deals to one unfamiliar with the facts and there are many which would convey to such a person an entirely erroneous idea.

To begin with it states of the report, "It contains valuable papers on American stratigraphical geology prepared chiefly by the chairmen or 'reporters' of several sub-committees, and interesting reading as the personal opinions on various questions which were gathered in by the assiduous secretary and some of the reporters through epistolary canvassing. But on controverted points it is a 'majority' report of the committee and of its several sub-committees, and a minority report as regards American geologists." "The canvassing gathered opinions but not final views which free discussion among the geologists of the country would have evoked. Moreover, the methods of the committee tended to suppress free discussion even in the sub-committees."

This statement so clouds the facts of the case that a not unnatural inference would be that it had been written by one who had never read the reports. It contains various and incongruous charges. In the beginning is the implied charge that the reports were written by chairmen or reporters, while in the end it is objected that there was "epistolary canvassing" for the views of American geologists. Then this epistolary canvassing only elicited "opinions, but not the final views which free discussion among the geologists of the country would have evoked."

The statement about controverted points if understood is unfounded. Each reporter had his own way of preparing his report. Some like Profs. H. S. Williams and Cope wrote didactically, preserving their identity throughout the report. Others were content like the writer to reflect the opinions of the leading geologists without seeking to improve them. And just here it is applicable to remark that in the judgment of many competent persons the record of the answers of some forty odd well

*A short answer embodying the gist of this communication was sent to the *American Journal of Science*, but was refused admission to its pages.

recognized geologists to the same series of important questions is a more valuable one than twice the amount of writing from the pen of any one, were he even the Nestor of American geology. Some such thought must have actuated Prof. J. D. Dana himself when he warmly complimented the writer and expressed his satisfaction at the writer's report during that session at New Haven of which he speaks.

All the reporters have largely quoted the opinions of others in their reports, on "controverted points" especially. No idea of adopting a side in a controverted question was ever entertained by the committee, of which the aim was "to represent," not to manufacture American opinions. The picture Prof. Dana suggests of these "opinions" being crystallizable into "final views" by any free discussion which the Committee could have brought about is extraordinary. How much free discussion for instance would have been required to transform his own and Mr. Marcou's "opinions" into "final views," and in what would the "final views" have differed from the "opinions," and by how much would these have been brought into harmony?

The alleged tendency to suppress discussion in or out of the sub-committee is diametrically opposite to the fact. After the sub-committees were appointed by Prof. Hall in New York, May 22nd, 1886, and they failed to report at Philadelphia December 28th, '86, and again in Albany April 6th, '87, (although all reports had been ordered to be prepared before May) on motion of Prof. Stevenson, the plan of the English Committee was adopted and "Reporters" were appointed, each charged with the duty of preparing as perfect a report as he could. These reports were to be submitted to the whole Committee at the subsequent meeting in Spring Lake N. J. and after thorough discussion there in the light of the contributions from all geologists which were invited were to be submitted to the judgment of Section E at the immediately following meeting of the A. A. A. S. in New York; and with the emendations there made, were to be finally printed and sent to England.

The fullest discussion was invited and was had during this time:] through private letters, cards in the scientific journals and lists of questions every effort was made to reach the ear and enlist the interest of every geologist in the country. It was therefore with astonishment and the disapproval (in some cases unexpressed) of a majority of his fellow members that at Spring Lake major Powell's proposition to interdict the expression by the Committee of formal approval of the reports, as reports, was heard. The only restrictions to free discussion, alteration, and amendment, up to the hour that the reports were going through the press, were proposed by him and those in the committee who followed him. After the Spring Lake meeting and the submission of the reports to and their formal approval by Section E in New York the time for discussion and alteration should have terminated, yet so anxious were the reporters to embody in their reports the latest results, that from August to December 29th, at which latter date a meeting in New Haven was held, as many duplicate galley proofs of his report as he desired were furnished to each reporter, and these were sent by him among his scientific colleagues for corrections and amendments. At the New Haven meeting all the reports were ready for the press with the exception of the Lower Paleozoic and the Interior Cenozoic, and the reason that the former was held open was stated by the Reporter to be his desire to have the most recent work of Mr. C. D. Walcott properly represented there, Mr. Walcott having withdrawn his former contribution to this report after it was in type thus deranging the entire text to which his essay was the largest contribution. Every effort was made by the committee as a body, by the reporter on the Lower Paleozoic, Prof. N. H. Winchell, and by the secretary, to induce Mr. Walcott to communicate his views (then being published in the American Journal of Science) but without avail. Finally late in May, 1888, the Secretary cut out such portions of Mr. Walcott's then completed communication as he thought epitomized Mr. Walcott's views, and sent them to their author for approval as a fair digest of his work; and received them back with two additions as "suggestions.' When Prof. Winchell's report embodying these excerpts was received the secretary wrote to Prof. Hall for guidance as to appending Prof. Winchell's comments on Mr. Walcott's paper to the report, and his decision was that Prof. Winchell's comments ought to appear. The printers who had held the type for nearly a year were anxious to release it, and the reports had then been finally revised with the exception of B. The latter, with some few modifications by the editor, was therefore printed as it came from the hands of its reporter.

The justice of the charge of suppression can be judged from the above. Prof. Winchell in a private letter in answer to one from the writer urging him to hasten the completion of his report, says: "Mine in particular being on a vital and long discussed question of nomenclature should not be forced. It ought to have the merit at least of having been open till the last moment for the reception of opinions and facts," etc. Prof. Dana further says: "The Preface of the published report states that 'all geologists were invited to meet the American committee in Albany during its session there (April 6th, 1887,) in order to aid it in arriving at a correct view of American opinion.' Such a call was published in vol. xxxiii of this Journal (1887) but the notice of the next meeting at Philadelphia communicated to the same volume by the Secretary, shows that it failed of the object announced."

The meeting in Philadelphia was held before the issue of the first No. of vol. xxxiii, or on December 28th, 1886. The notice to all geologists was printed in the last or June No. of vol. xxxiii, six months later. Prof. J. D. Dana has inverted the order of the years and their events. It was in fact the desire for this touch with American geological thought felt at the Philadelphia meeting which induced the committee to invite all geologists to the next following Albany meeting.

Prof. Dana says further, "At the only meeting attended by the writer, that of January last, at New Haven—not then resuming active membership, as the published report states in its preface, but taking my first experience in membership after receiving my first notice that I was a member," etc. This casts a doubt on the accuracy of the statement in the preface which is easily removed. The same preface in giving a history of the creation and changes of the American committee mentions that the names of G. H. Cook, J. D. Dana, and Clarence King were added to the American committee at the Saratoga meeting in 1879. At the Boston meeting of the next year the American committee was discharged and no mention is made of it for the two ensuing years. In the volume of the Proceedings of the A. A. A. S. at the Montreal meeting the committee reappears with some but not all of the names which it included when discharged. The same names continue in 1883. In the Proceedings at Philadelphia 1884, more of the original names are found with some new ones. It had frequently been commented upon that Prof. Dana's name was not on the committee, and after discussion it was considered more courteous to him to assume that this omission had been an oversight. This was declared to be the case by the chairman of the New Haven meeting and on motion of Prof. Stevenson "the Secretary was instructed (in accordance with the chairman's decision that Prof. Dana had already been a member of the committee since 1880) to invite Prof. Dana to be present at the future meetings of the committee." Whatever error the committee may have made in this case resulted from its desire to show respect to Prof. Dana.

Prof. Dana continues: "During the day the reports of some of the subcommittees were read and passed, but no opportunity was allowed for the discussion of any of the propositions to the International Congress which they contained." This statement is at variance with the minutes which say (Dec. 30, 1887) "The Chairman decided that no one can speak longer than five minutes except the originator of a motion who can close after the discussion is finished."

"The report on the Archean was called for and read by the reporter. Profs. Winchell, Cope, Hitchcock, Maj. Powell, and Prof. Dana discussed the report, and three motions concerning it were voted upon."

"The report on the Lower Paleozoic was called for in the afternoon." The major part of the report as printed was read and the Reporter explained why the complete report could not be prepared by that date. (This has been explained above.) The report was discussed by Maj. Powell, Prof. Dana, Dr. Newberry, Prof. N. H. Winchell, and Dr. Hunt.

"Prof. Stevenson moved that the report be re-committed to the sub-committee and adopted and printed as the sub-committee return it. Carried."

Prof. H. S. Williams' report on the Devonic was read in abstract, and discussed by Profs. Newberry and Stevenson. It was voted that this report be printed under the same conditions as the former reports.

Prof. Stevenson read the report on the Carbonic and the same vote regarding it was passed.

Prof. Cook read the report on the Mesozoic and it was discussed by Powell, Cope, Frazer, Winchell, and Newberry.

Prof. Cope read the abstract of his report on the Interior Cenozoic and a motion similar to that in the case of Prof. Winchell's report was passed. The report of Prof. E. A. Smith on the Marine Cenozoic was read, discussed, amended, adopted and ordered printed. The report on the Quaternary, Recent and Archeology having been called up major

Powell stated that he considered the abstract prepared for Section E, A. A. A. S., last summer his report. It was accordingly read and ordered to be printed like the others.

Dr. Frazer was unanimously elected editor of the reports; and major Powell and Dr. Newberry each subscribed $20.00 towards the publication of the reports. This latter circumstance is of interest as showing major Powell s feeling at the time of the last meeting he attended in person or by proxy (although in fact he never paid his subscription.) If Prof. Dana was not aware that the above votes had been passed, it was because he did not remain in the room either while they were passed or when the minutes were read.

"Finally at the April meeting it was voted that no copies of the report should be delivered before September 17th, or in other words that the printed report with its final additions should be kept from the members of the Committee until the day of meeting of the Congress in London."

In the minutes of the April meeting it is recorded that "It was moved that the Committee declare it to be their opinion that the report of the Committee should not be *made public* until the meeting of the Congress on Sept. 17th, 1888, and that the copies remain in the meantime in the custody of the Secretary until he can transmit the edition intended for the Congress to the Executive Committe thereof. Providing that each Reporter shall receive a copy of his own report, and that the chairman receive a copy of the volume containing all the reports. Carried."

It is scarcely necessary to italicize the two words above to exhibit the discrepancy between Prof. Dana's allegation and the actual state of things, nor is it worth while to defend the propriety of so obvious a proceeding as guarding the report to the Congress from the public until the Congress had received it. Every member of the committee was asked and expected to be familiar with every report and to contribute his best efforts toward perfecting it. So that when Prof. Dana continues: "Under such partisan management the conclusions in the printed reports of several sub-committees were not likely to represent fairly American geological opinions;" he makes a wanton and unfounded charge against the committee the vehicle for an illogical conclusion as to the fidelity with which it has represented the opinions of American geologists. Fortunately many letters from these geologists have been introduced into the volume, and (in the case of at least one Reporter) so introduced just to prevent a charge of this nature, which it was never thought would proceed from him, however.

"It is true that in connection with each of them (the reports) a large display is made of the names of the members of the sub-committees, and of all of them in each case as if they were alike responsible for the contents, and as if they had met, at least once, and consulted together, read the last emendations and signed the document." No man's name was attached to the reports without his consent or in spite of his objection. The writer believes that every member of every sub-committee received a galley proof of every report to which his name was attached which he was free to amend or alter as he liked and forward with his remarks to the Reporter. Whenever this was done it is believed that the reporter introduced a statement of the modification made into his report. In this case all the members of the sub-committees *were* equally responsible for the contents of the report even though no meetings of the members of the several Sub-Committees were held. Indeed such meetings would have been impossible as the members were scattered widely over the country, and in the adoption of the 'Reporter' system the idea of meetings was abandoned.

If major Powell has the right to complain that after his resignation from the committee his name was still retained on the Sub-Committees, he must know that this was done because the Committee decided, (in spite of objection on the part of some of its members) not to accept it at once out of courtsey to him. This is one of the penalties that he pays for enjoying his exalted official position.

"My name is on two of the sub-committees but has no right to a place on either, although I gave assent to the request," etc. The latter part of this statement answers the first. Moreover as the sub-committee of which the writer was the Reporter is one of those two he can state that he enjoyed and profited by the advice and assistance of Prof. Dana throughout his work. Not a word was printed which was not sent to Prof. Dana with a request for corrections, and those suggested by him were always made.

"In fact changes after the January meeting were made impossible except by the reporter."

Naturally so, some time limit had to be set in order to get the volume through the press, but up to the last page proof every effort was made to introduce any pertinent thing sent by any body.

"The views of Mr. Walcott are unfairly presented with great injustice to him," etc.

This subject has been treated before. If Mr. Walcott's views are unfairly presented the fault is solely his or that of those by whom he was controlled.

"It" (the report) "is now in the hands of the secretary of the London meeting of the Congress awaiting a second publication as if the expression of the views of the majority of American geologists. Its right to appear in the volume of the proceedings of the Congress for 1888 should be seriously considered if it is not already too late."

Its right to appear in the volume of the proceedings of the late Congress is unquestionable. 1st, Because it is the fruit of three years of patient and unremitting labor of a committee duly and legally appointed to prepare it for that Congress. 2nd, Because it embodies the independent views of all American geologists so far as those views could be obtained by questioning, reading and "epistolary canvassing." No clique of geologists is recognized and none is excluded from the report. It is American and pan-American. 3rd, It has already been distributed by direction and authority of the comite fondateur to the members of the Congress, and forms one of the most important of those documents which the Executive Committee of the Congress of 1888 agreed to send with its volume to the absent subscribers to the Congress. 4th, Its contents have been highly commended by some of the best judges in the world, and it should appear in the forthcoming volume by right of the information it contains, which can not elsewhere be obtained.

Major Powell objects to the use made of his name by attaching it to the report of the American Committee. Some of the members of the American Committee objected to this also but those who insisted upon it did so from outward respect to major Powell, and these were in the majority. He thinks that the subject matter of the report is not of such a nature that a deliberative body can determine it by vote, and every one will agree with him. The subject matter was determined so far as anything in geology can be by the work of many persons in the field, a d a comparison of their results. No votes on the subject matter, (for example on the truth or error of this or that theory of the relations of the rocks,) has ever been taken or was meant to be taken. The votes in the committee have had exclusive reference to the fitness of a report to go out over the names of the Reporters and their associate members of the sub-committees.

The subjects considered were very similar to those which were considered in the English report to the Berlin session of the Congress, but from all possible American standpoints. As is well known the Congress of London adopted a new and fair method of taking votes but actually took none. Major Powell says "there is no body of men so wise or powerful that it can establish the science of geology by authority;" and he might have added no body of men outside of a few official geological surveys have been foolish enough to make the attempt. He adds, "The papers which appear in the report were not presented to the committee in printed form while I was present, but most of them merely in abstract, and the Reporters finally published what they severally desired." The reports on the Archean, Devonic, Carbonic, Mesozoic and Marine Cenozoic were read in extenso in his presence twice—once at Spring Lake, and once at New Haven—as they were finally printed. His own report made six out of the eight; and this would have been printed exactly as it was read at New York (as an abstract) and New Haven, had he not withdrawn it after it was in print. The only two which were not in exactly the condition in which they finally appeared at New Haven (which was the place of the last meeting that major Powell attended) were Prof. Winchell's report on the Lower Paleozoic and Prof. Cope's report on parts of the Mesozoic and of the Interior Cenozoic. And even these were nearly the same. The difference in the report on the Lower Paleozoic consisted in adding the digest of Mr. Walcott's work which the editor of the reports was able to get Mr. Walcott's assent to only late in May, and which was appended to the report B which major Powell heard read, together with a note on the same of four and a half pages by the Reporter.

Major Powell adds, "The paper I prepared was brief, but was, I thought, pertinent to the subject in hand; but evidently it did not meet with the approval of the committee, for other reporters included the consideration of the Quaternary formations in their papers; that is, the members of the committee were determined that the Quaternary formations should be discussed in such a manner as to exhibit a supposed best classification, or at least such a one as they would recommend, all of which required a review of the general subject of the Quaternary formations of the country, and the more or less final settlement of many problems yet under discussion." Certainly no action of the committee justified major Powell in supposing that his abstract report did not meet its approval. As soon as he declared at New Haven that he considered his report to be the abstract (dictated and type-written at the Buckingham Hotel the evening before the meeting with Section E devoted to the American Committee, and read before it with the other abstracts) the committee ordered it printed like the other reports. It is true that Prof. Spencer contributed a part of Prof. Cope's report G treating of the Plistocene, but that was strictly in accord with the policy which major Powell so strongly insists on, of allowing freedom of thought to all, so that the best may finally survive. If "no body of men is so wise or powerful that it can establish the science of geology by authority," would he claim that one man can be so wise or powerful as to establish his view of the Quaternary by authority? This is clearly a case where two geologists, to use his own words, have "gone on devising, amending, and improving their systems severally, each new worker adopting such a system as he may think best, until by a course of intelligent selection, a common system is evolved." Yet so vastly easier is theory than practice that major Powell was not true to his own principles, for "seeing that the report prepared by myself was like that of Prof. Williams, upon a general theory of procedure different from that held by most of the persons who were present at the meetings of the committee, I withdrew it at the time I resigned from the committee and another member was appointed who prepared a paper more in harmony with the general views." But major Powell has already said that other reporters had treated of the Quaternary before he resigned. The newly appointed Reporter on the Quaternary therefore had the same difficulties, but nevertheless performed his work. It would be interesting to know what the general views of the American Committee on the Quaternary are. The writer is not aware that they have been expressed. The report of Prof. Williams "is in harmony with my conclusions and I believe germane to the purpose for which the committee was organized. The other papers are not germane to the proper function of the committee as understood by myself," etc. This reads like two premises with the understood conclusion that "papers which are not in harmony with 'my conclusions' are not germane to the proper functions of the committee." But if this be an argument, what becomes of the liberty of thought and freedom of the individual worker? It really looks as if major Powell were not consistent in this position, for immediately afterwards he assigns as a reason for not associating himself with the committee, that these Reporters have employed various taxonomic schemes, none of which are used in the U. S. Geological Survey.

Philadelphia, Dec. 17, 1888. PERSIFOR FRAZER.

I fully concur in the above statements made by Dr. Persifor Frazer.

T. STERRY HUNT.

Organizer and Secretary of the Comité-fondateur of the International Geological Congress; Member and late Secretary of the American Committee of the Congress; Vice-President at the Sessions of the Congress at Paris, Bologne and London; Member of the present International Geological Council.

New York, December 19, 1888.

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THE

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GLACIERS AND GLACIAL RADIANTS IN THE ICE-AGE.

BY DR. E. W. CLAYPOLE, AKRON, O.

The Glacial Theory has already in its comparatively brief existence seen several ebbs and flows. The great principle of glaciation laid down by Agassiz and Guyot has never been successfully assailed. That at least one era has occurred in the history of the earth when ice played a very conspicuous part is now doubted by few, though the exact extent of its action is among the unsolved problems in geology. It has been so with other geological questions that have from time to time passed under discussion. Long after the main principle involved has been accepted by all parties there remain numerous points of detail requiring for their final settlement tedious and careful investigation.

It is this, we may remark in passing, that often leads men not familiar with the subject to charge geology with uncertainty, to denounce it as a mass of speculation destitute of all solid base and to declare that what one age builds up the next pulls down. This is utterly untrue regarding the main doctrines of the science and to make the assertion indicates a want of exact knowledge of the subject.

Among other doctrines of geology that come in for their share of popular scepticism in this way is the glacial theory. Now the doctrine that ice has had much to do in comparatively recent times in moulding the contour of the surface in the higher latitudes of the earth is well established, but its influence has been alternately magnified and diminished as the pendulum has swung now this way and now that.

The author of this theory—the late Prof. Agassiz—in his perhaps pardonable enthusiasm over his new-found geological engine, went so far as to assert that evidences of glacial action could be found on the great plain of the Amazon at the earth's very equator, a statement which seems to carry as a consequence the glaciation of almost all the dry land at one time or another.

Dr. James Croll, of the Scottish Geological Survey, carried away with the belief that he had found an astronomical cause for the cold, has extended the time of the action of ice over 160,000 years, sees in imagination a vast ice-cap on either pole alternately many thousand feet in thickness and follows M. Adhémar in trying to compute the effect of such an ice-cap in changing the centre of gravity of the earth.

Professor Ramsay in a well known paper has advocated the opinion that the eroding power of a glacier was so great that it was able to excavate its bed in certain spots and thus to form basins or boat-shaped hollows. To this cause he attributed the existence of many lakes in the temperate regions of the globe and the great depth of many of the fiords along some of our northern coasts.

All the above mentioned writers have pushed the effects and the power of glacier-ice to an extreme in one direction, but on the other hand there are not lacking geologists who would confine this power within very much narrower limits. Some of these go so far as to doubt the ability of a glacier to erode at all and have even affirmed that the ice is a positive protection to the rocks on which it lies. When considering the phenomena of the ice-age they deny altogether the existence of a continental ice-sheet, and attribute all the observed phenomena to the action of local glaciers flowing off spots of elevated ground in the glaciated region, and aided largely by floating ice.

This conflict of opinion is a necessary stage in the investigation, and time and study alone can show exactly where the truth lies. As in many similar cases, it will in all probability be found between the two extremes.

The writer has on more than one occasion opposed the views of those glacialists who maintain an excessive abrading power for glacier-ice.* It is difficult to see in the facts brought forward any justification of the often expressed opinion that profound modifications of the surface have been wrought by this agent. Even admitting that valleys can be deepened unequally

*See the Canadian Naturalist for 1879, and the Proceedings of the American Association for the Advancement of Science for 1881.

by a glacier so that on the disappearance of the ice small lakes may occasionally appear or fiords of no great depth ensue, there is not sufficient evidence that lakes and fiords are generally due either entirely or chiefly to glacial erosion. And when the theorist advances to the position that most of the lakes in glaciated districts owe their origin to this cause and even maintains a similar view regarding the beds of the great lakes of North America his position becomes very unsafe. He is then carrying the effects of a small cause beyond all due bounds. His zeal and enthusiasm have got the better of his judgment.

In like manner the advocacy of an ice-cap covering the pole and extending far down toward the equator can scarcely be regarded as the product of calm calculation. There are no data of sufficient importance yet brought forward to warrant so vast a deduction. The past history of the earth reveals many startling facts but none that justify the construction of a shell of ice 6,000 feet thick at the pole and the consequent lowering of the sea-level by the conversion of so vast a quantity of its water into cloud, snow and ice.

On the other hand it is impossible to explain the observed phenomena, especially those of the North American Continent, by the existence of mere local glaciers. The marks of the ice-chisel are too numerous, too wide-spread and too nearly uniform in direction to allow of so partial a cause. Local glaciers on the highlands could never produce a general striation from the northward on the rocks in the middle and northern United States. Marks so produced would necessarily radiate from the centre of production and would not usually become confluent. Nor on this theory can we explain the existence of ice-printing on the surface of the rocks in the midland states—an almost level district, where no mountains and few hills can be found to afford gathering-ground for ice and snow. This difficulty has led to the advocacy of floating ice as the glaciating agent in regions where it was apparently impossible that water in sufficient quantities could exist.

The wisest course will therefore be to abandon both extremes and seek some middle ground. In so doing several conditions must be taken into account.

One of the chief conditions necessary for the production of a glacier is a large snow or rain-fall. Without this the material will be lacking. The north-eastern portion of the continent is now a region of great precipitation and the same was true, so far as any evidence to the contrary is concerned, at the time in question. We must consequently look for great developement of ice in that region. In consonance with this is the testimony of the ice-printing on the rocks, which, speaking generally, radiates to the south-east, south and south-west from that district, that is from the area near Hudson's bay. That the ice was there very thick is scarcely to be doubted. The evidence from the mountains of the north-east seems conclusive on this point. They were apparently buried in ice. We need not perhaps go so far as some have gone and suppose that the ice-sheet was so thick as to move over them without any diversion. This is scarcely probable. But all the phenomena point to a very great depth—probably greater than anywhere else in the eastern part of the continent. Westward however we fail to find proof of this great thickness. The south-westerly direction of the grooving of the rocks in that region indicates clearly enough that the flow of the ice was off the Laurentian highlands toward the great lakes and the valley of the Mississippi. And that all this country was also buried in ice can not be disputed. But that the ice-sheet in the midland states was very enormously thick we have no evidence to prove. Indeed what evidence has been obtained looks in the opposite direction and tends to show that the thickness was small when compared with that of the north-eastern glacier.

The massive glacier of Lower Canada and New England soon reached the Atlantic and its south-eastward advance was stopped by the water. Farther west the Laurentian ice felt the effect of the high ground of the Appalachian mountains which it was apparently unable to climb, and its southward progress was therefore arrested. But in the midland states these barriers did not exist and the striation shows that a vast extent of land in that direction was under an ice-sheet that traveled to the south-west. But that its thickness was not enormous seems evident from the fact that a large district in Wisconsin remained permanently uncovered and is now known as a "driftless area," showing none of those traces of ice-action that are so abundant in the surrounding country.

The direction above mentioned, namely from the north-east, is that in which the general flow of the ice over the midland district might have been expected to occur, if we allow due weight to the datum stated above. Granting a heavy precipitation in the north-east of the continent, where the land was also high, it is natural to expect that the ice would move off toward the valley of the Mississippi where the land is low. Accordingly we find the greatest southward extension in the states of Indiana, Illinois and Missouri. Farther west the line of the extreme south limit of the ice rapidly recedes to the north until it nears the boundary line or perhaps altogether retires into Canada.

This is in perfect harmony with the fact that this interior northern region is now the region of least precipitation. The same was most likely true at the time in question. The vast mass of the ice would be formed in the north-east and its quantity diminished to the west and south.

We may therefore regard the highlands of Labrador and the vicinity of Hudson's bay as the great gathering ground of the eastern ice-sheet which flowed away to the south-east. south and south-west in the way above described.

Data are yet scanty regarding the region to the north of this district. Extreme writers have taken it as a matter of course that it was covered with a sheet of ice creeping down from the area round the pole. But this has been for the most part a matter of inference or of assumption. Granting that in all probability the Atlantic border was the region of great precipitation here as in other parts of the continent it is nearly certain that the snowfall diminished inland, so that this region was under conditions similar to those that prevailed farther south.

Greenland was doubtless then as now a glacial radiant. The wild and desolate strip of land between Lancaster sound and Hudson's strait was another great gathering ground. But the vast polar archipelago around Melville sound was nearly in the condition of the midland plain of Canada and the states, and afforded less material for glacier-making. There seems to be consequently little basis for the construction of an ice-sheet of enormous thickness in this region.

In confirmation of this assertion we find from the geological reports issued by the Canadian survey that the indications are strongly in its favor. Thus in the volume for 1885 (p. 13 DD), in a report on the region of Hudson's bay the following remark is made concerning Gilmour island.

"Nearly the whole island bears marks of glaciation. On the southern and central parts the principal striæ run N. 20° to 40° E. Another set was found to run N. 75° E. On the eastern side of the island the grooves run N. 5° W." "The forms of the roches moutonnées and other evidence afforded by the grooving and fluting of the rocks of this island go to show that the direction of the glaciating force was from the southward and south-westward and not from the contrary direction." "Much of the shingle of the island consists of dolomite from the Manitounuck group to the southward."

In the same volume, in a report by Mr. Lawson on the region surrounding the Lake of the Woods, we find a long list of glacial groovings every one of which is in a direction intermediate between south and west. Some of these are as high as S. 75 W. (p. 132 CC.)

Again in the volume for 1886, in a report by Dr. Bell, the assistant-director of the Canadian survey, we find a similar list occupying a whole page, in which several striæ are given with a similar bearing and direction, and mention is made of a newer set whose bearing is in some cases as high as S. 80° W. (p. 35 G.) Dr. Bell also remarks, "The general direction of the glacial striæ is to the south-westward as is the case throughout the great Laurentian region between James's bay, lake Winnepeg and lake Superior."

Bearing yet more strongly in the same direction are some facts brought together by Dr. George M. Dawson of the same survey in the volume already quoted (p. 57 R). He says:

"Along the Arctic coast and among the islands of the archipelago there is a considerable volume of evidence to show that the main direction of the movement of erratics was northward. Thus, in the Appendix to Captain McClintock's Voyage, Prof. Haughton mentions boulders of granite, supposed to be derived from North Somerset, that were found 100 miles to the north-eastward, and pebbles of granite identical with that of Granite point, also in North Somerset, found 135 knots to the north-westward. The east side of King William Land is also said to be strewn with boulders like the gneiss of Montreal I. to the southward. Dr. Bell has also found evidence of a northward or north-eastward movement of glacier-ice in the northern part of Hudson bay."

The truth regarding the ice-sheet in that portion of North America seems therefore to be that there was not a huge accumulation of ice, thousands of feet in thickness over the whole northern region of the continent, but that the maximum occurred in the north-east on the highlands of Ontario, Quebec and Labrador—in fact around Hudson bay—where the precipitation was greatest; and that from this region, as from a radiant, the ice flowed east, south and west over the lower lands in those directions and probably also, as we have seen, over the equally low lands to the northward. No doubt it was everywhere re-inforced with a certain quantity due to local precipitation but this was quite inadequate to changing its line of flow or overruling the general directing force.

In thus stating the general direction of the ice-motion we do not ignore the fact that over the area above spoken of as the midland states a great number of instances may readily be found where the striation is in a slightly different direction—as for instance south-east or southward. Local causes of course prevailed locally and produced a divergence from the general azimuth. But looking at this area as a whole, little exception can be taken to the statement made above, especially in the northern portion.

In thus speaking of the Laurentian area as the great centre of radiation during the ice-age we do not desire to imply that it was the only one. The mountains of New England doubtless afforded their quota but at the epoch of greatest extension and for a certain time both before and after that date this centre of dispersion was completely confluent with the Laurentian ice, and of so much smaller mass that it might be considered only an extension of the Canadian ice-sheet. The same may be said of the glaciers which must have formed over the Adirondack region and descended to the surrounding plains. They too were merged in the wider flow from the great north-eastern radiant so that these three may for present purposes be considered as practically one.

In the Arctic regions also we can hardly doubt that other ice-centres existed, some of whose glaciers may have become confluent over more or less of the land lying within the Arctic circle. Indeed the climate of this area will warrant us in believing that the ice was continuous over large districts around the pole. But unless the configuration of the land and water was very different from that which now prevails we can scarcely in accordance with physical laws admit a solid mass of ice even in this extreme latitude. For glaciers do not form at sea and ice-bergs cannot be born where glaciers are not. Floe-ice and sheet-ice of even considerable thickness may form and float but no known conditions can produce a massive continental ice-sheet over a sea-area. And so far as we can judge from our present knowledge the region of North America toward the pole consists of an archipelago whose islands are not of great hight, while to the extreme north there is apparently a polar sea extending perhaps round the globe. Such an area would afford a not very good gathering-ground for snow and ice and consequently not a very good birth-place for an extensive glacier.

Should it eventually prove to be the case that the polar area is occupied by a deep and open sea nothing less than the severest evidence—proof beyond all controversy—could bring us to the belief in a polar glacier of enormous thickness. No case can be quoted from the existing geography of the earth where an open ocean is or has been a glacial radiant. For the production of a glacier in such a position ice must form on the surface and gradually thicken downward until the sea is frozen solid to the very bottom. Then the accumulation of snow could begin and the formation of an ice-sheet might become possible.

But the greater warmth of the sea-bottom would constantly dissolve off the roots of the ice-floe and the scanty snow-fall of those high latitudes would scarcely be able to keep pace with the continual melting below and the powerful action of a constant sunshine of six months' duration.

While therefore not denying the possibility that an ice-radiant existed at the very pole we submit that there is no evidence sufficient to support it but a very high probability against it. That huge ice-floes and heavy sheet-ice were formed there during the ice-age, as now, we fully admit. That these ice-floes may have been both constant and continuous so as to be unable to flow away through the narrow intricate channels of the polar archipelago we also freely allow. That currents may have borne huge masses of floe-ice far surpassing in size any of those seen by Nares in what he has somewhat poetically termed the Palæocrystic Sea may also be readily granted. But when all this has been conceded the result falls almost infinitely short of a huge polar ice-cap thousands of feet in thickness and covering the whole of the arctic and part of the north temperate zones.

Greenland also according to our present knowledge does not appear to extend in one continuous mass far to the northward of the great Humboldt glacier, in lat. 80°. Above this line it seems to pass into an archipelago by the meeting of the deep fiords from the two coasts, so that even of the Greenland ice a certain part may actually flow off that so-called continent to the northward into a polar sea. All this however must be left for the decision of further investigation.*

Meanwhile we may consider it plain from the indications above set forth that the conditions were not favorable for the production of a vast polar ice-cap of fabulous thickness and almost continuous down to low temperate regions.

I have already quoted the opinion of Dr. George M. Dawson on the direction of the ice-flow from the region of Hudson bay. It is consequently with very great interest that I have read a paper of his, published in August last, (1888) detailing the results of some investigations made in British Columbia during the summer of 1887.

Dr. G. Dawson had previously shown that a vast glacier once existed in British Columbia and the adjoining portions of the United States, covering with its confluent ice-sheets all the interior plateau between the Coast Range and the Rocky moun-

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*Since the above sentences were written there has come to hand the report of the last expedition to this greatest of glacial radiants now existing in the northern hemisphere. From the scanty anticipatory details thus far received (the explorers being caught by the lateness of the season and compelled to remain at Gotthaab till next spring) we are able to see plainly why the cold of Greenland is so intense and why that country is so prolific a parent of glaciers and ice-bergs. The adventurous ice travelers crossed on snowshoes from the eastern coast in latitude about 64° to the western coast in nearly the same degree. They at first intended to reach Christianshaab in latitude 68° but severe snowstorms compelled them to change their course and take the shorter route. Even at this comparatively low latitude, the leader, Dr. Nansen reports an altitude of 10,000 feet and a temperature in September of —40° to —50° C.

With these conditions prevailing it is not surprising that Greenland should be a powerful glacial centre.

tains, from the 49th to the 55th degree of latitude, and extending south over Washington and Idaho territories. He has also shown that the ice flowed across the Coast Range and down the fiords, which it filled, into the broad channel between Vancouver Island and the coast. This channel it entirely blocked and then escaped into the Pacific ocean through the narrow outlets between the islands. He farther states that the coast strip of Alaska presents similar features.

But beyond all this Dr. Dawson now adds that in the upper valleys of the Yukon, along the Pelly and Lewes rivers, at the north end of the range above named and on ground not hemmed in by high land he finds unmistakable evidence of a northward flow. Striated rock-surfaces were found on the Pelly river where it crosses the 136th. meridian and on the Lewes as far north as latitude 61° 40', of which he says that although local variations are met with yet the glaciation is not susceptible of explanation by merely local agents but rather implies the passage of a confluent or more or less connected glacier over the region. Again he says that the main gathering-ground or névé of the great Cordilleran glacier of the west coast of Canada was included between the 55th and 59th parallels of latitude in a region of exceptionally mountainous character.

Dr. Dawson sums up in close agreement with the statements of this paper that the facts already made known indicate a general movement of ice outward from the great Laurentian axis or plateau extending from Labrador round the southern end of Hudson bay to the Arctic sea while a smaller though still very important region of dispersal—the Cordilleran glacier-mass—occupied the Rocky mountain region on the west. South of the 49th parallel also there existed a series of radiants in the western range whose glaciers spread merely east and west because they could find no outlet to the north or south. In fact these ranges probably composed an almost continuous gathering-ground as far south as Lower California.

North America when looked at in this light shows us not one vast mass of ice covering all the northern part of the continent; but on the other hand we see a great glacial radiant in the northeast sending off its glacial streams to the east, south, west and in a less degree to the north, while several other and smaller radiants existed in the far west, in the Cordilleras of the Rocky mountains, from which in like manner the ice radiated west into the Pacific ocean and north and east in the lower lands there lying.

This view of the ice-age enables us to understand another fact. The Canadian surveyors have several times remarked that the distribution of the drift in the great inland basin of the Mackenzie river indicates rather the action of floating ice than the determinate action of a land-glacier. Obviously the theory here advocated will allow us to suppose that during at least some part of the time of duration of the ice-age a gulf of the Arctic ocean may have reached up to a considerable distance southward over this basin and have afforded a means for carrying ice-bergs and drift material. In that case we should expect however to find some traces of the presence of the sea in that region. Whether or not this is the case must be left to be determined by the future labors of the Canadian surveyors in this difficult and little explored country.

There is yet one other point that deserves a moment's consideration in passing. I allude to the depression which occurred in the northern part of the continent probably during the glacial era. Without entering here on any discussion of the causes of this depression about which great divergence of opinion exists the geological evidence clearly substantiates the statement that about that epoch some of the northern parts of the continent did subside to a very considerable extent—many hundred feet at least,—from which depression they have never fully recovered. Hence these lands now lie lower than they lay in pre-glacial days. The intricate lines of many of our northern coasts, such for instance as those of Maine, S. Greenland, British Columbia and Alaska, cannot as formerly be attributed to the eroding action of ice, but must be explained on the theory that they are submerged lines of inland drainage—the beds of streams that were once above the sea but are now depressed below it and into which the sea consequently runs as far as the level will allow. A very cursory examination of the valley of any river having many tributaries will show how closely in accordance with nature is the above explanation. The intricacy and the depth of these fiords show little resemblance to ice-valleys, even if the eroding power of ice were sufficient for the purpose.

but they are clearly parallelled by the intricacy and depth of many river valleys especially in hilly or mountainous districts. These, if submerged, would produce just such fiords and inlets as those which jag and fringe the northern coasts of America.*

This greater preglacial altitude of the ice-radiant regions will also aid in the outflow of the ice. If the Laurentides and the Adirondacks and the White and Green mountains were then higher than now, not only is this difficulty (if it formerly existed) removed, but another also disappears. It has sometimes been suggested that if an ice-sheet of the dimensions once asserted really existed, every point of high land on the eastern side of the continent must have been deeply buried beneath it and consequently no boulders could have been obtained and carried in moraines on the surface of the ice as was evidently done. This has been felt as a serious objection to the theory of a polar ice-cap but is obviously of far less weight against the theory here advocated when aided by greater pre-glacial altitude of land.

Having now shown the adequacy of the theory above enunciated to explain the phenomena of the ice-age in North America we will turn to the Eastern World and try if it agrees or disagrees with the facts there observed.

It is beyond all reasonable doubt that all northwestern Europe was, at a date not geologically very remote, covered with a sheet of ice which like that in North America moved over the surface in various directions. Observations show that the Norwegian mountains were the birthplace of a host of confluent glaciers which crept down the Dovrefeld Cordilleras to the Atlantic coast and even reached the British Isles, so that Scotland and the northern and central parts of England were clad in the same icy mantle. Over the plains of northern and eastern Germany we find evidence of the same condition. It appears as if the even now shallow Baltic was then no obstacle in the way of the passage of this northern glacier. European Russia shows signs of glaciation in striated rock-surfaces and travel-

*The tremendous precipices and profoundly deep water of the Saguenay and other parts of the Lower St. Lawrence can scarcely be explained without the admission of greater pre-glacial altitude of the land in Lower Canada.

led boulders indicating a movement of ice from the northwest. Erratics of Finland granite lie scattered over the great plain on which stands the city of St. Petersburgh.

How incompatible with the theory of a vast polar ice-cap are the observed phenomena in this part of Europe may be seen at once on reading the following passage from Sir Charles Lyell's "Elements of Geology" (p. 149, 1865).

"The signs of glacial action in Norway and in Sweden consist chiefly of furrowed and polished rock-surfaces, of moraines and erratic blocks. The direction of the erratics as that of the furrows has usually been conformable to the course of the principal valleys; but the lines of both sometimes radiate outwards in all directions from the highest land in a manner which is only explicable by the hypothesis of a general envelope of continental ice like that of Greenland. Some of the far-transported blocks have been carried from the central parts of Scandinavia *towards the polar regions;* others southward to Denmark; some southwestwards to the coast of Norfolk in England; others southeastward to Germany, Poland and Russia. Sir Roderick Murchison and his fellow-labourers, M. de Verneuil and Count Keyserling, have shown in the map illustrating their great work on the geology of Russia how this drift 'proceeded eccentrically from a common central region.'

"It appears from their observations that the blocks scattered over large districts of Russia and Poland agree precisely in mineral character with rocks of the mountains of Lapland and Finland while the masses of gneiss, syenite, porphyry and trap strewn over the low sandy countries of Pomerania, Holstein and Denmark are identical in their composition with the mountains of Norway and Sweden.

"It is found to be the general rule in Russia that the smaller blocks are carried to greater distances from their place of origin than the larger, the distance being in some cases 800 or even 1,000 miles and the direction from the N. W. or from the Scandinavian mountains over the low lands and seas to the south-east."

Obviously we have here no evidence of the portentous polar ice-cap. All the observations point in a different direction and indicate an ice-radiant in the north-west of Europe in Norway and Sweden of immense gathering power from which the ice radiated off to the west in which direction its progress was soon arrested by deep water of the Atlantic; to the south-west where it was reinforced in some degree by the ice from a small radiant in Scotland where, says Agassiz, the Grampians were covered with a vast thickness of ice whence erratic blocks were dispersed in all directions;* to the south where it spread over the low flat lands of Denmark, the Netherlands and N. Germany and to the east where the flat plains of Russia offered no impediment to its flow.

We may remark in passing though the subject is too large for investigation here, that in all probability the ice in this last direction terminated in an inland sea of considerable size over which the bergs that broke from the ice-foot transported vast masses of earth and stones.

The southward flow above spoken of was greatly strengthened by subsidiary but considerable glaciers coming off the mountains of northern Germany and France—the Sieben Gebirge, the Schwartzwald, the Vosges, &c.—each of which was doubtless a glacial radiant. In all probability the supplies coming down from these sources so lengthened out the ice-sheet from the Scandinavian Cordilleras that it became continuous with that which flowed from the great Alpine radiant of Switzerland. In this case there was one continuous glacier from the North Cape to the valley of the Po, and this may have been still farther extended to the southward by the assistance of smaller contributions from the higher ridges of the Apennines in Italy.

Accepting therefore this picture as that which the facts warrant us in drawing we see western and north-western Europe during the glacial era nearly buried beneath a vast sheet of ice produced by the confluence of a number of distinct glaciers flowing down off the higher lands of Norway, Sweden, France, Germany and Switzerland. Of its maximum thickness we can form little idea but the indications are that it was not at all inferior to its North American counterpart in this respect. As to area the smaller dimensions of its gathering-ground did not allow so vast an accumulation of névé and it did not probably

*Mr. T. F. Jamieson in 1858 adduced a grea' body of additional facts to prove that the Grampians once sent down glaciers from the central regions toward the sea in all directions. The glacial grooves he says radiate outward from the central hights toward all points of the compass." Lyell, Elements, p. 151.

in square miles cover so great a part of the surface of the earth as did the North American ice-sheet.

Here again as in the Western World we are confronted with the fact that the great mass of the ice was found where the precipitation was, or at least is now, greatest. The damp climate of western Europe is the most favorable place in the world for the production of glaciers. The warm west winds off the Atlantic, moisture-laden from the gulf-stream, on striking the colder highlands of Scotland and Norway pour down their watery contents in so great a quantity in some spots that these surpass in rainfall all others in the temperate regions. During the glacial era the intenser cold changed this to snow and on the mountain-tops and sides the mass accumulated until the confluent glaciers became one great ice-sheet which relieved itself in all directions along the lines of easiest flow.

In a less degree the same was true of the mountains of western Germany and of the Alps of Switzerland. The heavy rainfall of to-day was then a heavy snow-fall and the glaciers grew under this abundant supply to dimensions which would be incredible were they not established beyond all possibility of doubt by the classical investigations of Guyot and his comrades in that country. At that time the now puny glacier of the Rhone concealing itself in the secluded recesses between the Bernese Oberland and the St. Gotthard massif, so that to find it is not easy, grew to dimensions so vast as to fill the whole valley of the Rhone down to Martigny; to turn the angle formed by the opposition of the Mt. Blanc group; to bend round and enter the lake of Geneva; to fill that lake from end to end and down to the very bottom; to rise at its western end high up the slope of the facing Jura and failing to pass this huge barrier to split and send one fork to the north-east over the lake of Neufchatel and the plains of northern Switzerland and the other to the south-west along the present course of the Rhone, through the narrow gorge, where the mountains almost dam the river and of which Julias Caesar has given us the earliest and best description, down almost to the site of the present city of Lyons—a total distance from the St. Gotthard of more than 200 miles. When this was the gigantic size of the Rhone glacier we may readily believe that the other glens and straths of Switzerland were not behindhand in ice-production and that their united névés were a powerful radiant for the western part of central Europe.

Such facts are enough alone to establish the existence of an ice-age by necessary implication without any consideration of the direct evidence found to the north of Switzerland. It is impossible that glaciers could have been formed of such size there and have descended so low without the occurrence of a climate that must have covered the northern mountains with a still larger ice-sheet.

Of the condition of the northern isles at the date in question we need now say nothing. Of their severe glaciation there can be no question, but that Novaya Zemlia and Spitzbergen, Jan Mayen and Iceland sent down glaciers that became confluent with those of the continent so as to form one continuous polar ice-sheet, there is no evidence sufficient to prove. On the contrary the greater extent of the polar sea on the eastern hemisphere is directly opposed to any such belief. As we have already shown, the formation of glaciers is not possible on a marine area except under conditions so far from any now existing that the severest proof must be given of their past occurrence before the doctrine can be accepted. That the polar sea was covered with ice during the greater part of the ice-age may be readily admitted even over the European area and that the ice was very thick admits of little doubt, but that the whole Arctic ocean was solid to the bottom with ice so thick that it flowed away all round the pole by the pressure of its own mass is an assertion transcending all the bounds of legitimate deduction.

Passing now farther east we come to the Ural mountains. Were this range situated as are the Dovrefelds of Norway they must have formed another great gathering-ground for snow and ice. But in the drier inland climate of the great continent of Europe-Asia the rainfall is less and what is equally important in this connection the evaporation is much greater than on the sea-coast. Antecedently therefore the same results can scarcely be expected. We accordingly find, though the glacial geology of the Ural mountains is yet very little known, that the evidence of extensive glaciation is wanting.

The great ice-sheet which covered northern and central Russia though far from equalling that of midland North America has left abundant traces of its presence as far south as Kiev, Pultava and Voronetz but its boundary then turns northward and rudely coincides with the courses of the Volga, Kama and Petchora so far as it has yet been followed. East of this line the marks of glaciation have not been reported. It is evident that as in North America there is no close connection between the terminal moraine or the extreme marks of ice-action and the parallels of latitude. In all probability it will be found that a glacial radiant of considerable size existed on the northern part of the Uralian range whose ice may even have become confluent with the wide sheet that was advancing to meet it from Norway and Sweden. But testimony so far as it can be obtained is almost unanimous that in the middle and southern parts of the Urals no trace of ice-action can be found.

The evidence from Europe therefore places itself in line with that from North America and directly opposes the theory of a great polar ice-cap while favoring that which is here advocated of a number of separate radiants whose ice-streams sometimes became confluent and covered very large areas in the northern and western parts of the continent.

The area covered by the ice on the present theory is indeed equal to all that has been claimed by the partizans of the opposing view so far as depends on direct evidence. The fundamental difference between them lies in the fact that the former restricts the extent of the ice-sheet within those limits which the facts warrant, while the other extends it without ground over an immense area from which no evidence has yet been obtained and enormously magnifies its thickness. The latter has therefore been in large part a matter of secondary inference and there is no little reason to fear that in many cases an imagination, not truly scientific, has been the chief constructor of the edifice.

It should be further pointed out that we have in Europe as in America evidence of greater elevation of the land during preglacial and probably during early glacial times in the deeply indented shore-lines. The coasts of Ireland, Scotland and Norway show us the most intricate system of fiords and inlets that the earth's present geography affords. These excellent harbours are unfortunately for the most part situated where they are of little use for commercial purposes. As in America it would be a priceless boon to the Pacific coast if a few of the unused inlets of Alaska could be transferred to California, so in Europe both France and Spain would be immensely benefited by buying and removing at almost any cost a few of the Norwegian fiords or some of the deep bays of western Ireland now lying nearly idle. But however unsuited for the purposes of trade these northern inlets may be the geologist cannot help reading in them the story of a former higher level of the northern lands and a striking evidence of the unstable condition of the earth's crust. He watches ice-laden Greenland slowly sinking beneath its load and sees Norway now relieved of its icy burden as slowly regaining some of its former position and is tempted to ask if the load and the movement do not stand to one another in the relation of cause and effect.

Granting then this former greater elevation of Norway and Sweden their adaptation to the purpose of collecting snow and feeding glaciers was largely enhanced. And if, as seems likely from the structure of the basins of some of the Swiss lakes, the Alps also possessed greater hight then than now, their importance as a glacial radiant must have been proportionately greater.

Regarding the eastern coast of Asia we have at present almost no information bearing on the present subject. But what slight details can be obtained seem to indicate a development of glacial phenomena to a degree that is considerable but less than on the Atlantic coast of Europe. Indeed the evidence seems to show a smaller production of glaciers and less glacial action on the two shores of the Pacific than on the two shores of the Atlantic. This may be due to the fact that the precipitation along the Pacific sea-board is less than along that of the Atlantic and this again is in accordance with the small dimensions and less effect of the Japan current—the Kiwu-Siwu—the return equatorial current of the Pacific when compared with the gulf-stream of the Atlantic. The coasts of Kamtschatka and Japan though considerably indented do not by any means show a system of profound inlets such as those that fringe the coasts of Alaska, Maine and western Europe. In so far as these parts then of the evidence are concerned we do not find there the signs of extensive glaciation and change of level which we found on the coasts that we previously examined. But our knowledge of the glacial geology of these regions is so imperfect that they may be dismissed without further discussion.

There only now remains in the northern hemisphere for consideration the vast, dreary, desolate plain of Siberia without a mountain to break the monotonous level from the Ural mountains to the Lena, from the Altai to the Arctic ocean,—a region of permanently frozen soil, of scanty vegetation, of vast northward flowing rivers and of annual floods on a vast scale,—the widest plain and the coldest country on the face of the earth—the convict-prison of Russia. Cold as is the present climate of Siberia it nevertheless yields to the geologist none of those traces of severe and long-continued glaciation which are afforded by many other countries of happier climate and more fertile soil. This has been a standing puzzle to glacialists ever since the fact first came to light. No erratic blocks, no true drift, no striated rock-surfaces occur there to testify to the former presence and action of glaciers. Had a polar ice-cap ever existed it surely ought to have strewn evidence of its presence in a land where if glaciers were born mainly of cold the conditions for their birth were so eminently favorable. But if the chief conditions for the development of glaciers are, as here maintained, high ground and abundant prec pitation, we find the result in Siberia in perfect accord with what might be expected. Small glaciers very likely fringed the slopes of the northern Urals and moved eastward; others probably flowed northward from the Altai range and the high table-land of central Asia; a third group probably radiated from the Stanovoy and Tukulan mountains that skirt the Aldan river but these were apparently insignificant in size when compared with the vast plain into which they debouched. The fact remains that except along the borders of these ranges we find no evidence of ice-action over the great plain of Siberia. Obviously the reason is that there was no gathering-ground for the formation of glaciers in so level a district while the open ocean to the northward equally prevented their development in that direction. The glaciers were therefore cut off at their very source and their formation rendered impossible. On no other view are we able to explain the anomaly that the coldest area on the surface of the inhabited earth had no glacier-system and perhaps even no continental ice-sheet during the colder times of the ice-age. Doubtless this great flat between the Altai and the polar ocean was covered with snow and ice during the winter as now, but these most likely disappeared with the returning sun as they do at the present time. Or if the summer failed to melt the whole of the accumulation of the preceding winter, yet at any rate the reduction was so great that the mass never became sufficient to produce motion by its pressure.

We have now taken up all the leading features of the glaciation of the northern hemisphere that concern the rival theories regarding its cause. It is evident that the views here advocated are much more in accord with the facts than either the extreme theory of a polar ice-cap or that of merely local glaciers. As above enunciated it differs from the latter inasmuch as it requires an ice-sheet of continental proportions in both the Old and the New Worlds. But it attributes the formation not to cold and snowfall over the whole region covered but mainly to the accumulation of neve on the high lands which thus acted as gathering-grounds and from which the ice radiated in all directions, reinforced in some degree by local precipitation. It is more likely however that this latter contribution acted rather by protecting than by thickening the ice below it so that the summer sunshine, not probably then very intense, was compelled to expend a great part of its force in thawing the snow that fell during the preceding winter. In this indirect way local precipitation may have largely aided in lengthening out the existence and the extent of the continental ice.

On the other hand these views differ from the opinions of extreme glacialists less in regard to the temperate than in regard to the frigid zone. The members of that school will have little difficulty in accepting all that has been said of the former region. But the divergence begins when the area to the north of the ice-radiants above described is considered. Instead of looking to this part of the earth as the great gathering-ground for all the glaciers and ice-sheets to the southward and as a result seeing there, in imagination, a parent neve thousands of feet thick and even massive enough to affect the very centre of gravity of the earth we find no ground for the belief that there ever existed an enormous accumulation in that area. Viewed in the light of facts the supposition is extravagant and unfounded. Besides the arguments already given, the evidence of meteorology might be cited in the same direction. If the pole should turn out, as now appears probable, to be situated in the midst of a considerable ocean it will certainly be less cold than the surrounding zone and as every wind there is southerly the atmosphere must be dry and eager for moisture. The precipitation must therefore be very little and the evaporation very great. Both these causes would combine with those above given to prevent the formation of neve and glaciers over that area.

It will be obvious then that the theory above enunciated while avoiding the extravagant assumptions of the one party goes beyond the too narrow restrictions of the other. At the same time it is more in accord with observed facts than either and is we believe fully capable of explaining all the phenomena of glacial action as manifested on the earth during the ice-age.

In conclusion then we deduce from the facts and arguments stated above that all the observations of glacial action in the northern hemisphere are explicable by assuming the existence of enormous and confluent glacier-systems in and about the high-lands of Europe, Asia and America, which highlands became therefore glacial radiants and shed their load of ice in all directions over the lower adjacent ground along the lines of easiest flow; that this theory does no violence to the analogy of the existing order of things requiring merely an enlargement of actual glaciers by the intensification of actual conditions; that abundant evidence can be obtained, as for example, from Switzerland that the present glacier-system of the earth was once of sufficient magnitude to produce all the observed phenomena; that the most important glacial radiants in the northern hemisphere were, in North America, the district round Hudson bay, New England and the Adirondacks, with certain areas in the western Cordilleras, and in Europe the Norwegian Dovrefelds and the Alps, Asia apparently possessing none of commensurate importance; that it satisfactorily explains also the previously puzzling absence of glacial action over the great plain of Siberia, the coldest portion of the northern temperate zone; that the belief in a vast polar ice-cap thousands of feet thick covering the whole Arctic region and extending almost continuously down to low latitudes is an assumption doing violence to observed physical facts and to probability, that it is not required to account for the phenomena and in fact is contradictory to some of them.

(Geological notes from the laboratory of Denison University.)

II.

NOTES UPON THE WAVERLY GROUP IN OHIO.

By C. L. Herrick.

To all thoughtful persons any evidence bearing on the unity of geological history must have special interest. Every year adds fresh material to the already enormous mass of evidence attesting the correctness of the view that life has pursued a continuous though devious path from its humble origin in the dawn-period to the present. Though perhaps all competent geologists now assent to this view from a theoretical standpoint, as all biologists certainly do, nevertheless there are many stubborn groups of facts which even yet are difficult to bring into harmony with this general conclusion. It is easy to say in a sweeping way that each age or epoch presents us with a distinct advance in structure and type, but it is not yet possible in all or even many cases to indicate the intermediate steps by which the fauna of one epoch gradually passed into that of the immediately following geological horizon. For example, one need not be greatly at a loss to discover the general path of evolution during the time represented by the Sub-carboniferous limestones in the central basin, nor yet is his credulity taxed to believe that out of these faunæ there sprang the wonderfully homogeneous assemblage everywhere characteristic of the Coal Measures. But in the eastern portion of the central basin, where the integrity of the series is apparently broken and the limestones are nearly absent, the problem is very much more complicated. Indeed, the bridge between the Devonian and Carboniferous has proved all but a *pons asinorum*, and he must be bold who ventures over. Out of the shales and free-stones lying between well-marked Hamilton shale below and the mill-stone grit or Coal-Measures conglomerate geologists long ago erected an independent group called the Waverly or Cuyahoga division.

First supposed to be the stratigraphical equivalent of the Chemung in New York, it has of late been generally regarded as Carboniferous though no attempt was made to correlate its strata with any higher horizon than that of the Kinderhook.

Prof. Alexander Winchell who has most extensively studied the Waverly approached it in a comparative way, having already discovered its homologue in Michigan to be of composite nature, and subdivided it into the Huron and Marshall, the latter division being regarded as the specific equivalent of the fossiliferous upper portion of the Waverly.

The correctness of this view was shown by the discovery of Prof. Newberry that the Erie shale is a real equivalent of at least a part of the Chemung or Portage.* In spite of sundry suggestions, however, up to the present time the consensus of geologists seems to be that the Ohio formations lying above the Erie, including Bedford shale and Berea grit, constitute a unit of the column and should be assigned to an age at least later than the top of the Chemung and essentially Carboniferous in fauna. To this Prof. Winchell is an exception, though only hypothetically suggesting that some portion of the lower Waverly may be an equivalent of his Michigan Huron group.

It is not intended to here enter into a discusssion of the history of opinion of which Prof. Winchell has given an admirable summary.

The present writer was induced to enter upon an examination of the Ohio Waverly rather from the stand-point of a biologist than that of a geologist. The question prominently in mind throughout has been that relating to the vital conditions and changes indicated by the remains so poorly and fickly preserved in these sandy strata. The study has been of absorbing interest and the results are in some measure represented by the papers published during the past two years in the bulletin of Denison University. Incidentally a considerable number of

*The following species have been collected by us from the Erie shales. *Spirifer altus*, *S. disjunctus*, *S. præmaturus*, *Leiorhynchus mesacostalis*, *Streptorhynchus chemungensis*, *Orthis tioga*, *Terebratula* sp., *Rhynchonella sappho*, *Leiopteria*, sp., *Orthoceras bebryx*, *Productus* (like *lachrymosus*.)

species supposed to be new to science have been collected, of which 80 species or more are described by the writer while about 25 new species of bryozoa are described by Mr. E. O. Ulrich, whose kind services are worthy of special notice. But the portion of the study which has chiefly occupied and interested us has been the discrimination of separate and relatively distinct horizons and the effort to discover the historical interpretation which their relations warrant. The present purpose is to indicate in outline the conclusions to which the study has led. They are briefly these:

First, that the Waverly has no autonomous existence, but is a term of purely geographical value. The series of strata grouped under this head are to be distributed in all the subdivisions of American stratigraphy between the Hamilton on one hand and the St. Louis on the other.

Second, the prevailing character of the fossils in the upper, middle, and lower portions, respectively, permits their reference in a general way, to the age of the Sub-carboniferous limestones (Burlington and Keokuk), the Kinderhook, and a transitional zone partaking of upper Chemung characters without being its specific representative. That the middle portion is equivalent to the Kinderhook admits, in view of known facts, not the slightest doubt, yet we hesitate to make the specific correlation suggested by Prof. Winchell between the Kinderhook and Catskill, believing the latter an extreme and one-sided local factor in a series itself aside from the normal or generalized progression in time. That the Catskill is in some sense representative of the Kinderhook we readily admit.

The middle Waverly or Kinderhook has been strangely overlooked by Prof. Newberry and others who have based their opinion on the succession of strata called Cuygahoga shale. The recent study abundantly shows that in north-eastern Ohio the typical middle Waverly (that which has often been unhappily termed Waverly conglomerate) is entirely absent, but fossiliferous horizons, which in central Ohio are separated by over 100 feet of the most prolific rock, are in the Cuyahoga valley in juxtaposition.

Third, the Bedford shale forms no part of the groups above discussed. Its fossils which, contrary to the previous statements, are numerous and well-preserved in favorable localities, express great similarity with the Hamilton and Portage. A considerable number of species are indistinguishable from Hamilton forms,* others are obviously related but have at least varietal differences. In the characteristic chocolate beds of the Bedford in the Cuyahoga valley and near Columbus the same association of forms has been found with *no admixture of Waverly species.* This we desire to make prominent in view of the published statement of Dr. Newberry that *Syringothyris* etc. occur in the Bedford. The accompanying plate illustrates the above statement. (Plate II.)

Fourth, in spite of what has been said, it is true that a very few species extend with very slight variation, from the lower into the middle, and from the middle into the upper division, while a still smaller number appear to ascend from the middle of division I into division III. A number of species thought to give to the Waverly a decidedly Carboniferous aspect do not apparently enter the Waverly at all. Such are Productus cora, Chonetes mesoloba, Productus nebrascensis, etc. In some cases the mistake seems to be the result of false identification, while in others an accidental commingling or confusion of gatherings has been responsible.

It is not necessary to burden these remarks with lists of species as these are presented in the paper referred to. But it should be noticed that the statements above made indicate that there is no serious hiatus in the column from the Hamilton to the Coal Measures. In other words, we may here trace with some degree of confidence the changes in fauna gradually supervening under rather constant conditions through an

*List of Fossils from the Bedford Shale.

1. *Lingula melie*, H.
2. *Orbiculoidea newberryi*, H.
3. *Orthis vanuxemi*, H.*
4. *Chonetes scitula*, H.*
5. *Ambocoelia umbonata*, H.*
6. *Hemipronites*, sp.
7. *Macrodon hamiltonæ*, H.*
8. *Microdon bellistriatus*, Con. *
9. *Leda diversa*, var. *bedfordensis*, var. n. (*)
10. *Palæoneito bedfordensis* (=var. of P. constricta.)
11. *Pterinopecten*, sp.
12. *Bellerophon newberryi ?* (*)
13. *Bellerophon lineata*, H. ?
14. *Loxonema*, sp. (resembling *L. delphicola*.*)
15. *Orthoceras*, sp. (resembling O. linteum.*)
16. *Goniatites*, sp. (resembling Portage sp.
17. *Pleurotomaria* (cf. sulcomarginata.*)

*Species so designated are of Hamilton age or closely related to such species.

enormous interval, during which in most parts of the northern hemisphere there were remarkable disturbances. A slender thread of history piloting us through an epoch of disturbance and extermination must be most valuable.

Nevertheless, we are somewhat disturbed by the fact that, except for 100 feet of the Erie shale, only seen for a short distance along the north-eastern margin of the Waverly domain, the Chemung is apparently absent. The fact that the Bedford shale with an almost Hamilton fauna *rests upon* this shale still further complicates the matter. It is not possible in the limited space here afforded to discuss the reasoning employed, but we may simply indicate the conclusions tentatively advanced.

Notice first, however, a few points concerning the Chemung. Its area is different from that of the Waverly. It is a littoral formation. Where its western edge is interstratified with the Waverly is a sudden change of dip—instead of N. E. it becomes S. E. Its strata thicken towards the N. E., while those of the Waverly grow thicker southward. The Chemung has no Lingulæ, no trilobites, and its own fauna is one-sided and fickle in distribution. Our suggestion is that *in time* the Chemung in New York was equivalent to a continued Hamilton facies in Ohio. That the Bedford shale was such a belated member of a fauna preserved in the quiet weedy sea of Ohio after New York had been the scene of a sudden but one-sided development due to changing conditions. That littoral conditions are competent to greatly disturb the fauna is plainly shown within the Waverly domain. Thus to the east, in the Cuyahoga shales, the Devonian Atrypa reticularis and Strophomena rhomboidalis rise into association with species of the highest horizon (Keokuk) while in western Ohio they do not pass the littoral middle Waverly. The lower part of the Waverly, if we correctly read, contains a faunal but not an exact chronological equivalent of the upper Chemung. Here, then, we may expect to trace the gradual evolution of types exterminated by the conflicting conditions in New York. In fact we find a striking confirmation of the hypothesis. A complete succession of trilobites, including the Devonian genus *Phæthonides* of the Hâmilton in several species, several species of Proetus and one of *Dalmanites* or *Ceraurus*, in the lower portions, followed by

PLATE I.

Figs. 1–3. *Proetus (Phillipsia ?) præcursor*, Her.
Figs. 4–5. *Phæthonides spinosus*, Her.
Fig. 6. *Phillipsia meramecensis*, Shum.
Fig. 7. *Proetus minutus*, Her. Camera drawing of nearly perfect individual, highly magnified.
Fig. 8. *Phillipsia serraticaudata.*
Figs. 9-15. *Phæthonides immaturus*, Her.
Fig. 10 *Phæthonides occidentalis*, Her.
Fig 11 *Phillipsia serraticaudata ? ?* hypostome.
Fig. 12 *Proetus (haldemani ?)*
Fig. 13 *Proetus (Phillipsia)* sp. close to P. auriculatus.
Fig. 14 *Proetus (Phillipsia) auriculatus*, H. (=*shumardi.*)
Fig. 16 *Phillipsia (?) consors*, Her.

PLATE II.

Fig. 1. *Sphenotus valvulus*, 30 feet below congl. I.
Fig. 2. *Prothyris meeki*, Gann. Div. II.
Fig. 3. *Ctenodonta houghtoni ?* 30 feet below congl. I. Union Station.
Fig. 4. *Palæaneilo curta.* Freestone Div. II.
Fig. 5. *Dexiobia ovata.* Near congl. II.
Fig. 6. *Oracardia cornuta*, sp. n. Lamellibranch layer below congl I.
Fig. 7. *Dexiobia ovata*, Gann.
Fig. 8. *Oracardia ornata*, sp. n. Freestone, Granville.
Fig. 9. Hinge view of same specimen.
Fig. 10. *Oracardia ornata.* Large specimen.
Fig. 11. *Nuculana*, sp. Gann. near congl. II.
Fig. 12. *Nuculana*, sp. Freestone, Granville.
Fig. 13. *Nuculana similis* Below congl. I.
Fig. 14. *Palæaneilo consimilis.* Shale 1 mile east of Harlem, O.
Fig. 15. *Palæaneilo ignota.* Moot's run.
Fig. 16. *Nuculana saccata ?* Below congl. I.
Fig. 17. *Palæaneilo sulcatina.* 30 feet below congl. I.
Fig. 18. *Palæaneilo ? marshallensis.* Div. III. Rushville.
Fig. 19. *Macrodon newarkensis.* Div. III. Newark.
Fig. 20. *Spathella ventricosa.* Freestone, Granville.
Fig. 21. *Mytilarca fibristriata.* Moot's run.
Fig. 22. *Nuculana diversa ?* Peninsula, O.
Fig. 23. *Nuculana nuculæformis ?* Above congl. II. Newark.

PLATE III.

Fig. 1. *Edmondia sulcifera.* Right valve, Moot's run.
Fig. 2. Hinge view of smaller valve of same species.
Fig. 3. *Crenipecten cancellatus.* Moot's run.
Fig. 4. *Leiopteria (Leptodesma) ortoni*, largest specimen yet collected, 40 feet below congl. I.
Fig. 5. *Leiopteria*, sp. Freestone.
Fig. 6. *Leptodesma scutella.* Freestone, (Cf. vol. iii, Plate IV.)
Fig. 7. *Conocardium* (Cf. alternistriatum.) Moot's run.
Fig. 8. *Leiopteria*, sp. Freestone.
Fig. 9. *Crenipecten caroli, ?* Gann. Freestone.
Fig. 10. *Streblopteria.* Gann. Freestone.
Fig. 11. *Avicula? subspatulata*, sp. n. Div. III, Newark.
Fig. 12. *Pterinopecten cariniferous*, peculiarly modified left valve.
Fig. 13. *Pterinopecten lætus*, H. Moot's run.
Fig. 14. *Crenipecten crenistriatus.* Div. III, Newark.
Fig. 15. *Streblopteria*, sp. Div. III, Newark.
Fig. 16. Crinoid arm, Sciotoville.

PLATE IV.

Fig. 1. *Lingula melie.*
Fig. 2. *Orbiculoidea newberryi?*
Fig. 3. *Ambocœlia (umbonata.)*
Fig. 4. *Macrodon hamiltonæ.*
Fig. 5. *Goniatites*, sp.
Fig. 6. *Strophomena rhomboidalis.*
Fig. 7. *Atrypa reticularis.*
Fig. 8. *Palæaneilo bedfordensis.*
Fig. 9. *Microdon bellistriatus.*
Fig. 10. *Orthis vanuxemi.*
Fig. 11. *Bellerophon newberryi.*
Fig. 12. *Pterinopecten*, sp.
Fig. 13. *Leda diversa*, var.
Fig. 14. *Pleurotomaria*, sp.
Fig. 15. *Loxonema*, (cf. delphicola.)
Fig. 16. *Orthoceras*, sp.

All but 6 and 7 from the Bedford shale in central and northern Ohio.

PLATE I.

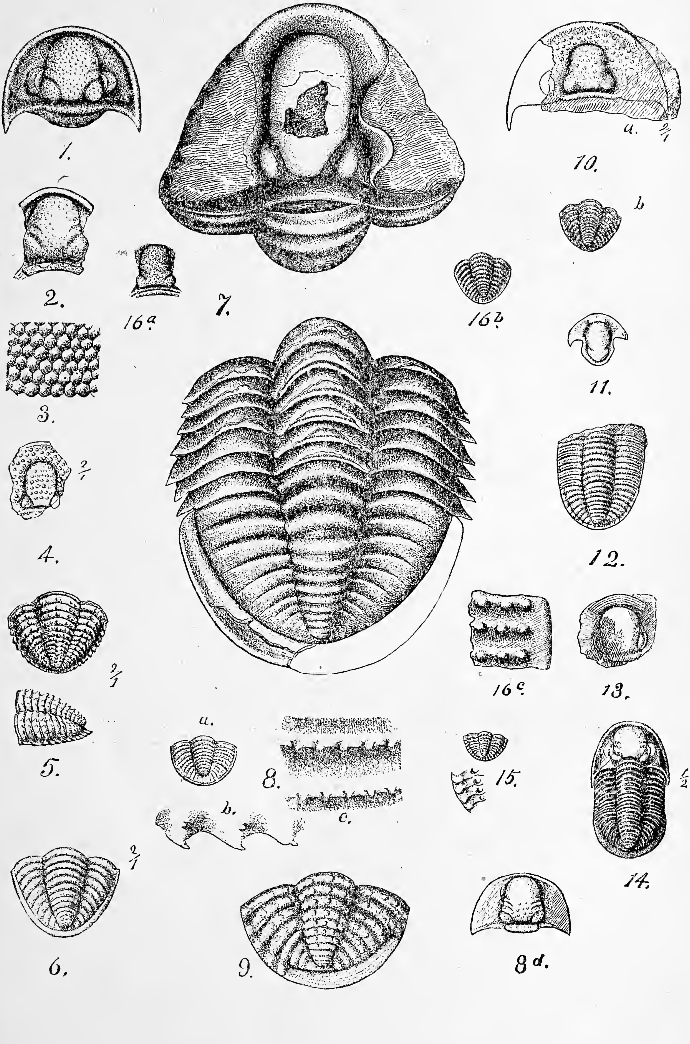


PLATE II.

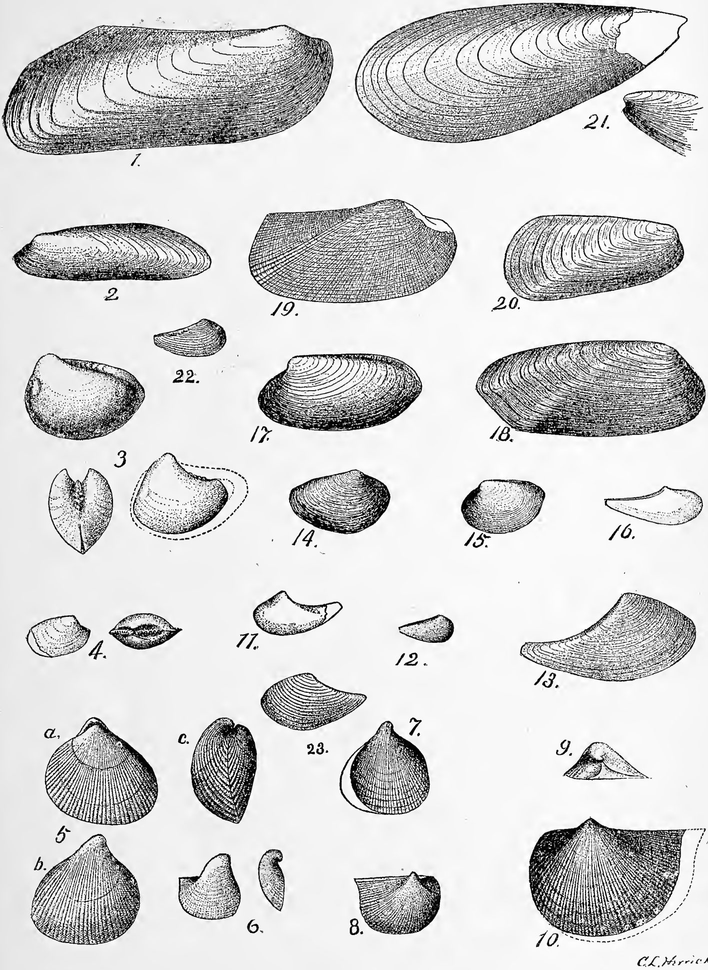


PLATE III.

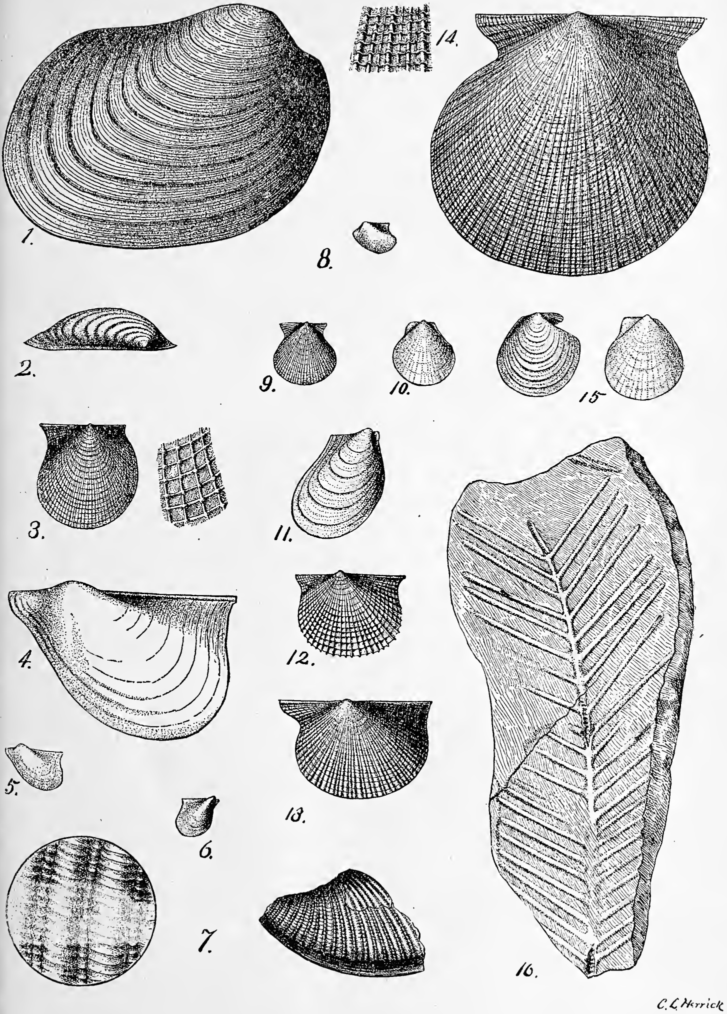
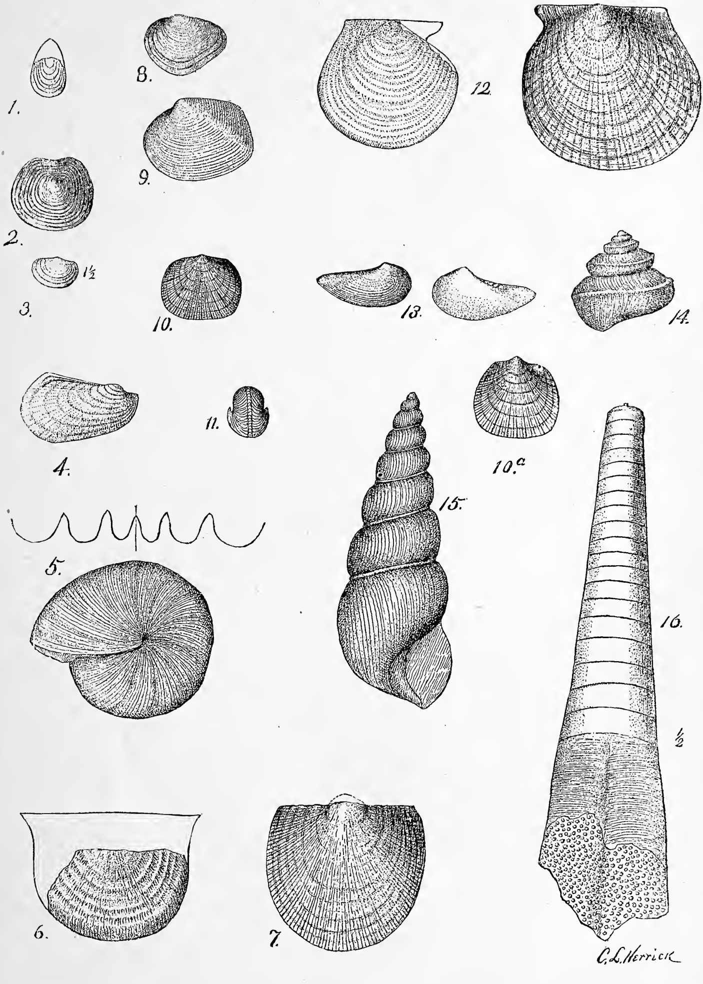


PLATE IV.



the Carboniferous genus Phillipsia, permits one to follow the evolution very easily. In the upper layers Phillipsia meramecensis is associated with numerous other Keokuk forms, especially bryozoa.

In like manner a succession of Lingulæ from forms like *L. subspatulata* to a close analogue of *L. scotia* of the Coal Measures affords the same kind of evidence. The lamellibranchs begin with *Pterinopecten* and *Lyriopecten* of Devonian habitus and by simple and easily-followed graduations lead to species of *Aviculopecten* and *Crenipecten*, while *Leiopteria* gives place to species of *Avicula* or the like.

The evidence of other groups is the same. Indeed, individually we rise from the study with the belief in the continuity of lines of evolution strongly fortified and the last vestige of leaning towards the geological dogma of cataclysms removed forever.

The plates accompanying are intended to convey an idea of the variety and character of the fauna as well as to incidentally illustrate these brief remarks.

Denison University, Granville, Ohio.

THE FOSSIL WOOD AND LIGNITES OF THE POTOMAC FORMATION.*

By F. H. Knowlton.

Perhaps no American geological formation, which has been made the subject of recent investigation, has given rise to more extensive discussion or has furnished more valuable scientific results, than has the Potomac formation. First clearly differentiated by Prof. W. B. Rogers as long ago as 1840, it has during the past decade, and more particularly during the last three years, been made a special study by Messrs McGee, Fontaine, Ward, and Marsh, and at the present time the history of its deposition and abundant animal and plant life, is better known than is the history of many of the European formations with which it has usually been correlated. Its stratigraphic position however is still unsettled although strong presumptive

*Paper read before Am. Asso. Advance Sci. Cleveland meeting, Aug., 1888. Resume of Bulletin U. S. Geol. Survey, (in press).

evidence is at hand. It was called by Rogers the Jurasso-Cretaceous or Upper Secondary sandstone. In 1885 Mr. W. J. McGee, arguing mainly from the then available paleobotanical evidence, considered it to be "Lower-Cretaceous in age—the American equivalent of the European Neocomian." Prof. Wm. M. Fontaine of the University of Virginia, who has so thoroughly worked up the plant impressions, regards it as Wealden, while Prof. O. C. Marsh who has studied the numerous vertebrate remains, claims for it a Jurassic age.

It is remarkable for containing the oldest dicotyledonous flora yet discovered. Of the 365 species of plants described from the Potomac formation by Prof. Fontaine, no less than 75 species are dicotyledons. They do not consist of the highly differentiated genera and species which characterize the other dicotyledonous floras, such as the Dakota group, but are new and archaic in appearance, showing that this class had, as has been argued by Prof. Ward, an ulterior period of development and transition.

My own studies of the Potomac flora have been exclusively devoted to an investigation of the internal structure of the lignite and silicified wood which is very abundant in this formation, and in this connection it may be well to speak of their mode of occurrence.

The Potomac formation, which has an aggregate thickness probably of more than 400 feet, is readily divisible into two members, an upper, called by Prof. Fontaine the clay-member, and a lower called the sandstone-member. The upper member contains little plant life and the material upon which the following observations are made, as also those by Fontaine, came wholly from the lower member.

The remains occur principally in lenticular pockets of hard, bluish clay, which pockets bear evidence of having been transported *en masse* from the original beds in which they were laid down. These pockets vary in their dimensions, some being only a few feet in length and one or two feet in thickness, while others are from ten to fifteen yards long and from three to ten feet thick. It is more than probable that originally this material was deposited in shallow water, which was fresh, or at most but slightly brackish. An unknown thickness, filled with the *debris* of vegetable growth, was here accumulated, after which there was a gradual uplifting of the land. This newly emerged land was now subjected to the powerful action of moving water which cut down and transported a large portion of it, leaving now and then these irregular or lenticular masses intact which were eventually surrounded and covered by a lighter material and the whole was finally buried under the Tertiary.

Good exposures of this formation, containing lignite and silicified wood, occur at Fort Washington, White House Landing and Acquia Creek on the Potomac; at Dutch Gap and vicinity on the James river; and also in the cities of Washington and Baltimore where excavations have been made. Cuts along the lines of rail-ways which pass through this formation often give good sections. Most of the material upon which the following observations are based, came from these localities.

The wood of this formation occurs under two widely different conditions, viz: as lignite and as silicified wood. There seems to be almost no transition between the two forms, although in one instance, in a silicified specimen from the new reservoir, Washington, a few small lignitized areas were detected. There is reason for supposing, however, that some of the silicified forms are also represented in a lignitized state; that is, owing to different conditions of fossilization some specimens of a species were silicified, while others were turned to lignite.

The lignite is much more abundant than the silicified form, occurring in the above mentioned lenticular masses in pieces of considerable size and in the loose surrounding material as minute fragments, which shows that this latter is the result of the wearing away of a large part of the original deposit. One of the largest specimens noted was found at Fort Washington. This was a log about five feet in length, eight inches in width, and four in thickness. A cross section of this specimen, of course, would have been lenticular, showing that it had been subjected to great horizontal pressure. A transverse section as seen under the microscope shows the cells completely collapsed and distorted by the pressure.

In color this lignite is almost uniformly jet black, in only a few cases being of a slightly brownish cast. It has a specific gravity of about 1.333, and breaks with a true conchoidal fracture like ordinary anthracite. When thus broken it does not exhibit superficially the slightest trace of organic structure, although careful microscopic examination of thin sections shows it to be generally present. It may, however, be split along certain lines, notable in a direction parallel to the medullary rays, where very plain structure shows superficially. Viewed as an opaque object, the outlines only of the wood cells and medullary rays are detected.

Supposing a priori that all parts of this lignite must exhibit traces, at least, of organization, its intense blackness naturally becomes a serious obstacle in the way of a satisfactory examination, since, in order to make a successful study with the higher powers of the microscope the specimen must be thin enough to be viewed by transmitted light. An attempt was made to grind down sections, after the usual manner of cutting rock sections; but, even when the sections were so thin as to begin to break in fragments and be torn from the slide, they still remained too opaque for even a ray of light to pass through. Other methods, as incineration, boiling in acids, etc., were equally unsuccessful. The method finally adopted, and which proved eminently successful, was that recommended by Griffith and Henfrey in their Micrographic Dictionary (2d Edition, p. 178) for the examination of coal. The specimens are macerated for a week or more in a strong solution of carbonate of potash, "at the end of which time it is possible to cut tolerably thin slices with a razor. These slices are then placed in a watch glass with strong nitric acid, covered, and gently heated; they soon turn brownish, then yellow, when the process must be arrested by dropping the whole into cold water or else the specimens would be dissolved. The slices thus treated appear of a darkish amber color, very transparent, and exhibit the structure, here existing, most clearly." The specimens are then best examined in glycerine, and may be mounted permanently in cells in this fluid.

The translucency obtained by this process is brought about by the dissolving out of the hydrocarbons by the potash. This shows that there can be little or no free carbon present, else it could not be dissolved by the liquids used. The intense yellow color produced is probably due to the presence of picric acid, of which, owing to its great coloring power, only a trace would be necessary.

The silicified wood occurs in situations similar to the lignite, but generally in larger pieces. One trunk seen by Messrs McGee and Ward at the new reservoir, Washington, was about twenty feet below the surface and was reported to have been between thirty and forty feet long. It had a diameter of nearly two feet and was but slightly flattened. Other smaller specimens from the same locality were more flattened, and a transverse section as seen under the microscope shows the cells to be distorted by pressure. Generally, however, the tissue is very perfectly preserved in the silicified specimens and admits of careful dissection and study.

In color the specimens vary from almost white to jet black, sometimes showing a transition between the two colors in the same specimen. The only examples of a decided yellow were collected by W. J. McGee in a cut on the Baltimore & Ohio R. R., half way between Montello and Reeves Station, D. C. These were small fragments yet they have the structure very perfectly preserved in places.

The method employed in preparing these woods for study is that commonly followed in the preparation of petrographic specimens, viz: slicing and grinding to the requisite thinness and mounting in Canada balsam.

SYSTEMATIC DESCRIPTION OF LIGNITE.

A great many specimens of lignite have been examined by the process mentioned above; from Baltimore; from the new reservoir and vicinity, Washington; from Fort Washington on the Potomac; from the Dutch Gap on the James river, and from other localities throughout the area covered by this formation; and the result, although not as satisfactory as could be wished, is probably all that could be expected under the circumstances. The most casual examination shows that this material has been subjected to great pressure, which has so entirely crushed and distorted the cellular elements that it is difficult in many cases to recognize the original form. The examination of a large series of sections serves however, to give a pretty correct general idea of it. A transverse section shows the lumen of the cells to be almost entirely closed up, the result of lateral pressure. This specimen, which was collected in the new reservoir, Washington, by Mr. McGee, is one of the best obtained. In most of those studied the pressure had seemingly been greater and consequently the original outlines of the cells were more difficult of determination as they had been crushed and crowded upon one another in great confusion.

A radial section shows the medullary rays to be in great abundance and, like the wood cells, to have been considerably distórted by pressure. In a few cases some of the cells of the rays were filled, before being subjected to this pressure, with a hard substance, which was more resistant to pressure, and consequently they retain nearly their original form. The number of cells entering into the composition of each ray varies considerably, ranging from as few as two or three, to as many as fifty or more. In most cases the rays are but one cell wood, although in a few cases sections have been obtained with the rays two cells wood. In one poorly preserved example there seemed to be several cells, perhaps as many as four, with a larger one in the center. This appearance may have been the result of pressure, and, if so, would have no value, but if natural it would indicate that the specimen belonged to the genus Pityoxylon. It is, however too indefinite to be more than suggestive.

As for bordered pits or markings, they seem to have been pretty generally wanting, or at most rarely to have been preserved in a satisfactory manner. They have been observed only in one instance, where only two pits or circular markings were noted.

In tangential section the medullary rays are seen to be very numerous, but this appearance is due partly to the collapsing of the wood cells by pressure, by which they are made to occupy nearly one-third less space than when in a turgid condition, thus bringing a greater number of rays into the field at once. Most of the cells are crushed flat, only the one mentioned above escaping.

In regard to the identification of this lignite it is manifestly impossible to attempt more than an indication of its general character and position. That it is coniferous is beyond question. The absence of cellular elements other than tracheds, which were provided in some cases at least, with borderered pits, and the number and arrangement of medullary rays, make the coniferous nature clear. From the abundance of the genus cupressinoxylon in the Potomac formation, as shown by the silicified examples, it is probable that most of the lignite may be also of this genus, particularly as there is in many cases a marked resemblance, so far as I am able to interpret the distorted structure, between it and some of the species described from silicified specimens. Also several species probably entered into the composition of this lignite.

SYSTEMATIC RELATIONS OF THE SILICIFIED MATERIAL.

As I have before stated the cellular elements are much better preserved in the silicified examples than in the lignite, and the results are more reliable and satisfactory. The tissues are here preserved with little if any alteration in shape and retain all their markings in the highest state of perfection.

This silicified material is all coniferous. It belongs to two well known genera, Cupressinoxylon with four species and Araucarioxylon with a single species.

CUPRESSINOXYLON. This genus as now understood has a somewhat comprehensive meaning, and includes according to Kraus what were at one time regarded as several distinct genera. Thus we have Thuioxylon of Unger and Endlicher; Physematopitys of Goppert; a part of Pinites of Goppert and Peuce of Witham all embraced under the genus Cupressinoxylon. It is the largest genus known in which the species are founded entirely upon internal structure, and it has representatives from the Carboniferous to the Tertiary. This genus is thought by eminent authorities, such as Goppert, Mercklin and Schmalhausen, to represent the wood of Sequoia, since the described species have a great structural resemblance to the living species of Sequoia, and moreover are usually found associated in the fossil state with leaf and cone impressions that undoubtedly belong to Sequoia. This view is strikingly confirmed in the present instance as Prof. Fontaine has described from leaf and cone impressions no less than twelve species of Sequoia from the Potomac flora, and typical cones have been found at Beltsville, Maryland, associated with the lignites and silicified wood. The individuals belonging to this genus must have been exceedingly numerous during the reign of the Potomac flora as their abundant remains testify. It is altogether probable that some of the species I have described from internal structure may represent the wood of some of those described by Prof. Fontaine from leaf or cone impressions, and it would, of course, be of great interest if these could be correlated, but until they are found organically connected this is manifestly impossible. This state of affairs is, however, no reason why both leaves and wood should not be named and described, for we shall now have two sets of criteria which will enable us to make out the life history of the genus and also furnish valuable remarks for stratigraphic determination.

The species, although having evident affinities with several described forms, are all regarded as new, and have been named as follows: *Cupressinoxylon pulchellum*, *C. Wardi*, *C. McGeei* and *C. Columbianum*.

ARAUCARIOXYLON. The genus to which I have referred the other species, has also been regarded as a comprehensive one although recent investigations of Grand, Eury, Felix, Morgenroth, and others make it probable that it must be again divided. It represents in a fossil state the wood of the Araucarian pines of Australia and the Pacific islands. It is characterized by the hexagonal areolations on the wood-cells, by the absence of resin ducts and faint line of demarcation between the annual rings of growth.

The species I have called *Araucarioxylon virginianum*. It was obtained from Taylorsville, Va.

CONCLUSION.

The conclusions reached in this paper are briefly as follows:

The fossil wood of the Potomac formation is all coniferous. It exists under two different conditions, viz: as lignite, which owing to the great pressure to which it has been subjected, is much metamorphosed and distorted and is incapable of specific determination; and as silicified wood. The latter material, very perfectly preserved, belongs to two genera, *Cupressinoxylon* with four species and *Araucarioxylon* with a single species.

U. S. National Museum, Washington, D. C.

PHYSICIAL THEORIES OF THE EARTH IN RELATION TO MOUNTAIN FORMATION.

BY T. MELLARD READE, C.E., F.G.S., F.R.I.B.A.

In an article entitled "On some investigations regarding the condition of the interior of the Earth," in the June and July numbers of the American Geologist, Prof. E. W. Claypole, has discussed from a geological point of view the effect of the discovery of a "level of no strain" in a cooling globe on current geological thought. The article is fairly and dispassionately written and evinces an appreciative knowledge of these later physicial investigations. There are, however, some underlying inferences with which I cannot agree and perhaps as being the first to demonstrate that there exists a stratum, or more accurately speaking a "level," in a cooling globe in which neither extension nor compression takes place, I may be allowed to discuss some of the points Prof. Claypole touches upon.

My views on the strains set up in a cooling globe were first published in chapter XI, "Origin of Mountain Ranges" 1886, though I had arrived at a clear conception of the existence of a neutral zone or shell five years previously, as can be conclusively proved by my notes. Since then, as described by Prof. Claypole, investigations have been carried on by Davison, Fisher and G. H. Darwin with the effect of fixing the limits of depth at which this neutral shell or "level of no strain" must occur in the case of our own globe.

And here I may remark—what appears to be lost sight of by these investigators—that the existence of such a level of-no-strain is quite independent of the general rigidity of the globe which is another question. In fact I was led to the discovery by considering the probable behavior of such a crust as is assumed by the supporters of the contraction hypothesis to exist in the case of our own globe. It matters not whether the nucleus be solid, fluid, or plastic; for so soon as the exterior shell becomes solid by cooling, within that shell there will exist a level-of-no-strain; always provided that the continuity of the shell is preserved by pressure produced by gravitation. This may not at first sight be obvious but it arises from the relations between the circumferential and radial contractions of such a cooling globe, by which the thickness of the solidifying crust is always greater than the depth of the level-of-no-strain.

Professor Claypole while giving due weight to these investigations thinks that the mathematicians may have erred in their numerical calculations, and placed the neutral shell in the case of our own globe too near the surface. His ground for thinking so is that rocks from a much greater depth than the calculations give for the position of the neutral shell have been forced up to the surface; the underlying idea evidently being that only by the compression of the exterior shell of the globe through secular contraction can this have happened. Is this not begging the question in favor of what is called the "Contraction" theory of mountain formation and ignoring other possible explanations of the origin of the corrugations of the earth's surface?

Professor Claypole seems to think that the strata immediately below the level-of-no-strain must be in a state of "aqueo-igneous" or even "igneous plasticity," and therefore we are driven to place the foci of earthquakes and other disturbances in the strata above the level-of-no-strain, a limitation of depth for which we have no warrant in observation. I fail to see in what way the existence of the level-of-no-strain affects the question at all. It can no more do so than can the existence of a neutral axis in a bent beam affect the solidity of the wood of which it is composed either above or below such a mathematical line.

When I developed the idea of the existence of a level-of-no-strain, or neutral shell, it was partly with the object of showing that the current ideas of the effects of secular contraction on the crust of our globe were undefined and fallacious, —"foggy" perhaps would be the correct word—and this though eminent mathematicians and physicists had been at work on the problem for some 50 years, curiously showing how a seemingly obvious result may escape minds that trust too much to mechanical modes of thinking.

It indeed seems extraordinary that a mathematician and a practical engineer like the late Robert Mallet, who devoted years to the development of a theory of volcanic action dependent upon the heat evolved by the crushing of the crust of the globe, should have failed to discover in such a crust the existence of a neutral zone. Had he done so, he would probably have abandoned his theory. Many pages of the transactions of the Royal society and much good mathematics would have been saved; but no doubt the working out of such problems, even if founded on false data, is one of the necessary steps in the development of true ideas concerning the complicated operations of nature.

The existence of a level-of-no-strain though most important was only one of the objections I had to urge against the acceptance of the contraction theory as an explanation of the origin of mountain ranges. It may not be unprofitable for me to summarize these objections, that those American geologists who have the opportunity and desire may test the ideas in the field.

One of the great arguments formerly relied on by the supporters of the contraction theory was the enormous amount of lateral compression which many mountain ranges had undergone.

This in the case of the Alps is estimated by Heim to show a shortening of 72 miles, and according to Prestwich, Prof. Claypole estimates the linear compression of the Appalachians at 88 miles. These of course are only meant as approximations, but I contend that the system of measurement is fallacious though I accept it for the purpose of illustration.*

The only possible way of accounting for such extensive movements was by a shortening of the earth's radius, which of course any theorizer is at liberty to do for himself on any scale he pleases so long as he does not work on known data. This shortening given and a crust in compression of the required thickness, the whole phenomena of mountain ranges are supposed to be accounted for. Let us see what such an hypothesis involves. Taking for example the Appalachians; as the whole of the strata from 8 to 10 miles thick from base to summit are said to be practically conformable, the shrinking of the earth cannot have affected this area from the commencement of the Cambrian period to the close of the Carboniferous, a space of time in which is comprised a considerable portion of the geological history of the globe. The Triassic rocks are unconformable to the Carboniferous, so that the main elevation of the Appalachians must have taken place between the latter part of the Carboniferous and the beginning of the Triassic periods. To this space of time then, we must perforce limit the transverse shortening of the strata. If correctly estimated at 88 miles and the whole were the effect of the earth's contraction it would, on the highly favorable assumption that the whole of the linear circumferential contraction was disposed of on this

*This is explained in the "Origin of the Mountain Ranges."

section of the earth's surface, mean a radial shortening of about 14 miles. The time taken in the elevation of the Appalachian chain, occuring as it did within the limits already mentioned, can only have been a fraction of the geological history of the globe; we are thus placed in the dilemma of invoking a sort of geological Frankenstein, for the total contraction of the globe since the dawn of geological time, on this estimate, is too tremendous to be admitted by any physicist. According to Sir W. Thomson, G. Darwin and other eminent authorities, the cooling of our earth cannot now have extended deeper than about 400 miles, so that the total radial contraction, on the most favorable assumptions, cannot have been more than from 10 to 15 miles since the first sedimentary beds were laid down. If therefore the earth's contraction is to be considered the cause of this estimated shortening of the Appalachians, we await the discovery of some contracting agent, other than loss of heat.

Having surmounted, if we are able, all these preliminary difficulties, we are met with another of a different class. All mountain chains so far as known are composed of enormous thicknesses of sedimentary rocks; a fact first pointed out by an American geologist. Why should the earth in contracting select these particular areas for the compression of its crust and the piling up of its surplus material? If sediments are thrown down only on weak places in the crust, as some are fain to believe, the compression would be continuous during the time of sedimentation. The exact opposite is the case. It has been attempted, in explanation of this awkward fact, to show that the rocks below have been weakened by sinking down into zones of higher temperature. This explanation is, it appears to me, altogether to pretty and complete; an individual case might be admitted but to assume that these several events always take place together, without exception, is rather a draft on one's scientific faith. But to what extent would the crust really be weakened? The sinking rocks though increasing in temperature would be as strong as those replaced at the same temperature; so that the supposed weakness would only arise from the replacement of the original surface rocks by the new sediments. These sediments while sinking are undergoing consolidation by pressure, chemical reactions and increasing temperature; so that, for all we know to the contrary, they may be as strong *in the mass* as the rocks they displace.

It is not, however, necessary though it would be no difficult task, to go on multiplying these difficulties by examples drawn from our own planet. If contraction by secular cooling is so potent an influence in creating the relief of our own globe we should expect to see in our satellite—the moon which has run out most of its history and is in astronomical parlance "dead,"—more marked examples of linear packing and folding than anything we witness here. A careful telescopic survey of the moon's surface fails to reveal anything of the sort; on the contrary she is covered over with innumerable volcanic cones which shew no evidence of distortion or displacement by lateral pressure, nor do the so-called plains exhibit it either. It seems strange when we have above us what is described as an epitome of the history of our own planet, and a warning finger pointing to what the earth will eventually become—which parenthetically I express my disbelief in—that none of the favorers of the contraction theory have looked to the moon for confirmation or otherwise of their theories, or if they have they have been silent.

These objections and reasons are so cogent and plain that the conventional scientific language of a treatise seems to me lacking in the graphic element necessary to bring them clearly before the ordinary mind. My object has been, in which I trust I have not altogether failed, to make it plain that we must look to some other cause than that of secular contraction, for an explanation of the building of mountain chains. Elsewhere I have attempted a systematic theory on other lines but it was not my intention, nor have I space, to expound it here.

For the final establishment of any theory much more information than we have is required concerning the actual structure of mountain ranges, and as American geologists have done so much in the past to supply us with what knowledge we possess, I trust that in the future they will not be found wanting.

THE CHOUTEAU GROUP OF EASTERN MISSOURI.

By R. R. Rowley, Curryville, Mo.

To the Missouri fossil collector there is no more interesting series of rocks than the beds denominated, in the old geological reports, Chouteau group. If these rocks are interesting to the collector they are doubly so to the skilled palæontologist, not that they yield any new or striking genera of fossils, but from the fact the species are peculiar to the beds, for the most part, and fail to point satisfactorily to the position of this group in the great palæozoic series of the Mississippi valley.

These beds have been at different times ranged under the Chemung, Hamilton and Kinderhook groups without any special reasons for the transfers, and at present they are quietly resting in the latter group.

We do not propose in this paper to disturb this sleeping relic of the by-gone ages and definitely refer it to any of the recognized divisions of the palæozoic rocks, but we do think it should retain the name of "Chouteau group," at least until sufficient evidence has been gathered to place it in its right shelf in the cabinet.

The first notice, so far as we know of this group, was in the old Missouri report by Prof. G. C. Swallow, and, after collections had been made at Chouteau Springs, Cooper county, Hannibal, Marion county, and Louisiana and Clarksville, Pike county, the beds were referred to the Chemung group and divided into the following subdivisions; "Chouteau limestone," "Vermicular sandstone and shales," and "Lithographic limestone," in a descending order, the latter division being said to rest directly on the Hamilton shale. Later on Dr. Shumard, in speaking of these beds, still left them where he had previously placed them, but when it came to Prof. James Hall's time to turn these rocks over and view them from a distance, he slid them down into the Hamilton shelf.

Meek and Worthen made the final transfer to the Kinderhook, and western geologists have generally recognized this disposition of the vexed question.

In the New York report for 1882, on Palæontology, Prof. Hall copied his figure of *Productella pyxidata* from the old Iowa report and stated the specimen from which the figure was drawn was found in Iowa, while in the former report he gave the locality in Missouri. He made a similar mistake in *Productella shumardiana*, which if it is found at all in the Lithographic limestone at Clarksville is only a young specimen of *P. pyxidata*. We doubt whether the original specimen came from Missouri at all.

We have never collected in person from the Chouteau limestone but have received fossils from it from other collectors. As to the other divisions of the series we have made thorough examinations of them, ranging through fourteen years and have collected five series of the beautiful fossils.

At Louisiana, immediately underlying the base of the Burlington limestone, is about three feet of a yellow argillaceous sandstone filled with worm-like burrows and casts of brachiopods, lamellibranchs, gasteropods, one goniatite and a peculiar fucoid. Beneath this sandstone are, perhaps twenty-five to thirty feet of dove-colored shales, entirely destitute of fossils.

The Lithographic limestone, forty or fifty feet in thickness, lies beneath the shales and is made up of thin layers of a very close-grained and hard, light-brown and pale-blue limestone, the strata increasing in thickness downward from an inch or two at the top to twelve or fourteen inches at the base. The material between the layers of limestone being yellow and toward the bottom but little harder than clay.

The Lithographic sandstone rests on two or three inches of a soft clay-like shale or sandstone of a yellowish cast, this latter passing downward into fifteen or sixteen inches of a dark blue shale.

A black shale of three feet in thickness underlies the blue shale and overlies an oolitic limestone referred by Drs. Shumard and Swallow to the Corniferous group but now known to be the equivalent of the Niagara. The black shales were referred to the Hamilton by the same authors, though they failed to find a single fossil in the beds. However, as we have found a few remains and all identical with species from the shales above these beds, undoubtedly, form the base of the Chouteau group.

The upper part of the Lithographic limestone is destitute of fossils, the middle beds yield the plume-like *Felicites gracilis*.

In the two or three base layers and in the yellow partings are found the characteristic fossils, while, higher up remains are scarce. In the underlying yellow shales and often passing into the blue is an abundance of fossils but largely crushed and half-valved specimens.

About five inches from the top of the blue shale is a bone bed filled with bones, teeth and coprolites of fishes, associated with one or two species of sponges.

In an inch layer of a white or ferruginous (white in fresh exposures but stained with iron in weathering) siliceous coarse-grained sandstone, near the base of the black shales are to be found the fish remains mentioned above, together with a small Lingula also identical with a form in the shales above.

The fossils in the Vermicular sandstone are casts and very poorly preserved, while the remains in the Lithographic limestoneand underlying shales are often in a fine state of preservation.

Three miles north-east of Curryville is an outcrop of a brownish, earthy, thin-bedded limestone that yields a series of fossils unlike either the forms from the Cooper county Chouteau or the Lithographic limestones. Unfortunately these fossils have been changed to calc-spar and defeat structural examination.

While the Lithographic limestone has but few and small corals, these beds offer quite a series of polyps, ranging from single corals an inch long to those five or six inches in length. One cyathophylloid is extravagantly frilled and may be Dr. White's *Chonophyllum sedaliense*, while another is very tortuous, strongly reminding one of *Amplexus yandelli.*

Another is spinose, like a Keokuk *Zaphrentis.* Along with the cyathophylloids are two species of *Michelinia*, one undoubtedly the *M. placenta* of Dr. White, described in Hayden's 12th annual report; the other an extravagant form mimicking a compound cyathophylloid. A fine *Syringopora*, an *Aulopora* and *Zaphrentis calceola* complete the list of most striking forms.

Among crinoids are a small *Actinocrinus* an *Ollacrinus* a *Platycrinus* and a small blastoid, like *Granatocrinus.*

Of brachiopods, a small *Spirifera*, an *Orthis*, like that from the Kinderhook (Lithographic) at Louisiana but much smaller, a little *Chonetes*, a small *Athyris* like hirsuta, a large smooth *Athyris*, a *Rhynchonella* and *Strophomena rhomboidalis*, like the Burlington variety.

The presence of *Zaphrentis calceola*, *Michelinia placenta* and *Chonophyllum sedaliense* seems to make these beds the equivalent of the Sedalia strata, referred to the Chouteau limestone by Dr. White. But as *Z. calceola* ranges through the entire Burlington group and an *Orophocrinus*, perhaps but a variety of

O. stelliformis, a well known lower Burlington form, has been reported from Sedalia, it may be a question of some doubt whether these "Placenta beds" are Kinderhook or Burlington. Near Curryville they strongly remind one of the Devonian from their abundance of corals.

It might not be improper here to state we have also found *Porcellia nodosa* in the Lower Burlington at Louisiana, associated with *Zaphrentis calceola*, *Z. elliptica*, *Granatocrinus melo* and *Spirifera grimesi*. *P. nodosa* was described by Messrs Meek and Worthen in the 3rd Ill. report as a Kinderhook species.

Along the railroad cut, one mile north-east of Bowling Green, Mo., the "Placenta beds" are also to be seen, while we have noticed a great thickness of them four or five miles north-west of Vandalia, Audrain county, Mo., also six or seven miles north-west of Curryville, on Spencer creek.

We subjoin a complete list of the fossils found at Louisiana in the Chouteau group, giving the specific names so far as we have been able to identify the forms.

Many of the species are rare and a number of them yet undescribed.

It might not be improper to state the Orthis was long ago identified by Prof. Hall in the Iowa report as *O. vanuxemi* but, no doubt, is quite district from that species.

Spirifera hannibalensis, *Cyrtina acutirostris* and *Athyris hannibalensis* strongly resemble species in the Lower Burlington at Louisana but are doubtless specifically distinct.

In the list the species found in the "Vermicular sandstone" are numbered 1. Those from the "Lithographic limestone" 2; from the underlying yellow and blue shales 3; and from the black shales 4.

3 & 4 Fish bones and teeth.
3 & 4 Coprolites.
3 Phillipsia sp? (mere fragments.)
2 Orthoceras (very rare.)
1 Goniatite (have seen but one specimen.)
1 Loxonema, like gasteropod (but one specimen.)
2 Undet. fragment of a gasteropod (one only.)
3 Platyceras sp?
1 An Avicula-like lamellibranch.
1 & 3 Allorisma hannibalensis.
2 Aviculapecten? sp? (but one example.)

2	Undet, cast (lamellibranch.)
1, 2, 3	Spirifera marionensis (very common.)
1, 2, 3	" hannibalensis.
2 & 3	" sp? (very rare.)
2	" sp? (spinose,) (but one.)
2 & 3	Cyrtina acutirostris, (common.)
2 & 3	" sp? (very small.)
2 & 3	Athyris hannibalensis (not rare.)
2 & 3	" sp? (small and rare.)
2 & 3	" sp? (very small.)
3	Terebratula sp? (rare.)
1	" sp? (cast.)
3	" sp? (very small.)
2 & 3	Rhynchonella missouriensis? (rare.)
3	" sp? (rare.)
2 & 3	Orthis sp? (like *vanuxemi*,) (common,)
2 & 3	Hemipronites sp? (not rare.)
1	" sp? (large.)
1, 2, 3	Productella pyxidata (very common.)
1	" sp?
2 & 3	Chonetes ornata (common.)
2 & 3	" sp? (very small.)
3 & 4	Lingula sp? (very small.)
3	Crania rowleyi (Gurley's species,) (rare.)
3	Crania sp? (rare.)
3	Discina sp?
3	Conularia sp? (fragments.)
2 & 3	Spirorbis kinderhookensis (Gurley's species.)
2 & 3	Cornulites carbonarius " "
2	Minute cyst-like parasites.
2 & 3	Dichocrinus? sp? (basal plates and columns.)
2 & 3	Zaphrentis? sp? (not rare.)
3	" sp? (rare.)
3	" calceola??? (one specimen.)
3	Undet. cyathophylloid-like fossil (one example.)
2 & 3	Favosites (Michelinia) sp? (not rare.)
2 & 3	Palæacis enorme (rather uncommon.)
2 & 3	Undet. incrusting bryozoan.
2 & 3	" " "
2 & 3	Bryozoan sp? (rare.)
3	Ptychostylus subtumidus (Gurley's species.)
3	Sponge??
2	Felicites graciiis (rare.)
1	Fucoid.

THE ARTESIAN WELL AT CITY PARK, DAVENPORT, IOWA.

By A. S. Tiffany.

This well is situated 160 feet above low water in the Mississippi, and 688 feet above the sea.

		Thickness—feet.	
Drift 100 feet	1.—Loess 40 feet; Boulder clay 60 feet.....	100	
Coal Measures 30 feet.	2.—Dark clay shale........................	30	130
Corniferous 390 feet.	3.—Hard drab limestone	220	350
	4.—Cream-colored limestone	30	380
	5—Hard, porous limestone, buff...........	20	400
	6.—Drab limestone, hard..................	90	490
	7.—Very dark blue calcareous shale........	30	520
Lower Helderberg, 80 feet.	8.—Soft, buff limestone, Le Claire..........	80	600
Niagara 175 feet.	9.—Hard, rough, drab limestone...........	50	650
	10—Drab limestone	75	725
	11.—Hard shaly limestone..................	50	775
Cincinnati and Trenton, 300 feet.	12.—Dark gray limesto e...................	125	900
	13.—Dark drab limestone	50	950
	14.—Soft white limestone	75	1,025
	15.—Soft white limestone	50	1,075
Calciferous group Magnesian limestone of the Mo. reports 512 feet.	16.—Blue clay shale, with silica............	10	1,085
	17.—St. Peter sandstone, white.............	90	1,175
	18.—Arenaceous shale, drab, blue and red...	15	1,190
	19.—Magnesian limestone, with ten per cent. silica; cement rock...................	210	1,400
	20.—No record.............................	25	
	21.—Sandstone, (by City engineer)..........	10	1,435
	22.—Limestone, (borings washed away)......	100	
	23.—Limestone............................	262	
		1,797	

Note.—No. 4 contained fossils, viz: Paracyclas tenuis Hall, Platystoma turbinatus Hall, Cyrtina hamiltonensis Hall. Cladopora and Pleurotomaria, undetermined; No. 7, contained Pantamerella arata Con. or P. papilionensis Hall.

It appears that 80 feet or more were eroded from the Corniferous before the coal shales were deposited. The upper 80 feet of the Corniferous at this place have well marked lithological features, which could be readily recognized in the borings. Nos. 4 to 7 do not outcrop in this county, having been depressed by the great fault, nine miles above at Valley City. The St. Peter sandstone furnished abundance of water, which stood within 50 feet of the surface. The porous strata at 400 feet let the water escape. The well was piped 1,100 feet, when the water stood 22 feet from the surface. Pumping 125 gallons per minute did not lower the water. The porous stratum No. 5 appears at the artesian wells at the glucose works at Davenport, and at the paper mill at Moline, two wells being adjacent at both places, and the water flows through this porous stratum from one well to the other.

BARRANDE AND THE TACONIC SYSTEM.

By Jules Marcou.

Mr. James D. Dana says that Barrande adopted "in his memoir in full the views of Emmons on the Taconic system"—"and thus *confusion* was introduced by Barrande along with the light. It would not have been so, we are sure from his careful Bohemian work, had he been within reach of the stratigraphical problem, for he would have withheld his general conclusion until he had investigated the region of the Taconic area" ("A brief history of Taconic ideas," *Amer. Jour. Sci.*, vol. xxxiv, Dec., 1888, pp. 410 to 427.)

That the person who has never found the Primordial fauna in the original Taconic area or anywhere, and has referred the Taconic system to the Champlain system "or younger" should speak of Barrande's having introduced "confusion" in American geology is such an extraordinary accusation, that at first I was inclined to let it pass without any notice. Barrande is so far above the imputation of the adversaries of the Taconic system, that it seems useless to answer. But the persistance of attacks, made as usual in the *American Journal of Science*, by Messrs. Dana and Walcott, call for a persistance in the defence.

Never has such a statement absolutely the reverse of truth been propounded on a geological question. It is to be regretted that Mr. Dana did not express his opinion before the death of Barrande; but as no one has been nearer Barrande in opinions, views, and friendship than I, the duty devolves on me to defend once more the great services he has rendered to geology in general and to American geology in particular.

Besides in one of his published letters to me, Barrande says: "You possess all the necessary qualities for those explorations (speaking of researches in the Taconic region), which require a clear intellect, an independent spirit and a true devotion to science." ("The Taconic system and its position in stratigraphic geology," by Jules Marcou, in *Proceed. American Acad. Sci.*, vol. xii, p. 194, Cambridge, 1885). The constant approbation of Barrande in all my work on the Taconic question, and our frequent interchange of views and observations by letters and in long conversations on the subject, impose on me the obligation to show who has made "confusions," and who has disentangled the Gordian knot.

Primordial fauna in Texas.—Barrande as far back as 1853 recognized the existence of the Primordial fauna in Texas, which Mr. Ferdinand Römer had described in his "Die Kreidebildungen von Texas," as belonging only to the Silurian system, without any reference whatever to the Primordial fauna of Bohemia and Scandinavia, well established eight years previously by Barrande with the complete approbation of Angelin for Scandinavia.

Primordial fauna on the Upper Mississippi and in Missouri.—In 1859, Barrande showed that eleven species of trilobites of the Upper Mississippi region, described by D. D. Owen, belonged to the Primordial fauna of Europe; saying that they have in their forms, "appearances which assimilate them to the *Paradoxides.*" The same year, Barrande referred Swallow and Meek's discovery of two trilobites in Missouri to the Primordial fauna.

Primordial fauna in the Taconic area.—Finally in 1860 and 1861, in his masterly written and extremely important memoire: "Documents anciens et nouveaux sur la Faune Primordiale et le systeme Taconique en Amérique," Barrande having at last received communication of Emmons' Memoirs, which until then he had never seen, did not hesitate; 1st, to recognize the priority of Dr. Emmons' discovery of the Primordial fauna in the original Taconic area; 2nd, to point out the great and very grave errors of the adversaries of the Taconic system, pointing out in a special chapter VI, p. 301, the extraordinarily incorrect

"Vertical transfer of the Primordial fauna of Sweden by James Hall;" and 3rd, to give conclusive evidence of the good determination of Dr. Emmons for his Taconic fossils, referred by him, as far back as 1844, as a special fauna. That paper of Barrande is a model of clearness, of straight forward opinions on the Taconic system, as well stratigraphic as paleontologic, and the most honest protest ever published on any controverted geological question.

Barrande by dates, descriptions and reasoning has proved beyond any possible doubt that Dr. Emmons has truly the priority over every body, even himself, on the question of the first discovery of the Primordial fauna, contained in strata which Emmons has called the Taconic system and which he has placed at its proper position in the stratigraphic scale, below the Champlain and as pre-Potsdam. And to think that such an honest and illustrious geologist, who has rendered to American geology such services and shown such a cosmopolitan spirit and such an unprejudiced and noble mind should be taxed of having introduced "confusion" into American geology, by a writer of a Manual of Geology for schools, who has failed during fifty years to recognize twenty-five thousand feet of strata as older than the Champlain system and the Potsdam sandstone, is a feat without a precedent.

Barrande's doctrine of Colonies.—As to the supposition that if Barrande "had been within reach of the stratigraphical problem, he would have withheld his general conclusion" it is simply a last expedient of an adversary of the Taconic forced in his last entrenchment. For Barrande, from the first moment he took the Taconic question into his hands, called my attention to his "doctrine des colonies," telling me that very likely there was something of that sort in the Taconic area. At first I was opposed to the doctrine, as it will be seen in my two papers of 1860 and 1861, in which no reference whatever is made to it. But conviction came little by little, by direct researches at Pointe Lévis, St. Albans bay, Swanton and Phillipsburgh; first recognizing the lenticular character of all the limestones inclosed in the slates, a great step to disentangle the complicated stratigraphy of the whole Taconic area, and secondly afterwards pointing out the prophetic types and colonies of the second fauna, found by me now and then, never continuously, in the Pointe Lévis and Phillipsburgh group as far back as 1862, and published that year in my "Letter to M. Joachim Barrande, etc.," Cambridge. Several years after, during 1873 and 1874, I recognized the same existence of prophetic types and colonies in the Swanton or Citadel Hill of Quebec slates group, and published my observations in 1880, in my paper, under the significant and very appropriate title of "Sur les colonies dans les roches Taconiques des bords du Lac Champlain" (*Bulletin Soc. géol., France*, tome ix, p. 18).

The last paper received the full approbation of Barrande, as it will be seen in his letter of the 10th of March, 1882, a part of which I have published in the *Proceed. American Acad. Science*, vol. xii, p. 220, Cambridge, 1885; and it will be sustained even more by numerous quotations in his last memoir, "Défense des Colonies," which will soon be published as a posthumous work of Barrande by the "Musée Boheme."

If Barrande had investigated and explored the Taconic area from Pointe Lévis and Quebec city to Phillipsburgh, Swanton, Highgate, Georgia, Bald mountain, Williamstown and Poughkeepsie, he would have recognized at first the existence of colonies, on account of his long practical experience of that phenomenon in the strata of Bohemia, and he would have advocated with all his power, as a writer and an observer of genius, as he was, the acceptation of the Taconic system of Dr. Emmons, with the addition only of that small and local group of the Potsdam sandstone.

I do not say that he would have extinguished all opposition, and removed all wounded self-love; for the reputation of being a good observer or a bad one hangs over the heads of all those concerned in the Taconic question, friends or adversaries; and the resistance he encountered to the acceptance of his "doctrine des colonies" in Bohemia, first from the Bohemian geologists, Zippe and Krejci, secured from the officials of the Geological Survey of Austria Haidinger and Lipold, third from the professors of paleontology at the school of Mines and the Jardin des Plantes in Paris, d'Archiac and Bayle, and finally from the messenger, Mr. John E. Marr, sent to Bohemia from Cambridge University, England, by the successor of Sedgwick, Mr. T. McKenny Hughes, prove that prejudices and error "die hard."

THE FINAL VERDICT ON THE TACONIC.—But with all the papers of Barrande and Marcou in his hands, every geologist may make up his own mind and draw his own conclusions. The final verdict may be delayed a few more years, until a thorough survey with geological maps on a large scale where every fact as it exists in the field will be noted and figured; and a detailed description of all the strata, outcrops, sections; fossils with all their meaning, such as abundance or variety, and associations carefully noted; of the entire Taconic and of the Champlain areas, have been completed.

The future of the Taconic system has been fully assured since the day of the publication of the joint paper of Barrande and Marcou, by the Boston Society of Natural History in December, 1860; and ever since opposition, confusion, obscurity, omission, contradiction, continual changes of opinion and unhappily also even "discourteous acts" have been the exclusive monopoly of the adversaries of the Taconic system. Unscrupulous and unintelligent; such are the two expressions properly applied to the consolidated association of those who since 1842 have constantly opposed and even denied the existence of the Primordial fauna and the Taconic system in America. Errors and misunderstandings may be reasonably expected in any difficult geological question; but for the last twenty-five years the discussions have degenerated into a struggle of wounded self-love, in order to cover, as long as possible the damaged reputation of three or four leaders, too deeply engaged to retrace their steps backward, and accept openly their defeat.

Mr. Dana's conclusions.—The conclusions of the last paper of Mr. Dana are in harmony with his appreciation of Barrande's "confusions" introduced in American geology.

Here are Mr. James D. Dana's anti-Taconic ideas, which according to his judgment and extreme desire must settle the Taconic question and suppress it forever:

"It is thus finally made positive that the Taconic system is not a pre-Silurian system, and that the claiming for it equivalency with the Huronian was but *a leap in the dark*. It is manifest in fact, that Taconic system is only a synonym of the older term, Lower Silurian, as this term was used by geologists generally, twenty, thirty and forty years since, and by many writers till a much later date."

"It is almost fifty years since the Taconic system made its abrupt entrance into geological science. Notwithstanding some good points, it has been, through its greater errors, long a hindrance to progress here and abroad. It has also been a promoter of investigations of wide bearing and influence. But, whether the evil or the good has predominated, we may now hope, while heartily honoring professor Emmons for his earnest geological labors and his discoveries, that Taconic ideas may be allowed to be and remain part of the past.

1841-1888."

(See "A brief history of Taconic ideas," p. 427, *Amer. Jour. Sc.*, vol. xxxvi, 1888.) A last but not least "leap in the dark," which completes the dozen leaps of the adversaries of the Taconic system.

The expression "long a hindrance to progress here and abroad" applied to the Taconic and its supporters, is simply a jewel, worth all the utterances of Mr. Dana.

"LEAPS IN THE DARK" OF THE ADVERSARIES OF THE TACONIC.—An enumeration of the progress claimed by Mr. Dana and his associates, is so curious a reading that I take great pleasure in placing it under the eyes of geologists, for it is unique in the history of progress of our science.

Here are a dozen of "leaps in the dark:"

I. 1843.—W. W. Mather says: the Taconic rocks are the same in age as those of the Champlain division modified in character by metamorphic agency.

II. 1847.—James Hall says: the rocks of the Taconic system are clearly Hudson River group acted upon by gradual metamorphism.

III. 1847.—James Hall says: the fossils described by Dr. Emmons are *unequivocally* identical with well-known species in the Hudson River group: Atops trilineatus is *unquestionably* the Calymene Beckii of the Utica slates.

IV. 1859.—James Hall says: the trilobites of Georgia belong to the Hudson River group, adding: "It would be quite superfluous for me to add one word in support of the opinion of the most able stratigraphical geologist (W. E. Logan) of the American continent." Barrande did not think it "superfluous to add one word;" and that word is "error" of Mr. Hall in trying to transfer the Primordial fauna above the second fauna.

V. 1861.—W. E. Logan says: the Quebec group is the equivalent of the Chazy and Calciferous; it is brought to the surface by an overturn anticlinal fold with a crack and a great dislocation running along the summit. This dislocation proceeds from lake Champlain to Quebec, keeping just north of the fortress, thence it coasts the north side of the island of Orleans, and from the east end of the island it keeps under the water of the St. Lawrence;—a leap in the water.

VI. 1862.—James D. Dana says: light came in again through the Vermont Geological Survey. Now in the report of this survey the Red sandrock is regarded as the equivalent of the Medina group, the Georgia slates of the Oneida conglomerate, and the Stockbridge limestone as Devonian and Carboniferous. So according to Mr. Dana the referring the Georgia slates with their Primordial fauna by Messrs. Hitchcock to the Upper Silurian is "light."

VII. 1862.—Charles H. Hitchcock proposes the "Georgia group" on account of the existence of the trilobites found in the township of Georgia, and he does not know where the Parker's quarry is situated, coloring on his geological map the whole part of the township of Georgia in which the Primordial fossils exist as Oneida conglomerate, or Upper Silurian; a "confusion" unique in the proposal of typical localities for a group in geology.

VIII. 1877.—Hall and Dana say: the eastern quartzite formation is of the age of the later Trenton or Cincinnati group; and Dana adds, or "younger."

IX. 1879.—A. R. C. Selwyn says: that the *anticlinal* fold of Logan is a *synclinal* and that it is a mistake to make it "pass to the *rear* of the Quebec citadel," for it passes in *front*, but under the river. Mr. Selwyn kept his "great St. Lawrence and Champlain fault," from the south of the city of Quebec to the middle of the Gulf of St. Lawrence, where he stops it, constantly under water; another leap in the water.

X. 1888.—Charles D. Walcott discovers a "Potsdam off-shore deposit" of calcareous and argillaceous mud; a leap in the mud. He gives a geological section across the Taconic area with fifteen faults; a leap among faults. Mr. Walcott "rules out the name Taconic from geological nomenclature;" he shows that "the name is not applicable" being "based on errors and misconception originally, and used in an erroneous manner since;" and he proves that "Barrande was misled into crediting Emmons with a discovery that was based on errors of field observations.'" He "invalidates the claim of priority of the discovery of the Primordial fauna" put forward by Barrande. He regards Emmons' primordial fossils as a "fortunate happening," and "not a scientific induction based on accurate observation and comparison." And finally Mr. Walcott makes a declaration of his "principles," which he proclaims are "the result of accuracy of his original observations" made "hammer in hand;" and having all the time "in mind," (1) "priority of definition," (2) "scientific induction," (3) "accuracy of original investigations," and (4) "the light of later results of his field work;" an array of imposing and weighty sentences never brought up before in American geology; and anything but creditable to its author.

XI. 1888.—Re-statement of the transfer of a part of the Primordial fauna above the second fauna, by Mr. Walcott who thinks that "Dr. Emmons had not a clear idea of the position of the shales of the Hudson river valley that contain the graptolites described by Prof. Hall, nor of the shales of Pointe Lévis carrying the graptolitic fauna;" and consequently Mr. Walcott transfers the second and third zones of graptolites to the Utica slates or upper part of the second fauna;—a leap among the graptolites.

XII. 1888.—Mr. J. D. Dana discovers the "confusions introduced by Barrande;" which have been "a hindrance to progress here and abroad." He advocates the total suppression of the Taconic system, referring all the Taconic rocks of Dr. Emmons to the Champlain division, as Mather did as far back as 1842, burying with great solemnity and honors the "Taconic ideas."

What a record of progress entirely due to the adversaries of Taconic ideas. It would be easy to duplicate that dozen of "leaps in the dark," but it is best not to abuse quotation; enough has been said of the "principles" used by the adversaries of the Taconic and of their "abrupt entrance into geological science," to satisfy the appetite of those interested in the controversy.

Honoring Professor Emmons.—However I shall call the attention, to another most extraordinary feature of the opposition made by some of the adversaries of the Taconic. They say: "heartily honoring Professor Emmons for his earnest geological labors and his discoveries" (Dana's *A brief history of Taconic ideas*); "Professor Emmons was right in his Berkshire stratigraphical observations" (Dana's, *The views of Professor Emmons on the Taconic system*); Dr. Emmons deserves great credit for the work that he did;" also "There is no doubt that Dr. Emmons was correct in classifying the upper Taconic as pre-Potsdam. To him belongs the credit of recognizing and describing the Middle Cambrian series of North America as a distinct formation, both on structural and paleontologic grounds;" and also "I cordially unite with M. Barrande and Professor Marcou in according to Dr. Emmons the credit of publishing the first fossils of the Primordial fauna in America" (Walcott's* paper, 1886-88).

Notwithstanding those fine sentiments expressed in such glowing language, Messrs. Dana and Walcott's conclusions are an entire suppression of all the discoveries and good work of Dr. Emmons, the destruction of the best part of the national record of American geology, and the complete surrender to the English geologists of all the right of priority belonging to America.

The friends of the Taconic have simply sustained Dr.

* A few months after uttering those eulogies on Dr. Emmons, Mr. Walcott changed his attitude in regard to honoring Dr. Emmons' researches and discoveries, in his paper: "The Taconic system of Emmons and the use of the name Taconic in geologic nomenclature." Not only does he not honor any more Dr. Emmons, but he attacks him on every possible point, trying to crush to atoms all his discoveries and descriptions on the paleontology, stratigraphy, lithology, nomenclature, use of the name Taconic, right of priority, as a collector of fossils, and even as to the disappearance of his geological map from the first volume of the *Agriculture of New York.* What a pity that Mr. Walcott was not at Albany in 1846, for he would have obtained at the office of the secretary of state of the state of New York, the three thousand copies "stolen or destroyed" of that most important map.

Emmons' discoveries and nomenclature, and maintained without flagging and sternly the rights of American classification and nomenclature of the Lower Paleozoic strata. Barrande has stepped forward without any hesitation or reticence. His memoir and letters [thirteen letters have been published by Marcou in the *Proceed. Boston Soc. Nat. Hist.* and *Proceed. American Acad. Arts and Sci.*] on the subject are models of justice and honesty, entirely cosmopolitan in character, and free from all prejudice as to nationalities or as to observers.

On one side are men who have constantly, during fifty years united their efforts to suppress and destroy the greatest discoveries made in American geology; and on the other side men who have sustained the truth in its full meaning. On one side men who care nothing about names used in geological nomenclature, and on the other side men who think that priority of discoveries cannot be set aside. On one side men who prefer the maintenance of their errors even at the expense of the national record, and on the other side men of "elevated minds," cosmopolitan in the best acceptance of the word who do not hesitate to recognize truth when they find it in America as well as in Europe.

Friends of the Taconic.—This paper is addressed to the independent American geologists, who have shown already by their publications of papers on the matter, and also by their private good words of sympathy for the cause of discoveries made on this continent, that they have at heart only the truth and the good reputation of American geology.

The future generation of geologists will not easily understand how it came that the best and most creditable observations made on American classification and nomenclature, have been kept so long in the back-ground, and how errors of the most stupendous character have been maintained and adhered to with such persistency. Wounded self love combined with a jealousy unparalled in geology have never acted so openly and with so much help from geologists who know not what they do, and who being unable, either by their subordinate position or by their limited knowledge, to form or express an independent opinion, have simply fallen into the ranks at the command of their leaders.

Billings had the courage to publish in 1872, the following remarks, which are applicable even now: "It frequently happens that a science, such for instance as that of geology, possesses a sort of aristocracy, consisting of the most talented, learned, active and influential of its devotees. The views of this body of men, on any difficult problem that may present itself, are usually regarded as conclusive, and are quietly adopted by the less distinguished members. Indeed, the opinion of any one of these latter, would be scarcely listened to, provided it should happen to be contrary to the established creed of the dominant party. As a general rule the leading men are right, and yet it will sometimes happen that they are wrong. One of the most remarkable instances on record, is that of the great question in American geology, relating to the age of the rocks which Dr. Emmons called *the Taconic system.* Upon this question nearly all of the leading geologists of North America arranged themselves upon one side, and, as it turned out after twenty years discussion, *on the wrong side.* Although they were wrong, yet so overwhelming was the weight of their authority, that for nearly a quarter of a century, Dr. Emmons stood almost alone. He had a few followers, but they were not men who had made themselves sufficiently conspicuous and influential to contend successfully against an opinion that was supported by all the great geologists of the continent in one compact body. In consequence of this powerful opposition, the Taconic theory gradually sank so low in reputation, that it was at length considered to be scarcely worthy of the notice of a scientific man.

"During the last thirteen years, a great revolution of opinion has occurred with regard to the views of Dr. Emmons. Although not entirely adopted, they are now considered to be, in a general way, well founded. The opposite theory, that all of those rocks which he placed in the Taconic system are above the Potsdam sandstone, instead of below it, as he maintained, is completely exploded. It is at this moment dead, more so than was the Taconic theory in 1859, the year in which the subject was reopened. As I understand it at present, some of the Taconic rocks are certainly more ancient than the Potsdam, others may be of the same age, and perhaps some of them more recent. The details are not yet worked out, and judging from the manner in which the strata are folded, broken up and thrown out of their original position by almost every kind of geological disarrangement, I venture to say that no man, at present living, will ever see a perfect map of the Taconic region.

"The theory, that the Taconic rocks belonged to the Hudson River group, was an enormous error that originated in the Geological Survey of New York, and thence found its way into the Canadian Survey."

* * "Dr. Hunt, in his published address to the American Association, in August last, indirectly associates Prof. Hall with me in the rectification of the mistake, whereas neither Prof. Hall nor Dr. Hunt contributed any aid whatever, but on the contrary, opposed the change that has been made to the utmost." ("Remarks on the Taconic controversy," in the *Canadian Nat.*, April, 1872.)

The aristocracy complained of by Billings, although not composed of the most talented and learned American geologists, has succeeded in maintaining its influential position notwithstanding their three or four dozen of "leaps in the dark." It is not that their position is as secure as it was formerly, nor that they form so compact a body as it used to be in 1860; but it is still solid enough to control in a certain degree and keep under their influence the majority of less active or less influential geologists, who do not dare yet to shake off the yoke under which they have labored so long. Their submission has become for many of them a sort of matter of course, almost a creed.

The control of the whole body of American geologists by two men, backed by half a dozen assistants, a little less conspicuous, but also strongly intrenched in official positions of some sort, is still an easy task, although it is not so easy as it was thirty-five or even four years ago. There are signs of relaxation in the old and powerful hold of the leaders. American geological questions are no more the monopoly of a privileged few; and the confidence that those leaders as a general rule are right, has received so many and repeated shocks that if it were not for the complication, the ingeniousness and perfection of the machine (as it is called in politics), the whole would have fallen into pieces, and would have been for some time "part of the past." At the present moment American geologists do not know exactly how to extricate themselves from their sad condition of ancient and total submission to unprincipled leaders, and they remain in *statu quo* fearing that a change would be for the worse; that is to say for fear of falling entirely into the hands of "geologist politicians," another breaker which has constantly menaced them during the last twenty years.

Fifty years of misrule cannot be blotted out in a few months. It will take a long time, several years at least, to obliterate the past, and bring back a right spirit of honesty and fair play, and replace American geology as it was at the time of L. Vanuxem, Samuel G. Morton, Ebenezer Emmons, Charles T. Jackson, T. Conrad, Charles Lyell and E. de Verneuil, all of them well-trained field practical geologists, excellent observers, scholars, and gentlemen.

ADVERSARIES OF THE TACONIC.—The pathetic appeal of Barrande, which I shall repeat here for it is too good, fell on an association of deaf men. He says in his letter of the 14th of August, 1860* "I can well imagine, from the position previously taken by our learned American brothers on the subject of the Taconic system, that the final solution of which I speak will not be obtained without debate, and perhaps some wounding of self-love, for some opinions that appear to be dominant must be abandoned. But experience has taught me that in such cases the most elevated minds turn always first to light, and put themselves at the head of the movement of reform."

Unhappily there was not a single "elevated mind" among the adversaries of the Taconic; all resisted in one way or another, contesting every point and granting always most ungracefully the concession of the existence and true geological position of the Primordial fauna, and of twenty-five thousand feet of fossiliferous strata below the Potsdam sandstone.

Controlling everything in American geology, the association lead by Messrs Hall and Dana know well their list of American geologists. They feel sure that having and retaining in their hands a combination of the directors of the Geological Surveys of states and provinces, and of the general government of the United States and Canada Dominions, with all the scientific periodicals under their control and in their possession, that they will be able to encounter fearlessly the small band of opponents.

From 1842 to 1860 they have easily suppressed all the obser-

*"On the Primordial fauna and the Taconic system by J. Barrande, with additional notes by J. Marcou," p. 376; and also "The Taconic System" by J. Marcou, p. 183.

vations made and published by Dr. Emmons and Jules Marcou on every point of American geology; and after the publication of the joint paper of Barrande and Marcou, they thought that it would be just as easy for them to continue their suppressions. They kept in their possession the copy of the letter of Barrande to Bronn during six months without a word of answer, hoping that the letter written in French, would be published only in Europe, in French or in German; and they did not fear its influence here. But the publication in English of that letter with two others, and remarks of my own, was the beginning of an opposition which they did not expect, and they met it by an omission of my name, showing their contempt for the collaboraator of Barrande on this side of the water. So much so, that Barrande in one of his letters to me, dated 27th March, 1861, says: "I have noticed that in the article of the *Silliman's Journal* your name has been omitted. It is a mean act of the editor."

At that time the number of geologists interested in the Taconic question was very small, only ten or twelve; two-thirds of whom were uncompromising adversaries of the Taconic system under any form, the very name being hateful. But now, and since the publication in 1885, of my paper: "The Taconic system and its position in stratigraphic geology" it is very different; the "elevated minds" hoped for by Barrande are numerous and do not fear to express openly their adhesion to Dr. Emmons' discoveries and nomenclature. The friends of the Taconic instead of being limited to only three or four, are now ten times that number, with almost all the young geologists as sympathizers and friends, while the adversaries have remained stationary, hardly being able to fill up the vacancies in their ranks caused by death or desertion.

Public opinion of American geologists.—The constant and persistent errors of the adversaries of the Taconic are not of the kind always freely allowed in all geological descriptions and nomenclature; such for instance as the union of some subdivision with one group or even a system to which it does not belong truly; but by their nature the errors affect the whole classification and nomenclature of American geology. For it is no small concern to know, (1) whether a great fauna is above or below another; (2) whether twenty-five thousand feet and more of strata are at the base of the scale of formations or belong to systems far above; (3) and whether we shall have to abandon stratigraphy and lithology to the mercy of incompetent palæontologists—incompetence proved again and again by their inability to determine fossils, blundering not only in their identification of species, but even in their determination of *genera* and families.

Never have so many errors, as well in stratigraphy as in palæontology, and even in lithology, been committed. In any country where there exists a great number of free and independent geologists—say one thousand or fifteen hundred geologists, instead of two or three hundred as we are still limited to on this continent—the maintenance of such extraordinary errors during so many years;—almost fifty years—would have been materially impossible, more especially after the interference of Barrande and Marcou. The want of a free geological "public opinion" has been taken advantage of with great and persistent alaccrity, and an easy coalition of Directors of Geological Surveys and editors of scientific periodicals, has imposed their ideas and conclusions without any sort of control, going so far, even until this day, as to omit systematically every fact and every memoir or paper which it is disagreeable for them to answer.

But free and independent geologists have begun, during the last five or six years, to be conscious of their own existence as a body, in committees, in new periodical journals, and in associations of scientific men; there are now enough to constitute a certain "public opinion," with which all the Geological Surveys and partisans associations should be obliged, before long, to reckon, and look for approbation or disapprobation of their purely scientific work. It is a long wished for *desideratum* in North America. And now, we can say with certainty that the errors of the last fifty years will not last another half of a century before they are "allowed to be and remain part of the past."

Mr. Dana's letter to von Dechen.—The cause of the Taconic system is just and has raised the interest of all geologists, the world over. My paper: "The Taconic system and its position in stratigraphic geology," 1885, and a French translation of it, chapter vi, "Taconic *versus* Cambrian and Silurian" in the *Bulletin Soc. géol.*, France, tome xii, p. 517, 1884, have been read most extensively and have put the question on such a strong basis that it can now stand all attacks. Mr. Dana to thwart as much as he could its effect, has written a letter to the Honorary President von Dechen, of the "Congrès Géologique international," at Berlin, in 1885. The volume of "Compte-rendu," issued only in September, 1888, contains that letter at pp. cxx and cxxi; it shows some new "leaps in the dark" even more startling than those we are accustomed to. For instance, he says: (1) "The Taconic rocks, or those of the Taconic range * * are of Lower Silurian age, *none* of them older than the Potsdam sandstone of the New York series. (2) There is no horizon of unconformability at any place in the series between the quartzites representing the Potsdam sandstone and the top of the Lower Silurian. These results are based on long-continued stratigraphical investigations, and also on the existence of fossils in portions of the rocks where least metamorphosed."

Against those clear and short results and conclusions, taken even in the "light" used by one of the association of the adversaries of the Taconic there is a margin of eighteen thousand feet of strata containing primordial fossils, confronting Mr. Dana. For Mr. Walcott regards the Georgia formation, fourteen thousand feet or more of strata, and the "eastern quartzites" two thousand or more feet thick, as being all below the Potsdam sandstone of the New York series. Mr. Walcott's* researches have been made in the original Taconic area of the Taconic range of mountains and of Washington county, and his views express the "result of the accuracy of his original observations."

Eighteen thousand feet of strata form a very respectable system, thicker and more important than any recorded in the general nomenclature of American geology; for according to Dr. Emmons' estimate the three superior systems above his Taconic; that is to say the Champlain system, or true Cambrian, the Silurian system and the Devonian system, all three together have only a thickness of eight thousand feet. Eighteen thousand feet of Taconic strata according to Mr. Walcott, in the

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* Mr. Walcott has not yet recognized the two most important groups of the uoper part of the Taconic: the Phillipsburgh and Pointe Lévis group and the Swanton and Citadel hill group, which he continues to refer to as the equivalent and the homotaxis of the Calciferous, Trenton and Hudson of the state of New York. It is the last hope and a forlorn hope, which will be made use of with the tenacity peculiar to the not "elevated minded" adversaries of the Taconic system.

original Taconic area, is certainly a system which is not to be despised and passed over.

So the words, "none of them (the Taconic rocks of the Taconic range) older than the Potsdam," as his result of "nearly ten years of study in the Taconic region," are anything but creditable to one calling himself an original *investigator*.

As to his "no horizon of unconformability at any place in the series between the quartzite and the top of the Lower Silurian," it is even more, if possible, in discord with the results arrived at by his associate, Mr. Walcott, who gives in the only section he has published of the original Taconic area, no less than fifteen cases of uncomformability by faults.

Not being sure that his letter to von Dechen would insure the suppression of the Taconic system, as he intended it to, Mr. Dana succeeded, after one year of hard struggle, in drawing to his side Mr. Walcott of the United States Geological Survey. Only if he has succeeded with Mr. Walcott, there is an element most essential in the question, on which he has not made the smallest impression; I refer to the rocks themselves, which remain there in the Taconic area, exposed every day to the full light of day. Nobody can monopolize them and keep many thousand square miles of Taconic rocks shut up in drawers of collections, or inclosed in the series of volumes of the *American Journal of Science.*

Opposition, omission, use of erroneous classification and nomenclature for geological maps, sections and memoirs will come to an end. The sort of revival given to the adversaries of the Taconic by the defection of Mr. Walcott will not last long. Careful surveys in the Taconic and Champlain original areas will put promptly an end to that face about (*volte-face*). The course taken by Mr. Walcott will do him more harm than any one else, and it will not affect the final result; for to try to break down and destroy the national record of American geology, is an herculean task, far above the power of any man or combination of men. It will hurt neither the Taconic system nor Dr. Emmons nor Barrande, nor Dewalque, nor Marcou. I have full hope in the future; the rights of American geology will be recognized and accepted, and the time will come when the Taconic system of Dr. Emmons will be used on all the continents, and will contribute the foundation and the first step of the geological nomenclature of the world.

Nomenclature is International.—If anything in geology is ever international, it will be certainly the classification and nomenclature of strata of the whole world. To impose a nomenclature by voting has, at last, been recognized as an impossibility, at the London Congress of 1888; thanks to the exertions and excellent objections and reasons given by Messrs. Mojsisovics and Neumayr at the Berlin Congress, and the remarks contained in my paper: "American geological classification and nomenclature" against the abuse of temporary majorities as variable as the places of meeting of the Congress. Such a solution as the acceptance and use of an harmonious, just, and well balanced general classification and nomenclature in historical geology, must come little by little, by mere conviction and a better knowledge of all the complicated elements of the question; and not by the voting of a very limited number of geologists, combined more or less with an association and a previous understanding of five or six of the most powerful and important Geological Surveys. Liberty and complete independence in science, have always been the last word on every question and it is good always to remember that very often one good observer is right against all others. In geology we have the remarkable examples of William Smith, Alexander Brongniart, de Charpentier, Louis Agassiz, Sedgwick, Barrande and also certainly of Dr. Ebenezer Emmons.

At the Berlin Congress of 1885, Mr. A. Geikie said: "the question of the classification of the Cambrian and Silurian rocks is mainly (*avant tout*) an English question." (*Compte-Rendu*, p. lxxxii.) *Loud murmurs* was the sentiment at once expressed by the majority, almost the unanimity, of the geologists present at the meeting; and ever since I have received many protests against such an exclusive assumption on the part of English geologists. I shall quote an extract from a letter of the Director of one of the most important Geological Surveys of Europe: "Comme vous avez très bien dit en combattant la manière de voix de M. Geikie, qui voulait donner une nationalité anglaise au probleme de subdivirer le Cambrien et le Silurien; cette question, comme toutes celles qui se rapportent a la géologie sont éminemment cosmopolites, et leur solution rentre dans la catégorie des affaires internationales."

The work of classification and nomenclature has begun in

Europe, and is extending gradually all over the world. In that extension America has proved to be a pioneer of the first order; and not contented with recognizing the great geological system of Europe, has succeeded in creating the most important of all the systems, because it is the first stepping stone and consequently the base of the whole structure, discovering at one stroke the Taconic system and the Primordial fauna. A discovery accepted and proclaimed as good and true by Barrande, the "father of the Primordial fauna."

The Secretary of the International Commission for the uniformity of nomenclature, professor G. Dewalque, has accepted the just claim of America, and in his two reports at Berlin in 1885, and at London in 1888, he has insisted on the recognition to America of the right of having first discovered and proposed the first and oldest system of stratified rocks containing special faunæ. M. Dewalque with great candor and justice says, "that the acceptance of the Taconic system in the general nomenclature has the advantage to give a place to American geology; at the same time that it conforms to rights of priority as they exist in natural history."

So Barrande and Dewalque, the two most competent men in Europe on questions of nomenclature, have recognized and publicly made known that to America belongs the honor of having established the Taconic system and discovered the Primordial fauna. The competence of Barrande is indisputable; as to professor Dewalque he was elected secretary of the commission for the uniformity of nomenclature at the congress of Bologna in 1881, and his numerous and remarkable memoirs and geological maps, joined to his well established reputation for independence, and the honesty of his character as a free geologist (*géologue libre*), is well established.

Murchisonian and Sedgwickian controversy.—In England the questions of priority and discoveries of the Taconic and its Primordial fauna have never been contested in any paper or periodical article.* Privately, I know that almost every English geologist admits the American claim as right and in-

* Professor Charles Lapworth, is the first English geologist, to my knowledge, who has admitted the priority of Dr. Emmons' discovery of the Olenellus fauna, in 1844. ("On the discovery of the Olenellus fauna in the Lower Cambrian rocks of Britain," *Geol. Mag.*, vol. v, November, 1888, p. 484, London.)

contestable, but they have recourse to old habits, and their pride is too much and too deeply engaged in the matter, to expect from them justice, for at least two or three generations of geologists to come. They have first to settle among themselves the question of priority in regard to the second fauna, appropriated by Murchison as an annex and subdivision of the third fauna, which has always been justly contested by Sedgwick as a special system, forming half of his too great Cambrian system. Murchisonians and Sedgwickians are as much divided as ever, and as far from a compromise as at the time of the discussion between their two great leaders.

The Geological Survey of the United Kingdom led by its present Director-general, Mr. A. Geikie, with all his influence not only in England and Wales, but also in Scotland, Ireland, India, Canada, Australia and New Zealand, maintains all the claims of Murchison to keep the second fauna as a part of the Silurian system while Cambridge University and its Woodwardian professor, actually Mr. T. MacKenny Hughes, backed by other universities, colleges and museums, cling strongly to the possession of the second fauna as belonging by right of discovery to Sedgwick, with a certain tendency, however, to accept as a compromise a new name for the second fauna; but as a matter of course a Welsh name (Ordovician); for all the rights of other nations are kept carefully in the background and completely ignored, because as Geikie says, "it is mainly an English question."

With two such factions, matters will remain *in statu quo* for several generations. One of the ablest of rising young English geologists, writes to me: "Taconic has the right of priority, still in England Cambrian has acquired a right by prescription which it would be impossible to dispute successfully; the same applies to Silurian, and I doubt if geologists here are prepared to add a new name (referring to Ordovician)."

Conclusion.—Time has always favored the Taconic system and the Primordial fauna; while on the contrary it has constantly brought up most disagreeable surprises for their adversaries. *Attendons!*

EDITORIAL COMMENT.

A New Glacial Theory.

The elaborate review of "glaciers and glacial radiants" by Dr. Claypole published in this number of the Geologist seems to point to the necessity of two conclusions that bear on the main question of the cause of the glacial epoch. 1st. The cause, whatever it was, was terrestrial rather than cosmical. There does not appear to have been that general polar ice-cover which has been supposed. The northern part of Asia, under cosmical causes, must have been as well fitted for glaciers as northern America or Europe. 2nd. The cause which exempted Asia from perpetual land-ice and not America and Europe could not have consisted in any seasonal or annual increment of average cold for the northern hemisphere but must have been due to some change in the physical relations of the continents to the climatal agents that determine the existence or absence of perpetual ice.

These reflections are prompted by a new "glacial theory" that has been proposed by Prof. Franklin R. Carpenter of the Dakota School of Mines, with which the considerations presented by Prof. Claypole are in perfect accord.

In a recent letter to one of the editors he suggests that the great Tertiary, or Quaternary eruptions of molten lava which spread over large areas in North America and Europe, had a profound effect on the climate of those continents. Such effect must have been a local elevation of temperature. The effect of such local elevation of temperature would be the certain and long continued transference of the moisture that is borne by the western and south-western winds further toward northern latitudes. Once within colder latitudes and beyond the effect of the lava sheets, this moisture would be precipitated in great volume in certain areas wherever it met with the condensing action of northern winds or higher altitudes. "The eruptions were accompanied probably by vast volumes of steam and clouds of volcanic ash. The effect of the first would be to augment the amount of precipitation, and the second, slowly settling to the north, would intercept the sun's rays and tend to increase the cold, as the ashes of Krakatoa seem to have done."

There are two lines of research that have borne evidence of the validity of this hypothesis, and Prof. Carpenter appeals to both. *First.* There is a continually increasing amount of evidence that the glacial epoch was comparatively recent. He refers to the conclusions of Prestwich, placing it not more than fifteen or twenty-five thousand years ago, terminating probably eight or ten thousand years ago; the late revised calculation of the recession of the falls of Niagara (see the Proceedings A. A. A. S. Buffalo meeting, 1886) as well as of that of the falls of St. Anthony (vol. II, Final report of the Minnesota geological survey); also the results reached by Dr. Andrews in his discussion of the "great lakes as chronometers of post-glacial time," and other data that have been employed to determine the date of the glacial epoch, conspire to bring it still nearer the present, and probably within the limit of ten thousand years.* According to Prof. Jos. LeConte the great over-flow eruptions of the western part of the United States occurred at the close of the Miocene and this seems to have been within the human period, reasoning from the human remains reported by Prof. Whitney from beneath it in California.

Second. Prof. Tyndall says: "Cold will not produce glaciers; you may have the bitterest north-east winds without a flake of snow;" and again: "It is perfectly manifest that by weakening the sun's action, either through a defect of emission or by the steeping of the entire solar system in space of a low temperature, we should be cutting off the glaciers at their source." (Heat considered as a mode of motion.) In short Tyndall has shown that in order to have a glacial epoch we need more heat, not less, that we must make our "pumping engines" do more work, to supply greater precipitation. Dr. Croll says (Climate and Time, p. 74): "Heat to produce evaporation is just as essential to the accumulation of snow and ice as cold to produce condensation." Sir John Lubbock says (Prehistoric Times): "Paradoxical as it may seem the prevailing cause of the glacial cold may be after all an elevation of the temperature of the tropics." Prof. Jos. Henry in a communication to the Washington *Philosophical Society* (Bulletins, vol. 2, pp. 35 and 37—1875 to 1880) held a similar view, and applied it to the existence of "extensive

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*Compare also, "The life-history of Niagara." by Dr. Julius Pohlman, in the *Am. Inst. Mining Engineers.*

outbursts of submarine volcanoes in equatorial regions sending out immense volumes of steam," suggesting a hypothesis similar to that of Prof. Carpenter. Mr. J. E. Clayton presented a paper to the California *Academy of Sciences*, (Proceedings, vol. E, pages 123-131) advocating a similar view, in which he calls attention to the sheets in question. Mr. R. C. Hills in a recent communication to the Colorado *Scientlfic Society* has mentioned the probable influence of a certain overflow in Colorado in expanding a Tertiary lake which he describes. None of these, however, seem to have applied the resultant heat as a primary agent in the transference of moisture in the manner required by the theory of Prof. Carpenter.

"A sheet of lava hundreds of miles long, hundreds of miles broad and thousands of feet thick, like that of the western part of the United States, was an 'engine' of immense power. This sheet was only one of many. They would cause the transfer of a large amount of the precipitation, which prior to their eruption fell in middle latitudes, to the north. The moisture-laden air would lose none of its load in passing over these sheets —nay would be additionally laden by the temporary elevation of temperature that it would experience. * * * An ice-sheet once established, acting as a powerful condenser, would exist for ages, and would disappear much more slowly than it was formed. The heated outpourings, occurring at intervals, would cause the ice-sheets to advance and retreat, thus forming the interglacial periods." Prof. Carpenter will elucidate his theory and enforce it with facts, and calculations on the climatal effects of these lava sheets, in a future number of the GEOLOGIST.

GEOLOGICAL SOCIETY OF AMERICA.

On the twenty-seventh of December last a national geological organization was effected at Ithaca, New York. This is a consummation which has been contemplated for several years. Efforts have been initiated on different occasions for its accomplishment, and though they failed temporarily, it was generally admitted by American geologists that an independent organization would necessarily arise in the fullness of time.

The first movement was made by the geologists assembled at the meeting of the American Association at Cincinnati, in 1881. A committee was appointed to consider the advisability of the project, and take requisite preparatory steps. Professor N. H. Winchell was chairman and professor C. H. Hitchcock, secretary of the committee, but no published records preserve the names of the other members. Circulars were issued by the committee, and 126 answers were received, all but two of which favored the organization of a separate society. The committee reported to Section E. at the Montreal meeting of the Association, in 1882. It was there voted expedient to establish a geological magazine. A proposed constitution for a society was presented, discussed and laid on the table for future consideration. Some hesitation was manifest on the part of some of the older members who had not participated in the earlier proceedings. It was suggested on one hand, that Section E. of the Association offered all the advantages of a geological society; and on the other, it was alleged that the requirements of Canadian geologists were met by the recently organized Royal Society of Canada. It was also suggested that the organization of a separate society might conflict with the interests of the American Association. The whole subject, therefore, was laid over to a subsequent occasion. At the Minneapolis meeting of the Association, in 1883, the consideration of the magazine and the society was resumed; but little was accomplished beyond the appointment of a committee to confer with the Mineralogical and Geological Section of the Philadelphia Academy of Natural Sciences. For various reasons, the subject was not discussed at the Philadelphia meeting of the Association in 1884, the Ann Arbor meeting in 1885, or the Buffalo meeting in 1886. Meantime, the necessity of a separate geological organization became more apparent; and some who were at first indifferent, began to express a desire that further steps be taken. At the New York meeting in 1887, no action was taken by Section E.; but the American Committee of the International Congress, which existed under the sanction of the American Association, adopted the following resolution: "That the American Committee of the International Congress will approve of a call for the meeting of an American Geological Congress, whose object shall be the discussion of important geological questions."

In accordance with the judgment of American geologists present at the Montreal meeting, that it was "expedient to establish a geological magazine," an association of seven geologists, representing different portions of the country, began on the first of January, 1888, the publication of "The American Geologist," a monthly periodical, with editorial management fixed provisionally at Minneapolis. In the June number of this periodical appeared from the Chairman and Secretary of the committee which had been constituted at Cincinnati in 1881, a call "upon all American geologists" to assemble at Cleveland on the day preceding the opening of the meeting of the American Association, for the purpose of organizing, if deemed expedient, a national geological society. The basis of organization suggested in this circular restricted membership in the contemplated society to the members and fellows of the American Association, and devolved on the Association the election of the president and secretary of the new society. It was also contemplated that the permission of the Association should be asked for Section E. "to hold meetings at such time and place as they may desire."

Promptly on August 14, 1888, in pursuance of the published call, the geologists in attendance at Cleveland assembled for the purpose of discussing the organization of a national society. Alexander Winchell was chosen chairman, and Julius Pohlman secretary. It was at once apparent that interest in the proposed organization amounted to zeal. It was unanimously resolved that an American Geological Society was now desirable. As to the relation which it should sustain to Section E., of the American Association, different views were expressed; but they were speedily harmonized. It had been often urged as an objection to the projected society, that it might impair attendance at the meetings of the American Association. With a view to avoiding all conflict, it was suggested on one hand that the membership of the society should be coextensive with that of Section E., and on the other, that its officers should be the same as those chosen for Section E. Some, with more zeal for the interests of geology than for those of the Association, advocated complete independence. Both ends were reached by a compromise which provided that the "original members" of the geological society must be active workers or teachers of geology, who were either members or fellows of the Association; but, that after January 1, 1889, other persons would be eligible. The compromise further provided that a summer meeting should always be held at the same time and place as the meeting of the Association; but the business meeting of the society was to be during the winter holidays. The meeting pronounced in favor of publications, and, in this view, an annual assessment of ten dollars. A committee was appointed to draft a constitution to be presented at an adjourned meeting on the following day. The committee consisted of Alexander Winchell of Ann Arbor, chairman, J. J. Stevenson of New York, secretary, Edward Orton of Columbus, Charles H. Hitchcock of Hanover and J. R. Proctor of Frankfort.

At the adjourned meeting, August 15, the committee presented the form of a provisional constitution which, with slight changes, was adopted. As to membership, meetings and fees, it embodied the instructions of the earlier meeting; and beyond this, contained only the usual provisions for name, officers and amendments, and a clause providing for going into effect. The same committee was continued, with instructions to give the requisite attention to the completion of the organization.

It is noticeable that the action at Cleveland was not undertaken by Section E., but by American geologists in pursuance of a call addressed to "all American geologists." Nor did the plan of organization contemplate restricting the society to persons connected with the Association. It is thus in no way subordinated to Section E., nor to the Association, though it proposes to hold an annual meeting conjointly with the Association. It possesses complete autonomy of its own, and requires no sanction from the Association in its attempt to represent the interests of American geology.

Thirty-seven eligible persons subscribed to the constitution before the adjournment of the Association. Immediately after adjournment, the Committee of Organization resumed its efforts, and by November 1, more than one hundred names had been obtained, and the first meeting was promptly called to assemble at Ithaca, under the hospitality of the Cornell University. An informal conference was held on the afternoon and evening of December 26, and at 10 a. m. December 27, the formal meeting convened in the hall of Sage College. The attendance was small, but it was well understood that the attendance was not an exponent of the deep and general interest felt in the movement. The meeting was called to order and presided over by the chairman of the Organizing Committee. In a preliminary statement made by the committee, it appeared that 137 persons had given their adhesion to the Society, of whom 70 were fellows of the American Association, 45 were members, and 22 were not connected with the Association. Of the 115 "original fellows," 89 had paid their fees, and during the progress of the day, this number was raised to 102. On a canvass of the ballots returned through the mails, to the Organizing Committee, it appeared that 22 others had been eleoted, who by the constitution, would become active fellows after January 1, 1889.

When the meeting proceeded to the election of officers, it was agreed that candidates standing highest on the nominating ballots returned through the mails, should constitute a ticket. On duly balloting, the board of officers was found elected as follows:

James Hall, Albany, President.
James D. Dana, New Haven, } Vice Presidents.
Alexander Winchell, Ann Arbor, } Vice Presidents.
J. J. Stevenson, New York, Secretary.
H. S. Williams, Ithaca, Treasurer.
J. W. Powell, Washington, } Fellows of the Council.
J. S. Newberry, New York, } Fellows of the Council.
C. H. Hitchcock, Hanover, } Fellows of the Council.

The foregoing board constitutes the Council of the society.

A committee was chosen by ballot for reporting a revision of the constitution. This consists of Alexander Wincnell, H. S. Williams, J. J. Stevenson, H. L. Fairchild and C. H. Hitchcock. The subject of publication is one of the most important questions to be considered by the Council of the society; and an Advisory Committee was chosen consisting of J. L. LeConte of Berkeley, California, W. J. McGee of Washington, I. C. White of Morgantown, West Virginia, N. H. Winchell of Minneapolis, and W. M. Davis of Cambridge.

The name of the society was discussed, and though fixed by the constitution for the present, as American Geological Society, it was generally agreed that a preferable title would be "The Geological Society of America." It was also formally agreed that fellowship in the society should be indicated by the initials "F. G. S. A.," and it was recommended that this title be employed on all suitable occasions.

It was finally voted that the secretary should prepare a report of the meeting to be printed in pamphlet form for distribution to the fellows and others; but it was distinctly provided that this should not stand as No. 1 of the recognized publications of the society. The form and style of publication remain to be fixed by the Council and Advisory Committee.

At the close of the business the chairman called upon the president elect to address the society. Professor Hall, the veteran American geologist, still in the possession of abundant vigor, ascended the platform, and in an address of thirty minutes, tendered the society thanks, congratulations, counsel and a reference to historic events stretching over a period of fifty years. His choice as first president of the society he considered the greatest honor of his life. The organization of a distinct geological society was something he had long desired and long expected. It was the working geologists of America who formed that first nucleus around which had grown up the bulky organization of the American Association. For many years the Association proved of great service to geology, but he had felt for some years past that younger men were becoming so numerous that the day had arrived for the pioneers to stand back. At the same time the popular character of the Association had rendered it somewhat an undesirable arena in which to introduce the results of the profounder labors of geological investigation. He counseled harmony and mutual forbearance. He understood what provocations sometimes arise. He had sometimes himself yielded to them, and had always thereafter suffered regrets. New circumstances present ever new provocations; but he hoped every American geologist would be mentally prepared to pursue a course of justice, and if need be, of forbearance and conciliation, in order that peace and harmony may reign throughout our ranks. The President's remarks were exceedingly well received, and produced an excellent impression.

In the evening a reunion was held at the private residence of Prof. H. S. Williams, where a brilliant and accomplished hostess, with her aids, rounded off delightfully the graver occupations of the day.

The Geological Society of America begins its existence strong in numbers, ability and finances. It has enlisted the adhesion of almost every working geologist of the United States; and none have found entrance who are unworthy. This body will hereafter speak for American geology; and it will speak without asking the assent of a heterogeneous organization which cannot know what is best for geological interests. It is earnestly to be hoped, however, that in arriving at its official utterances, the counsels of its first president will be studiously heeded. This result will be attained if each fellow forbears to push, against the will of a majority, ends in which he feels a special, or perhaps a personal interest; and if the minority finding itself such, will yield gracefully to the sentiment of the superior number. *Pax nobiscum!*

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Useful Minerals of the United States. By ALBERT WILLIAMS, JR. This paper, embracing pages 688 to 812, is an abstract from "*Mineral Resources of the United States, Calendar Year 1887.*"

Under the head of useful minerals, etc., is a partial list of ores, minerals, and mineral substances of industrial importance, arranged alphabetically by states and territories.

Of the facts presented in this report, among the most encouraging in connection with the settlement and development of our Northwestern States and Territories, is the occurrence of the extensive coal deposits of Colorado, Dakota, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming. The coal is chiefly of Cretaceous or post-Cretaceous (Laramie Group) age, and appears as lignite, bituminous coal, semi-bituminous coal, or anthracite. The bituminous and anthracite coals of the west are, in many cases, equal in grade to the corresponding varieties from the Carboniferous series of Pennsylvania. Few who have not seen them can have any conception of the extent and value of these magnificent coal deposits.

The Structure and Development of the Visual Area in the Trilobite, Phacops rana Green. By JOHN M. CLARKE. [Reprinted from the Journal of Morphology, vol. ii., No. 2, November, 1888.] Barrande, Walcott, Packard and a number of others whose names are familiar to geologists, have devoted attention to t e elucidation of certain peculiarities of structure or development among tribolites. The efforts of these observers have been attended with remarkable, and often with unexpected success. The author of the paper here reviewed devotes his attention chiefly to one species, and to one feature—namely: the development of the visual area. Mr. Clarke divides tribolites into two groups, according to the character of the visual area. The first includes those having the visual area covered by a smooth, continuous, epithebial film or cornea through which the lenses of the ommatidia are visible by translucence; the second, those in which the cornea is transected by the protrusion of the sclera. The author had at command some thousands of specimens for study. For convenience he regards the lenses of the eye as arranged in oblique rows, and points out that the number of these rows is variable, the number of lenses in the visual surface of each eye is variable, the number of lenses in successive rows is variable, a definite relation exists between the number of lenses of the eyes and the size (*i. e.* age) of the animal, the number of lenses increases from youth to maturity and decreases from maturity to senility.

The unexpected fact of decrease in the number of lenses in old age is explained "either by the gradual envelopment of the lenses of the upper margin by the sclera and palpebrum, and their entire concealment in the substance of the latter, unless it is possible that atrophy of the ommatidial nerve branches and concomitant reabsorption takes place with advancing old age."

We quote the author's conclusion:

"The study of the eye of *Phacops rana*, as here presented, allows the statement of the following points:

1. The schizocroal eyes (such as occur in Phacops and its allies) of the trilobites are aggregated and not compound eyes. The visual organs of *Harpes* may prove to be of similar character.

2. The scleral portion of the visual surface is of the same structure as the test, and is a direct continuation of it.

3. No evidence appears of any continuous corneal layer covering the entire surface.

4. The corneal lenses are wholly discrete from the epidermis, but are of epidermal origin. In the addition of new lenses to the visual surface, they appear to arise from a thinning of both surfaces of the integument.

5. The corneal lenses were hollow or filled with some matter not homogeneous with the cornea itself.

6. The corneal lenses, and, therefore, the ommatidia, are added to the visual surface with advancing age until the mature growth of the individual is attained; thereafter they diminish in number, with increasing senility.

7. The addition of corneal lenses occurs regularly at the extremities of the diagonal rows.

8. No evidence is preserved of crystalline cones in the ommatidial cavities, though they may have been removed in the decomposition of the soft parts of the eye."

Geological Survey of the State of New York, Palæontology. Vol. VII. By JAMES HALL, assisted by JOHN M. CLARKE. This volume worthily maintains the reputation of the splendid series of which it forms a part. It is devoted to the description and illustration of the trilobites and other crustacea of the Upper Helderberg, Hamilton, Portage, Chemung and Catskill groups. There are 222 pages of descriptive text, preceded by LXIV pages devoted chiefly to a synopsis of genera. A carefully compiled synonymy of each genus is also a valuable feature. There are 127 Devonian species distributed among 28 genera described in the volume, and in addition we have given descriptions of 17 species of crustacea not Devonian.

Geological Survey of the State of New York, Palæontology. Vol. V., Part ii. *Supplement.* By JAMES HALL. This supplement is bound in with vol. vii., noticed above. It contains descriptions and illustrations of Pteropoda, Cephalopoda and Annellida. The Annellida were not embraced in the original plan of volume v. They are here introduced for the sake of comparing typical forms of *Tentaculites* with certain species, chiefly from the Hudson River group, that have from time to time been referred to the genus *Tentaculites* and with other more or less closely related forms. The large amount of material in the hands of the author afforded unusual facilities for making such comparisons.

The result of the comparison has been to lead Professor Hall to the conclusion that the Lower Silurian *Tentaculites* are not *Tentaculites* at all. Moreover, many of the genera and species that palæontologists have been laboring industriously to establish, emerge from the investigation with scant claim for further recognition. For example, the author claims that the material in his possession demonstrates that the following forms are simply different stages of development of what appears to be *a single species of the genus* CORNULITES! *Spirorbis cincinnatiensis, Ortonia minor, O. conica, Conchicolites corrugatus, Tentaculites sterlingensis, T. richmondensis, Cornulites flexuosus, C. immaturus, C. incurvus, C. distans, C. clintoni, C. arcuatus, C. proprius, C. bellistriatus, C. crysalis, C. cingulatus and C. tribulus.*

The larger part of the supplement is devoted to Cephalopoda. Twenty species, not illustrated in vol. v., part ii., are here described, together with a number previously described, but here described and figured from new material illustrating features additional to those before illustrated.

On the attachment of Platyceras to Palæocrinoids, and its Effects in Modifying the Form of the Shell. By CHARLES R. KEYES. This paper, embracing fifteen pages of descriptive matter, illustrated by one plate, was read before the American Phosophical Society October 19, 1888. The fact that Platycerata occur attached to the bodies of crinoids has long been known. The fact that they always occur in a particular way, with the anterior part of the aperture covering the ventral opening of the crinoid, is one of comparatively recent recognition. The situation of the anal opening in crinoids is such that the attached shell is often embraced by the arms, and this led the earlier observers to conclude that the crinoids fed on the gasteropods, and that death sometimes overtook the predaceous echinoderms while they were in the very act of devouring their victims. Moreover, the earlier palæontologists regarded the ventral opening as the mouth of the crinoid, and so far as the position of Platyceras with reference to this opening was noted at all, it only tended to confirm the belief in the carnivorous habits of crinoids. A history of recorded observations on the relations of Platycerata to crinoids is given, and this is followed by an account of the author's observations, made on an extensive series of illustrative examples in the magnificent crinoid collection of Wachsmuth and Springer.

The observations of Keyes support the views entertained by a number of modern palæontologists, to the effect: 1. That Platyceras, like Capulus, was sedentary, attaching itself to foreign bodies and remaining fixed during life. 2. That the association of Platyceras to the crinoid to which it is found attached was permanent, not temporary. 3. That the Platyceras attached to the body of a crinoid fed upon excrementitious matter.

One of the new facts, and one of great interest, developed by the observations of Keyes, is that the anterior border of the aperture of an attached Platyceras retained constantly the same portion, and that as the aperture enlarged in the process of growth the posterior border was successively moved further and further back. Lines drawn on the vault of the crinoid indicating the outlines of the aperture of the commensal Platyceras at different stages of growth, are eccentric and all pass through the point which makes the anterior border. This anal aperture of the crinoid lines within the eccentric outlines and near the point is common to all. By carefully removing the Platyceras it is found in some instances that the size and position of the aperture of the mollusk at different stages of growth are indicated by more or less perfectly defined grooves on the ventral plates of the crinoid. The significance of the facts here stated is manifest, the mouth of the mollusk at all periods of growth was placed directly over the anal aperture of the host. There are no indications that the presence of Platyceras interfered in any way with the convenience or success of the crinoid.

The American Anthropologist, published at Washington, born the same year and month as the GEOLOGIST, begins its second year vigorously. It includes, but is not confined to, the transactions of the Anthropological Society of Washington, and aims to be a medium of communication between students in all branches of anthropologic science. The managing editor is Mr. H. W. Henshaw, Washington.

In the January number of the London Geological Magazine, Dr. Traquair discusses the two species *Homosteus* Asmuss, and *Coccosteus* Agassiz. The utter confusion in which the nomenclature of some of our fossil fishes is now placed is well shown in his introductory remarks. He states that in 1840 Eichwald founded the genus *Asterolepis* for some Russian Devonian fossils. Soon afterwards Agassiz named these same specimens *Chelonichthys*. This name he withdrew and adopted *Asterolepis*, erroneously placing in this genus certain bones and plates from Dorpat of which he had received only casts. Hugh Miller following Agassiz consequently applied the name *Asterolepis* to the massive plates which he received from Robert Dick of Thurso, though these plates had no affinity to Eichwald's *Asterolepis*. The name *Asterolepis* has therefore two meanings, that of its author and that of Agassiz.

In 1856 Asmuss described the Dorpat fossils and founded the two genera *Homosteus* and *Heterosteus*. "In the former of these is clearly to be recognized Hugh Miller's so-called '*Asterolepis*' of Stromness." Pander subsequently changed Hugh Miller's name to *Homosteus*. This change has been adopted on the continent of Europe but not in Britain.

Dr. Traquair goes on to show how Agassiz' work led Hugh Miller into other mistakes so that he attributed to his Asterolepis "the teeth of *Dendrodus* and the scales of *Glyptolepis*.

Pander classified *Homosteus* next to *Coccosteus* and rightly considered as its medio-dorsal plate the "hyoid" of Miller. A specimen found shortly afterwards and now in the Museum of Science and Art at Edinburgh conclusively proved that he was right.

Dr. Traquair then discusses at great length the structure of *Coccosteus* and *Homosteus* demonstrating their close relationship and concludes by naming the species of which he gives a figure, H. milleri.

Prof. T. McK. Hughes, of Cambridge, records the discovery of other fossils in the Lower Cambrian rocks of North Wales, in the great slate quarries at Penrhyn. They are very imperfect but appear to be the casts of the carapace of a trilobite of nearly the same size and outline as *Conocoryphe viola*, the species recorded in 1888 from these slates.

Prof. Hughes enters into a consideration of the possible causes which led to the preservation of fossils in a single spot or in a few isolated spots in so vast a mass of unfossiliferous slate. For it should be mentioned that although these quarries have been worked for many years and are among the most extensive in the British Isles yet no fossils had been previously reported from any part of them.

He thinks that the slates before metamorphism may have been affected by a "fault and fold" disturbance whereby certain parts may have been caught and preserved from the intense pressure to which the rest of the rock was exposed and which has produced its perfect slaty cleavage and in so uniform a mass has totally effaced all pre-existing structure.

Mr. Harker calls attention to the importance of pressure considered by itself as an important factor in metamorphism. "Many geologists" he says "require of mechanical force nothing except the liberation of heat by the crushing of the rock-masses." But he insists that pressure alone is of great importance by its direct effects on chemical action even unaided by induced heat. He divides metamorphism accordingly into thermo-metamorphism and dynamo-metamorphism, and points out four sets of conditions which may be expected to govern the process in different places. These are

1. Low temperature and low pressure.
2. High temperature and low pressure.
3. Low temperature and high pressure.
4. High temperature and high pressure.

He points out that a distinction between these different conditions may explain the frequent occurrence of certain minerals such as andalusite, garnet and idocrase with stratified rocks that have been altered at high temperatures, while other changes accompany the metamorphism of similar rocks at low temperatures unless the conversion of pyroxene into amphibole, of plagioclase into saussurite, of potash-feldspar into white mica and quartz, and of titaniferous iron ore into sphene.

As to the action of water in the process he regards the water as itself one of the minerals involved, and remarks that its increased solvent power under increased pressure must lead to solution where the pressure is greater and deposition where it is less.

Mittheilungen aus dem mineralogishen Institut der Univerisität Kiel. Band 1, Heft 1. Dr. J. Lehmann issues the first of a proposed series of publications by the Mineralogical Institute of the University. Among the articles included in the first issue is one entitled "Ueber die eruptive Natur gewisser Gneisse sowie des Granulits im sächsischen Mittelgebirge," by E. Danzig, of Rochlitz, Saxony. After referring to the different opinions which have been held by geologists concerning the nature of the Saxony Mittelgebirge (Naumann, Stelzner, Credner, Dathe and Lehmann) he gives his own observations on the granite dykes of different kinds in the granulyte, and on the gneiss-granite in the granulyte and gneiss-mica schist. Many of these observations, as well as the figures to illustrate them, are strikingly similar to observations made by Mr. A. C. Lawson in the region of the Lake of the Woods and by the Minnesota geological survey, illustrated in the fifteenth report of that survey. Following is a brief statement of his conclusions:

1. The granites of our mountains belong, as was first proved by J. Lehmann, to a single geological formation, though perhaps they originated periodically. The separation of bedded granite (granite gneiss) and secretion granite (believed to have been formed by lateral secretion) from the granites in the granulyte, which former had already been recognized as indubitably eruptive, is not justified by the knowledge obtained.

2. As far as the observations extend the gne ssoid rocks of the granulyte mountains of Saxony, wherever they cannot be designated simply as gneiss, must be considered in the main as mixtures of granite material with that which was originally sedimentary; but also partly as schistose beds produced through metamorphism due to dislocations in the granulyte.

3. In spite of the bedded structure displayed in members of the granulyte formation, and notwithstanding its differentiation into beds which are variously composed, chemically and mineralogically, which are apparently stratigraphically equivalent, it cannot be considered as a sedimentary formation, nor one which has resulted from metamorphism of such a formation. The light colored granulyte seems much more eruptive since it contains the characteristic inclusions, and sends out branches into the surrounding rock. The pyroxene granites are not genetically similar to the other kinds of granulyte, but probably represent altered inclusions in the granulyte magma.

The author did not undertake the consideration of all the rocks of the granulyte mountains. The garnet-serpentines, whose close relation to the pyroxene granite has been recognized, will be the subject of a later paper. On the other hand the facts concerning the gabbros and the bronzite serpentine do not appear to furnish sufficient data to answer the question of the origin of this rock if we set aside the description by Dr. Lehmann of the metamorphism of the gabbros brought about by mechanical forces. The hornblende schists in the mica schists and phyllytes, as well as the green schists around Hainch, may perhaps, from the results obtained elsewhere, be considered properly to be diabase or dioryte metamorphosed, which were erupted before the granitic rocks (including the granulytes)—especially since in the Hartz mountains a diabase belongs with the pre-granitic eruption.

It is very remarkable that Naumann's hypothesis of the origin of the granulyte mountains has been confirmed to a far greater extent than was at first expected, notwithstanding some necessary corrections and additions. The same hypothesis approached very near the truth in regard to the gneisses in the granulyte, inasmuch as this must lie at the base of a supposed schist broken through by granulyte. Such schist, or gneiss, may have been penetrated by granitic masses either before or after its enclosure in the granulyte.

It would be of great value to prosecute an examination into the origin of certain crystalline schists in other Archæan regions, especially in the neighboring Erz mountains. Perhaps many will be found to be eruptive which are now taken to be portions of the oldest sedimentary rocks. Especially would it be well to investigate the "red gneisses," with a view to ascertaining whether they do not also present features which may prove them to be eruptive in the same manner as those from Böhrigen and Rosswein. Their transition into granite appears to give some foundation for such a prediction.

PERSONAL AND SCIENTIFIC NEWS.

PROF. J. W. SPENCER WAS RECENTLY APPOINTED state geologist of Georgia.

DR. J. S. KINGSLEY, EDITOR OF THE AMERICAN NATURALIST, and too well known in scientific circles to need farther introduction, has been elected to the chair of Agriculture and Biology in the University of Nebraska.

DR. CHARLES A. SCHAEFFER, PRESIDENT OF THE STATE UNIVERSITY OF IOWA, is now at work on analyses of some clays and chalky beds that occur in the Cretaceous deposits of Woodbury county, with a view to ascertaining their availability as materials for the manufacture of Portland cement. The indications are that with proper handling a superior quality of cement could be made from them, and the cost would be such as to yield a fair profit.

PROF. W. H. BENEDICT, OF PORT HENRY, N. Y., has made an important discovery in the Potsdam sandstone near that place. He has found a layer marked by tracks and trails of a crustacean inhabiting the ocean of the Potsdam era. They are in connection with fine ripple-marking, making a most excellent appearance. A quantity of the stone has been quarried and will be displayed in the state museum.

MR. OTTO L. SYRSKI, who was mentioned in some of the early numbers of the *Geologist*, now confined in the Ohio penitentiary for theft of scientific books and apparatus, was recently visited by Prof. E. T. Nelson, of Delaware, O. This gentleman, who was formerly "deaf and dumb," has recovered his voice, and has made a fine record in the penitentiary, where he teaches the night-school.

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CONGLOMERATES ENCLOSED IN GNEISSIC TERRANES.

By Alexander Winchell.

The region which is the special subject of the present article lies on and near the International boundary, northwest of Lake Superior. It is embraced within the great Archæan area of the North, between the parallels of 47°30′ and 48°30′ north latitude, and the meridians of 90° and 91°30′ west longitude. The surface is occupied by gneisses, crystalline schists and earthy schists, all standing quite conformably, in an attitude nearly vertical, and trending east-northeast. Occasionally, over limited areas, the gneisses appear destitute of bedding or foliation, and for this reason, and also the unimportance, for geological purposes, of the distinction between gneisses and ordinary massive granites and syenites, I have frequently recorded as "granite," the crystalline masses underlying the crystalline schists. For similar reasons, usage has affixed the name "granite" to rocks in which the dark mineral constituent is hornblendic, as well as to those in which it is micacic. With this understanding, it may be stated that the region here considered extends into and embraces portions of three granitic regions which superficially appear to be wholly separated from each other by earthy schists. The most easterly I have elsewhere described as the "Saganaga granite;" the most westerly, as the "Basswood granite," and the more southerly, as the "White Iron granite"—these taking their names from the lakes whose shores they occupy.*

Of the lithological characters of these granites it is not proposed to speak particularly at present, nor of their structural and mineralogical relations to the crystalline and the earthy schists which lie along their borders. It may have a bearing however, on the object of the present article, to state that the Saganaga gneiss holds hornblende for its dominant dark mineral. The same is true of the White Iron gneiss, though augite sometimes usurps the place. The Basswood gneiss is chiefly micaceous, and the mica ranges from muscovite to biotite and hydromica. Not unfrequently however, a hornblendic constituent intervenes, and this is sometimes replaced by a viriditic mineral. A chloritic constituent often appears in all these gneisses, more or less blended with the feldspars. As usual the feldspar is chiefly orthoclase; but generally, a small proportion of plagioclase can be seen. In the Saganaga gneiss the quartz individuals are generally of very large size.

It will have a bearing also, on the interpretation of the phenomena which I propose to describe to state that between the gneisses and crystalline schists no structural discontinuity anywhere appears—a gradual transition in mineralogical and stratigraphical characters being everywhere apparent.† Nor is there any abrupt break between the crystalline schists and the earthy or semi-crystalline schists; and consequently, no such phenomenon as a contact between crystalline and uncrystalline terranes is known to occur. Nor do I find any unconformability between the proper and very distinct bedding of the earthy schists and the foliation of the crystalline schists and gneisses. It could not be expected under these circumstances, that any of the phenomena of local metamorphism should occur along the zone of gradual transition from the crystalline rocks to the uncrystalline.

**Sixteenth Annual Report Minn. Geol. and Nat. Hist. Surv.*, pp. 330–334. These three gneissic or granitic areas appear to be discriminated by Irving in his "Preliminary Geological Map of the Northwest," in the Fifth Annual Report, U. S. Geol. Surv., p. 181.

† These facts have been fully set forth in the XVth and XVIth Annual Reports of the *Geol. and Nat. Hist. Surv. of Minn.*, to which reference may be made.

Throughout the whole extent of these three granitic masses, as far as explored, *rounded pebbles* are found disseminated. They are by no means uniformly distributed; and in the Basswood and White Iron granites they are infrequent. They are however, mentioned in my reports.* The Saganaga granite (syenite, gneiss) is more numerously supplied with them. In coasting along the shores of West Seagull, Seagull, Red-rock, Granite and Saganaga lakes, one or more pebbles may generally be seen at intervals of one or two rods. On the north shore of Seagull lake they become rather abundant.† The pebbles here, as elsewhere, are distinctly limited and fully rounded, presenting the ordinary appearance of shore pebbles, and generally of a dark color. In size they range mostly from two to six inches in diameter. They are sometimes so firmly imbedded in the gneiss as not to be separable from it; at other times, they may be removed. In mineral character, many of the pebbles appear diabasic, chloritic and augitic. Some of them are syenitic, and even approach the Saganaga syenite in character. I found pebbles of this which themselves embraced fine granulite, chlorite rock, chlorite schist and copper carbonate. Other syenitic pebbles were fine-grained and unlike the Saganaga variety; and these in other cases, were stratified. Besides worn fragments, the outlines of large angular masses may be traced in the midst of the usual gneiss. Some of them are a fine-grained granulite with a very little hornblende. They attain a length in some cases of several feet, with a width of a foot or less. In other cases they appear like sheets three or four inches thick. They are all firmly united to the common mass of gneiss.

At another locality on the shore of a large island in the same lake, a real conglomerate occurs. This is chlorito-graywackenitic, and somewhat resembles the remarkable Ogishke-conglomerate, but it is not the same. The groundmass holding the pebbles is not of a syenitic character, but rather graywacke-like, though the whole is surrounded by the prevailing syenite of the region.

A conglomerate is also reported to me from an inland position on the northwest of West Seagull lake.

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* XVth Ann. Rep. Geol. Minn., pp. 79, 85, 88, 105, 113. In other lakes, XVIth Ann. Rep. Geol. Minn., pp. 227, 229, 241.

† See details of facts in *XVIth Ann. Rep. Minn.*, p. 298.

The most extraordinary occurrence of all is found on a small island which I named Wonder island, near the south-east shore of Saganaga lake, and supposed to be located a short distance beyond the international boundary.* This island lies far within the gneissic region. The contiguous main shores are characteristically gneissic. On the south I have traced the gneissic terrane eight miles, to its culmination in the Giant's range and its southern limit near Gunflint lake; on the southwest, nearly to Frog-rock lake, twelve miles; on the west, to Oak lake, twelve miles; on the north, to the north shore of Saganaga lake, six miles. The point is therefore several miles from any boundary of the great mass of the Saganaga gneiss.

At this place rounded pebbles are accumulated in such abundance as to constitute a real conglomerate. Two patches are exposed to view and disappear beneath the level of the water. One of the patches as far as exposed, is four feet wide, and the other three. The breadth of the intervening gneiss is about ten feet. In neither are the pebbles generally in contact. In one area, the conglomeritic condition disappears gradually around the margin; in the other, somewhat abruptly—except that a single pebble is quite separate. The intervals between the pebbles are filled with the common gneissic material in full possession of its usual characters. The pebbles are of all sizes up to four or five inches in diameter; and they are generally dark green in color. Mineralogically, as far as I could judge in the field, they consist principally of the following species and varieties: Lamellar augite in coarse agglomerations; lamellar augite in fine agglomerations, with a minute quantity of light feldspar disseminated in strings and grains; lamellar augite with conspicuous grains of feldspar; a mixture of augite, feldspar and epidote; a lamellar mineral soft as talc or chlorite; a pale green augite, inclosing lamellar augite; augite hyposyenite or perhaps diorite; greenish transparent augite in slender prisms; lamellar augite in coarse agglomerations, but of a pale green color. There were no pebbles of syenite, none of quartzite, none of jasper, none of any sedimentary rock. In one instance, I saw two or three large grains of quartz imbedded in a large pebble

* The location is mapped on page 218 of the *XVIth Ann. Rep. Minn. Geol. Surv.*, and the facts are given in detail on the succeeding pages.

composed of lamellar augite and feldspar. This conglomerate therefore, differs from the Ogishke conglomerate of north-eastern Minnesota both in the mineral character of the pebbles and in the nature of the groundmass.

Though the list of pebbles differs somewhat from that cited from Seagull lake, the general resemblance is noteworthy. The dark pebbles elsewhere scattered through the gneiss of Saganaga lake are also very similar in character; and the evidence is quite clear that the pebble-supply of all parts of the region has had a common origin.

The presence of pebbles so widely disseminated through the gneiss reveals this great Laurentian terrane in quite a new aspect. This character seems especially adapted to awaken reflections in the minds of those who hold to the theory of a purely igneous history for the crystalline rock-masses. No other origin for rounded pebbles possesses any plausibility in comparison with shore action. Such pebbles are everywhere regarded as evidence of fragmental accumulation. The great Ogishke conglomerate, whose borders are not over fifteen miles distant, is stocked with similar pebbles; and no one could entertain other theory respecting them than that of slow fashioning along an ancient shore. The *prima facie* evidence in reference to the Saganaga pebbles is entirely in favor of a similar origin. I shall hold it as incontestable that these pebbles are due to attrition along a shore.

I do not forget the dictum of Von Buch in reference to the eruptive origin of certain conglomerates,* nor the application made of the principle by the founders of the "Azoic System," to the well known conglomerates of the cupriferous region of Kewenaw Point.† But the pebbles in the latter case are associated with amygdaloids of unquestionably eruptive origin; and moreover, they are alleged to consist chiefly of rocky material of the same nature. In both respects the Saganaga pebbles differ. They are not pebbles of the contiguous rock, and it is inconceivable that they have become rounded by friction during projection through it while in a molten state, or by contact

*Von Buch, *Geognostische Briefe*, pp. 75–82.

†Foster and Whitney, *Report on the Lake Superior Land District*, 1850, pp. 69-200; and *Amer. Jour. Sci.*, II, xvii, 1854, pp. 11-38, 181-194. The same view was advanced by Houghton in 1841.

with fissure walls existing in it after solidification. The late Prof. Irving however, may be regarded as dissipating finally, any such allusions in reference to the cupriferous conglomerates,‡ since, as geologists generally have discovered, "the pebbles are only in very subordinate quantity of 'trap' or amygdaloid, being almost wholly of some sort of acid eruptive rock, *i. e.* felsite, quartziferous porphyry, quartzless porphyry, granitic porphyry, augite syenite or granite. The fundamental difference between such pebbles and the associated basic, massive rocks is alone enough to overthrow the theory, even were there not other sufficient arguments against it. Further, the pebbles are just as plainly water-worn as those of any other conglomerates, though they may have, in some cases, had the polish removed by surface alteration."

The evidence for the igneous origin of the Saganaga pebbles is incomparably less than that for the Kewenaw pebbles. An attentive consideration of the case confirms this conclusion. The conglomerate described on Wonder island is not one consisting originally of a mass of pebbles over which a fluid magma has been poured at some date perhaps long subsequent to the formation of the pebble deposits. I have seen a pile of angular fragments over which fluid gabbro had been poured, which flowed into the interstises and filled them. But the preexisting fragments were self-supported—they lay in direct contact with each other. On Wonder island the pebbles are not in contact; they could not have lain where they are before the gneissic magma existed. The gneissic magma was present, and it was this which supported the pebbles and prevented their contact. *The gneissic magma was contemporaneous with the pebbles.* But its condition was not that of molten fluidity, for so vast a molten mass would have fused the comparatively few pebbles immersed in it—still more the single pebbles which we find so widely distributed. It must however, have been sufficiently fluid or plastic for extraneous bodies to be moved in it. But a molten sea would have destroyed the pebbles and obliterated all traces of them. The plasticity therefore, was *low-temperature plasticity*—igneo-aqueous plasticity.

We cannot, to avoid such a conclusion, seek to propound the

‡Irving, *The Copper-bearing Rocks of Lake Superior*, 1883, U. S. Geol. Surv., Mon. v. pp. 9, 31-2.

theory that the conglomerate of Wonder island is one having origin long subsequent to the gneiss, and embraced in it by a process of folding and squeezing together. For, (1) the conglomerate has never been a conglomerate by itself; it never rested on another terrane, and could never have been caught in any sharp fold of the Saganaga gneiss; (2) If it were a formation so caught, we should find it revealing a greater extent along the line if strike; (3) The supposition of a close fold for the Wonder island conglomerate is not applicable to the isolated pebbles scattered through the gneiss across the whole breadth of the belt. These were in some way introduced from without into the plastic mass in all positions along lines transverse to the bedding.

If the pebbles were neither older than the gneiss nor newer than the gneiss, they were of course simultaneous with it. No other view would be conceived unless there were some preconceived theory of the non-sedimentary origin of gneiss to be cared for.

In connection with the interpretation of the Wonder island conglomerate, other facts must be considered. I have already stated that large angular beams of schistic and gneissic character have floated as bodies of extraneous origin in the gneissic magma which once existed. In connection with the Basswood gneiss I have elsewhere described* many occurrences of this nature, and many others in which the schistic fragments attain such length, and with so little displacement, as to constitute a complicated interbedding of gneissic and schistic strata. I have also maintained on such evidence, the original sedimentary condition of the gneissic terranes, as against the extravagant hypothesis of a succession of almost countless "dikes" perfectly parallel with each other and with the beds of the intersected formation, and separated from each other by only a few inches or even a fraction of an inch of the formation thus wonderfully perforated by "dikes."* I have more recently, in a newly discovered region, estimated as many as five hundred alternations of uralitic schist and uralitic gneiss in the breadth of about fifty feet,† and I feel confirmed in opinion that the gneisses and crystalline schists were originally sedimentary. Thus the facts

* *Fifteenth Ann. Rep. Geol. Minn.*, pp. 40, 41, 43, 46, 54, 63, 78, 83, 84, 88, 89, 96, 97, 113, 116.

cited in reference to the Saganaga pebbles are simply corroborative of views supported by other classes of evidence on which I do not here enlarge. Though merely touching the general problem of the origin of gneisses and granites, I wish to avoid all misapprehension by stating that I recognize the important agency of heat in connection with water, in the transformation of the original sediments; I do not conceive that the characteristic features of these terranes are any legacy of sedimentary conditions; but I hold, with Scrope, de Beaumont, Scheerer, Hunt and others, that the primitive materials, through the agency of heat, water and chemism, have entered into combinations not existing in the original sediments. I hold that the transformation attained different degrees of completeness in different localities and different horizons; and I hold that pressure—especially shearing pressure—has emphasized the bedded arrangement. Thus, as I believe, the sediments were brought to a state of incipient crystallization in one place, and completer crystallization in another; while in others, the thermal action was intense enough to reduce the magma to a state of such complete fluidity or plasticity as to obliterate all traces of bedding, or allow squeezing into fissures, or even surface overflows of any such extent as observation may establish. I wish to add the important suggestion that the agencies which would transform the common magma would also transform the included pebbles. By softening and pressure, their forms have been changed; and by metamorphic action they have ceased to present, in some cases, their original mineral constitution.

Such views on the history of crystalline masses though not widely entertained, will be found supported by considerable evidence of the same nature as that afforded by the pebbles and conglomerate of the Saganaga gneiss. In 1833, Professor Edward Hitchcock called attention to certain features of a conglomerate occurring near Newport, Rhode Island.‡ The pebbles showed evidences of a former softened state, and of a partial transformation, in certain cases, to "a mica schist with a cement of talcose slate." Similar conglomerates were described by Dr.

* *Fifteenth Ann. Rep. Minn.*, 1886, p. 264.

† *Sixteenth Ann. Rep. Minn.*, 1887, p. 264.

‡ E. Hitchcock, *Report on the Geology of Massachusetts*, 1833. See also, the Reports of 1833 and 1841. The same was more particularly described by Professor C. H. Hitchcock in *Proceedings Amer. Assoc.*, 1860, pp. 112-118.

E. Hitchcock "along nearly the whole western side of the Green Mountains in Vermont."† President Hitchcock states that the Vermont conglomerate occurs on both sides of the Green Mountains. He found it "in connection with quartz rock, mica and talc schists and gneiss; sometimes merely in juxtaposition, sometimes interstratified;" and he gives a diagram showing that gneiss is sometimes superposed on the conglomerate. The pebbles are generally elongated and flattened, and give other evidence of former plasticity. At Plymouth, on the east face of the mountains, conglomeritic phenomena of a similar kind, are still more strikingly shown. Here, as in Wallingford, and in the Saganaga gneiss, the pebbles do not lie in contact with each other. Mineralogically, they are here mostly of quartz, but sometimes of granite or gneiss. Dr. Hitchcock found that the pebbles were sometimes so elongated and flattened as to reduce the conglomerate to a schistic state; and he says: "We doubted for a time, whether we could justly include gneiss among the rocks that may be originated from conglomerate; for we had not found, as yet, decided examples of pebbles in this rock." "We do not despair however, of finding pebbles in gneiss, now that we have learned how to look for them." Dr. Hitchcock argues that by metamorphic action, many of the pebbles have been mineralogically changed without destroying their character as pebbles.

In support of the doctrine of the metamorphism of pebbles, Dr. Hitchcock cites a conglomerate found along the eastern border of Vermont and southward into Massachusetts. "We define this rock," he says, "as a conglomerate with a cement of syenite or granite, or as a syenite or granite with pebbles in it, sometimes thickly and sometimes sparsely disseminated." Speaking of an outcrop of this conglomerate on the southwest point of Little Ascutney, he says, "on one side it passes without any intervening seam into a porphyry, and this into a granite, all forming one undivided ledge, so that the conclusion is forced upon us that the granite and porphyry have been formed out of the conglomerate. Most of the rock on Ascutney takes hornblende into its composition, and thus becomes syenite, and this abounds in black rounded masses which are for the most part

† *Geology of Vermont*, 1861, pp. 29-44. One of the localities is in the northeast part of Wallingford. This passage was first published by Dr. Hitchcock in *Amer. Jour. Sci.*, II, xxxi, 372-392, Mar., 1861.

crystalline hornblende with some feldspar, and which are probably pebbles transmuted."*

At Granby, in Vermont, "the pebbles, manifestly rounded, are either mica schist or white, almost hyaline, quartz * * * and the base is a fine-grained syenite, passing sometimes almost into mica schist." "When the pebbles are highly crystallized, they become so incorporated with the matrix that it is difficult to separate them with a smooth surface; and, if we are not mistaken, they pass insensibly into those rounded nodules chiefly hornblendic (augitic?) so common in syenite, especially that of Ascutney. We think those are produced from the metamorphosis of pebbles which have become crystalline since they were formed into conglomerate. * * * These facts certainly give great plausibility to the view which supposes granite and syenite to be often the results of the metamorphosis of stratified rocks."†

At the meeting of the American Association at Springfield, in 1859, Professor Hubbard, of Dartmouth College, exhibited a specimen of pure white granite from Warren, New Hampshire, in which there lay imbedded a rounded bowlder of hornblende rock more than a foot in diameter, and easily separable from the granite.‡

Dr. G. A. Hawes, in 1878,§ recorded some mica sheets at East Hanover, New Hampshire, which are "mottled by what are apparently pebbles of various sorts and sizes, that have been flattened out between the layers." He recognizes the evidences of their former plasticity and of their metamorphism, even when not carried to such a degree as to entirely obliterate all signs of the original constitution of the sedimentary mass.

None of the examples cited from America possess evidence of such strength as that afforded by the Saganaga gneiss in reference to the former fragmental condition of the oldest crystalline rocks. The Saganaga gneiss is massive, insomuch that it is gen-

* Compare the black pebbles in the Saganaga syenite before mentioned and set down as apparently augitic; and my independent suggestion that they are the products of metamorphic action.

† The views of Dr. Charles T. Jackson on this question may be found in *Proc. Bos. Soc. Nat. His.*, 1860. Professor W. B. Rogers' views are found in same, 1861, cited in *Am. Jour. Sci.*, II, xxxi, 440-2, May, 1861.

‡ *Geology of Vermont*, p. 44. Dr. Hitchcock enumerates other localities of occurrence of conglomerates with flattened pebbles, in Bernardston, Mass., where the matrix is a mica schist. The same is true at Bellingham, Mass. These features are still more decided in bowlders near Northampton.

§ Hawes in *Geology of New Hampshire*, vol. iii, pt. iv, p. 220.

erally recognized as a syenite. It has indeed passed almost beyond the stage of alteration in which traces of sedimentary bedding remain. Nor is there any considerable mass of crystalline schists within less than five miles of Wonder island. The evidence for fragmental origins is thus carried fully into the midst of those crystalline masses so commonly regarded as centres of molten eruption.

The earliest mention which I find recorded of any analogous phenomena in the old world is by Dr. Sauer of Leipzig.* In the valley of the Mittweida near Annaberg, and about twenty-five miles south of Chemnitz, occurs a section of crushed conglomerate intercalated among the gneisses and mica-schists distributed over that part of Saxony. This appears, from the accounts, quite analogous to the pebble-bearing beds of the Green Mountains. I avail myself of a description of this occurrence recently published by Professor Hughes.† The complete sequence was not observed, but the vicinity is generally underlaid by muscovite schists and gneissic rocks. At Obermittweida, a grey feldspathic granular rock occurs, with apparently superinduced schistosity. In this were seen scattered pebbles of felsitic and quartzose rock which soon became so numerous that the rock was obviously a coarse conglomerate. "In the conglomerate were fissile sandy beds which, even when crushed, were quite unlike the mica-schists which cropped out above and below." According to a diagram given, the series of beds dip about 40°.

In theorizing on the occurrence, professor Hughes remarks that "there was plenty of room for, and strong probability of, a fault along the valley below the section." "On the whole, I was inclined to believe," he says, "from an examination of the rock in the field, that the conglomerate might belong to quite newer beds caught in a sharp synclinal fold." In support of this conclusion, he says: "The character of the two rocks, that is, of the gneissic series and the two beds associated with the

* "Ueber Conglomerate in der Glimmerschiefer-formation des Sächsischen Erzgebirges"—*Zeitschrift Für die gesammten Naturwissenschaften*, Band lii, S. 706, 1879. The occurrence is noted on the *Geologische Specialkarte von Sachen*, Massstab 1-25,000, Section Elterlein, nebst zugehörigen Erlaüterungen. Prof. Justus Roth of Berlin, published a paper on these conglomerates in 1883, in *Sitzungsberichte der Kgl. Preuss. Akad. der Wissensch.* zu Berlin, 1883, (Physikal-mathemat. Klasse,) xxviii, 14 Mai; and he later mentioned them in *Allgemeine u. Chemische Geol.*, ii, Bd., S. 427-428, Berlin, 1887. Roth gives a full account, copied from Sauer.

† *Quar. Jour. Geol. Soc. Lond.* xliv, Feb. 1, 1888, pp. 20-24.

conglomerate, is so different that I am unwilling to admit that they can both belong to one series and have been subjected to similar conditions." He mentions also, the absence of any passage from one to the other; the identification of both series with others known to be discordant to one another, and the analogy of other similar foldings in, of newer rocks, so as to produce on the surface the effect of a true sequence. The explanation was admitted however, to be purely hypothetical. In the discussion of professor Hughes' speculation before the Geological Society, every one admitted the possibility of an infolding, and could cite cases in illustration. Mr. Bauerman thought the explanation offered of the Obermittweida occurrence was probably the true one. Dr. Geikie mentioned a case of Cambrian conglomerates in Scotland, of which he was reminded, where there is "a passage from crushed conglomerates and sandstones into mica-schist."

The Obermittweida conglomerate has been discussed also microscopically by professor T. S. Bonney.* The matrix of the conglomerate, though clearly fragmental in origin, suggests that "a certain amount of metamorphism *in situ* has taken place. * * * The gneiss has a superficial resemblance to this matrix, but is rather more distinctly micaceous." The gneiss is quite characteristic and resembles one of the older Alpine gneisses. The matrix does not give evidence of much squeezing. It has essentially the constitution of gneiss, but at the same time, "the fragmental character of the rock is indubitable." He does not incline to regard it as post-Archæan, but it is probably long subsequent to the gneiss, and its appearance of consecutiveness is probably illusory.

Such an explanation, I repeat, will not apply to the case of the Saganaga conglomerate, where the matrix is absolutely of the same character as the gneiss of the contiguous region.

The German geologists, as would be expected, endeavor generally to explain the Obermittweida conglomerate without recognizing its real fragmental character. Von Hauer referred to it as only something *like* a conglomerate. J. Lehmann says the pebbles cannot be regarded as rolled stones, notwithstanding the complete rounding and smoothness of some of them.* Roth does not admit the pebbles were included rolled fragments, but

* *Quar. Jour. Geol. Soc.*, xliv, Feb. 1, 1888, pp. 25-31.

refers them to concretionary action. Dr. Sauer, while admitting the pebbles to be genuine "Gerölle," holds that the conglomerate is altogether newer than the gneiss, and that it has been "folded and faulted in." Dr Credner suggests however, that such an explanation should not be advanced as a mere hypothesis, but ought to have some facts of observation to sustain it. He gives the occurrence a common sense interpretation when he says: "Especially significant for the sedimentary origin of the fundamental gneiss formation is the presence of conglomerates embraced within it."† In this conception he includes not only cases where a conglomerate is distinctly embraced in a gneissic mass, but those where conglomerate terranes alternate with recognized crystalline masses. "In Canada" he remarks, "we find a complex of beds over 300 meters thick in which rounded fragments of syenite and diorite, of greater and less magnitude, are held together by a quartzose binding medium rich in mica." "In Michigan," he says, "several conglomerates formed of rolled fragments of gneiss, granite and quartzite are imbedded in an arenaceous talcose groundmass. In Vermont, is a similar zone of conglomerates; while near Konigsberg is a conglomeritic sandstone which alternates with gneisses and fundamental schists."

The foregoing information has been assembled for the purpose of placing before geologists a body of little known and less considered facts which must be brought into account in every attempt to reproduce the history of the oldest known crystalline rocks. The facts appear to the writer most intelligible on the hypothesis of a sedimentary origin of such rocks; but it has not been his purpose to argue that view except so far as evidence is supplied by the presence of such conglomerates as have here been passed in review.

NATURAL SCIENCE AT THE UNIVERSITY OF MINNESOTA.

By N. H. Winchell.

The universities and colleges of higher grade in the United States have in many instances begun as classical academies or

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* Lehmann *Untersuchungen über die Entstehung der altkrystallinen Schiefergesteine*, 1884, S. 128.

† Credner, *Elemente der Geologie*, S. 373.

theological training schools for the novitiate of the Christian ministry. In these schools the natural sciences have had a hard struggle to reach that recognition which their work and their disciplinary qualities justly demand. It is not so with those so-called "western institutions" that have sprung up spontaneously under the behest and guidance of the people in their corporate capacity.

Historical.—When the University of Minnesota was established it was first a territorial institution which had an existence on paper, and a Board of Regents that soon involved it in debt for buildings for which it had no use. On the adoption of the state constitution and the revival of the endowment it was resucitated and opened under better auspices. After a few years given to "preparatory" instruction the higher departments were organized. The report of the Regents for that year, (1869) shows that eighty students were then in the "agricultural and scientific" course of study, twenty-one in the "German scientific" course, and fifty-six in the "Latin scientific" course. There were at the same time twenty-one in the "classical" course, and thirty-three in the "Latin and German" course. This shows that even in the preparatory years scientific instruction had become firmly established, and that in the zeal with which it was entered upon by the students it had a large preponderance of their voluntary choice.

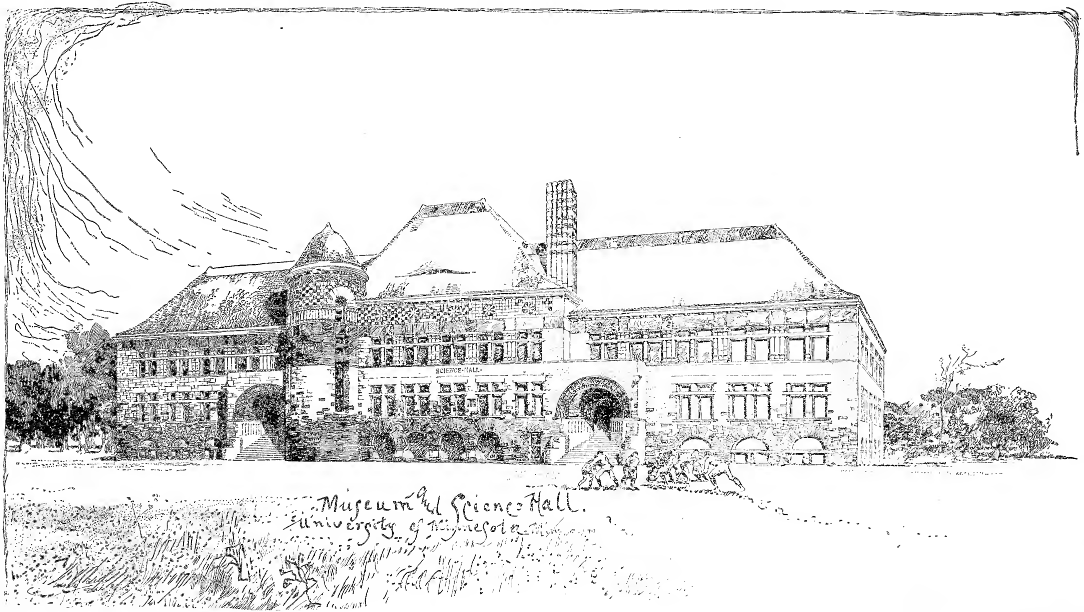
The same year Col. W. W. Folwell, a professor in Kenyon college, Ohio, was elected president. A classical scholar, Mr. Folwell still had imbibed enough of the spirit of the age from his practical engineering experience in the army to appreciate the value of science in a college curriculum. The newly elected faculty embraced E. H. Twining, professor of Chemistry and Natural Science, and Arthur Beardsley, a recent graduate of the Troy Polytechnic School. Gen. A. D. Robertson was professor of Agriculture. In these early days a "geological museum" was planned for, and a local *Minnesota Natural History Society* was organized, as one of the voluntary institutions of the University, an agent for conserving and extending the scientific interests of the institution and of the city, if not of the state. When, the following year, the plan of organization of the University, as outlined by president Folwell, was adopted by the Regents, it was found that scientific work in the University was not only fully recognized, but its place was made first in the scheme. The main department of the University instruction was entitled "Science, Literature and the Arts." President Folwell's plan, while providing for the professional and literary classes the old college discipline in its best form, also was calculated to furnish to the industrial classes that "liberal and practical education" contemplated in the laws which had conferred upon her a large part of her endowments. A great number of prominent American educators testified their approval of this plan. With slight modifications it has remained to this day, and all the developments which the institution has witnessed in its undergraduate course and in its professional schools, have been in general accord with the early forecasts and recommendations of the first president.

In president Folwell's second report, dated Dec. 1, 1870, may be found the first suggestion for a geological survey of the state under the auspices of the University. "I would respectfully submit the question whether steps might not soon be taken towards the employment by the state of our scientific instructors in making a complete survey, geological, mineralogical and topographical, of the state. A prime object on our part would be the opening of a grand field of practical instruction for the young men taking scientific courses." In accordance with this suggestion the Legislature of 1872 enacted the organic law of the survey, as drafted by Pres. Folwell. This survey was begun in the fall of that year and has continued to the present without interruption.

With the commencement of this survey began the rapid growth of the museum, and the equipment of the departments of geology and zoology in the University. The work of the survey itself was continually expanding. Soon it became necessary first to separate chemistry from the natural sciences, and then to divide the department of natural sciences into separate professorships, requiring the appointment of new men. Whereas when the appointment of the state geologist was first made he was expected to do a certain amount of teaching in the undergraduate course in the University, in about six years he was relieved of this and directed to devote himself entirely to the supervision of the survey and the museum. At the present time, in addition to some temporary and one constant assistant on the survey proper, the work which at first was embraced in the professorship held by the state geologist, has been further divided so that two professors and one instructor are occupied the greater part of the time on the work that the state geologist was relieved of. This expansion has been accompanied by a corresponding extension of all the usual and necessary appliances that are needed for the equipment of scientific departments. Latterly, however, the lack of room and proper facilities in the main University building where these departments have been accommodated became so pressing that a general demand was made on the Regents, and by the Regents on the Legislature for a special building adapted to the accommodation of all the museum and survey collections and the laboritories and lecture rooms of natural science. This building has been erected at a cost, at present, of about $100,000. It will require still about $100,000 to finish and furnish it. It probably will be occupied in about six months.

The new Science Hall. The accompaning plate represents the front of this building. It is constructed of two sorts and colors of sandstone native to the state. The darker one is used where in the figure the shaded portions appear. It is the brown Lake Superior sandstone. The lighter one was obtained from the gorge of the Kettle river a short distance north and east of Hinckley. It was examined carefully by the writer and reported under the name Hinckley sandstone, as a building stone of very high grade, in the chapter devoted to the building stones of the state, in Vol. 1 of the final report of the survey in 1882. It was this first examination of this rock that proved its excellence and called attention to it. Since then it has been introduced extensively into the markets of Minneapolis and St. Paul, and perhaps supplies more material for construction than comes from any other single point in the state. This result may be cited as one of the immediate benefits of the survey. Being in an inhospitable and then inaccessible region it probably would have remained to this day unnoticed.

The building is 244½ feet long and 77 feet wide, and of fine architectural appearance. The left end, the more distant from the reader, is intended for use as a museum with library and reading room for the use of the professors on the basement floor. The central portion is divided among the instructional


SCIENCE·HALL·
Museum and Science Hall.
University of Minnesota

departments of Geology, Biology, Botany, with their lecture rooms and offices, and the office and laboratory of the geological survey. The mineralogical and biological laboratories of the respective departments, fitted with tables and apparatus, are in the end of the building nearer the reader. There is to be, according to the plan, a school of mines with the necessary conveniences in the same part of the building, the general assay room being in the basement, and the office and drafting rooms on the first floor in front.

In the accomplishment of the progress of the University in these departments during the past twenty years, briefly rehearsed above, the chief agent has been, manifestly, that enlightened public spirit and appreciation of science which characterizes generally the communities of the western states. It is evident, however, that this alone would not effect the result so quickly unless it be directed by enlightened and judicious administrative application. The Board of Regents of the University during this double decade have not been a fluctuating and uncertain body. Some of the present members have served uninterruptedly through the whole period, and they have uniformly been friendly to the development of the scientific aspects of the institution.

FOLIATION AND SEDIMENTATION.

A Reply to Prof. Alexander Winchell.

By Andrew C. Lawson Ph. D., of the Geol. Survey of Canada.

In the fifteenth annual report of the state geologist of Minnesota, Prof. Alexander Winchell discusses* some considerations bearing upon the origin and history of the Laurentian gneisses which were advanced by me in a report† on the Geology of the Lake of the Woods.

The criticism came to my notice last spring and as the arguments put forward in it to show how he "would propose to overcome Mr. Lawson's difficulties," seemed very inadequate to enable me to overcome the only difficulty which I experienced, namely, the insuperable one of swallowing the currently accepted metamorphic theory, in its application to the Laurentian

* P. 199, et seq.

† Annual report of the Geol. Survey of Canada, 1885, part CC.

gneisses of the region in question, I promised a reply. I was called away to other duties, however, immediately after, and have not till the present had an opportunity of fulfilling my promise. Now that the time is at my disposal I shall endeavor, while gratefully acknowledging the fair and sincere spirit in which Prof. Winchell has examined and reviewed my work, to show that many of the contentions advanced by him in opposition to my own views are untenable, and that others argue strongly for and not against the position I have taken. The question at issue is not merely one of controversial interest, but is as Prof. W. states of fundamental importance in Archæan geology.

To state the question fairly I must quote the proposition which Prof. W. combats in the words in which I first stated it:

"It is highly improbable that the foliation of the gneiss has anything to do with an original sedimentation. Numerous instances have been cited in the preceding pages of the brecciated condition of the contact of the gneiss and schist. Gneissic foliation is seen to have been developed in a rock, which was once in so liquid or viscid a condition as to permit the passage through it of angular blocks of schist, to considerable distances from the source from which they were detached. A rock, to have been in a state so yielding, must necessarily have had all traces of an original sedimentation, if any such existed, obliterated. Furthermore, the existence of a well marked foliated structure in dykes which have been injected within the schist, both parallel and transverse to its lamination, and which are sometimes traceable in unbroken continuity with the main area of the gneiss, proves conclusively that such foliation was induced in the rock subsequent to its having been soft enough to have undergone injection, and therefore to have had any traces of sedimentation destroyed. In other words, the foliation of the granitoid gneisses is developed in rocks once viscid or plastic, quite independently of any arrangement due to sedimentation they may or may not have possessed. This conclusion does not necessarily imply that the gneiss and schist may not have been originally sedimentary and conformable. As a matter of opinion* I incline to the belief that the granitoid gneisses of the Laurentian were never aqueous sediments, but the conclusion, which the facts adduced lead to, is independent of either the origin of the rocks or their original stratigraphical relations. It simply proves that foliation is no indication of sedimentation and so far as the question of conformity depends upon it there is nothing to go by."

This being my position on the question, Prof. W. proceeds to assail it, and in a categorical series of fourteen propositions to

* I have now abandoned this opinion which was based on the absence of evidence to the contrary and I have always left myself quite free to recognize that the Laurentian rocks were once sediments or volcanic rocks or surface rocks of any kind.

"summarize briefly the facts which have led him to believe the foliation of the gneisses sustains a relation of dependence on an antecedent sedimentary structure."

I shall deal with these propositions, or the more important parts of them, seriatim, referring to them by the same numbers as are given in Prof. W's. report.*

1. Prof. W. says: "The gneissic foliation follows very exactly the planes of schistic sedimentation. * * * The fact is admitted by Mr. Lawson."

I admit that it is generally true, but in my report I cite exceptions where the foliation is transverse or oblique to the schistosity, and figure cases on pp. 32, and 73. It is one of those questions where the exceptions are of much more importance than the rule.

2. Prof. W. says: "No reason can be given for supposing subsequent foliation would so closely follow the schistic sedimentation unless a sedimentation had originally existed in the gneisses strictly conformable with that of the schists."

There are very excellent reasons. I conceive the foliation of both the Laurentian gneiss and the Keewatin schist to be due to the same cause acting on rock matter in two different physical states. Given a magma crystallizing into a solid with extreme slowness, and passing through a thickly viscid stage prior to final solidification; and given in contact with this, a solid rock either of sedimentary or volcanic origin, and the whole subjected, while confined at great depths, to enormous pressures, so that the solid rock was not only folded on the large scale but sheared in its minute structure, and the crystallizing magma caused to flow in response to the same pressures, we would have eventually, as the result, the very conditions which we find today at the contact of the Laurentian and Keewatin.

In the same paragraph, speaking of the schists Prof. W.

* In the preliminary portion of his criticism Prof. W. makes two misstatements which, although apart from the main question at issue, it may be as well for me to correct. He states that the Keewatin series of the Lake of the Woods "is *completely* isolated from other schists." I state in my report (p. 61, CC) that "it occupies an area which presents the appearance of an almost isolated patch;" and show both elsewhere in my report and in my map that the area is continuous with similar rocks to the S. E. Prof. W. also states that with me "the sheets interbedded with the hornblende schists are dykes and belong to a later age and a different mode of geological action." This is a misunderstanding. I have never entertained any such opinion nor in any way given expression to it.

states that "the foliated structure as everyone knows follows closely the planes of the original bedding."

This again is a rule to which there are very numerous and important exceptions, and many dykes and other masses of unbedded rocks have been shown to possess an eminently schistose structure. Both in bedded rocks and in dykes the planes of schistosity may make any angle with the strike although they are commonly parallel to it.

3. Prof. W. says: "The gneisses and crystalline schists are cognate in composition as well as in structure."

This is true of some gneisses, so-called in the indiscriminate application of this word, but not true of the granite gneiss of the Lake of the Woods, or of most of the Laurentian gneiss of Central Canada which I have seen, except in some cases, in which, as any rock may be, they appear to have been sheared and rendered schistose over and above any foliation they may have had originally. Then their structure may be said to be "cognate" with that of some schists. I cannot regard the hornblende schists which prevail at the base of the Keewatin as "cognate" in composition with the granite gneiss of the Laurentian except in the very wide sense that all rocks are cognate in composition.

4. Prof. W. says: "If the gneisses possessed a very *different* mineralogical constitution, that would not forbid the reference of their parallel planes of metamorphism to similar causes."

This proposition as it stands is quite incomprehensible and I cannot therefore discuss it.

5. Prof. W. says: "It seems eminently improbable that the gneissic beds intercalated in the schists should be of the nature of dykes."

I am sorry for this eminently improbable aspect of things, but it is an aspect which many truths have when they are first considered, and one for which in this particular case I cannot hold myself responsible.

The intrusive or injected character of the gneiss at the contact with the schists is proved conclusively by the field evidence stated and figured on p. 76. Figs. 10 and 11 are not weakened by an exclamation mark, or by a page of them. Preconceived notions of improbability are but poor arguments to array against explicit facts. All the evidence whereby an igneous rock of any age is known to be intrusive is available here, and to the unprejudiced mind its validity is at once apparent.

The number of the gneissic sheets, their parallelism due to their penetrating along the lines of fission of the schists, and the sometimes slender partitions of schist between them, all of which are cited as arguments against the injected character of the gneissic sheets, have absolutely no weight in disproving their injected character. There is nothing in the conditions cited which is at all incompatible with a process of injection of a viscid magma within a shattered schistose rock under the great pressure which existed at such depths.

6. Prof. W. says: "Fragments of gneiss very frequently occur in the schists. Hence the gneiss is older than the schists and could not have been injected into them." This statement is of considerable importance, and I reserve any extended comment upon it till more fully informed as to the precise nature of the conditions alluded to. The identity of the fragments of the gneiss in the schist with the ordinary gneiss of the country should be established in order to make the argument effective; and then the question should be investigated as to whether the schists in question are really of Archæan age, or, as Irving conceived the Vermilion schists to be, of a later age, such as the equivalent of the Animikie, which is clearly post-Archæan. In the Huronian of lake Huron there are boulders of gneiss in the conglomerates but according to Irving the Huronian is post-Archæan. I have seen boulders of granite in the conglomerates of the schists of the region with which I am familiar, but none of gneiss; and have regarded them as probably derived from the floor upon which the upper Archæan rocks of the region were first laid down, but which by subsequent fusion and recrystallization gave rise to the Laurentian, which is so clearly newer than the upper Archæan though underlying it. Included boulders or pebbles of gneiss might have a similar origin, and if proved to exist in the upper Archæan, through which the Laurentian is intrusive, we would be forced to assign some such origin to them.

7. Prof. W. says: "The gneissic fragments in the overlying schist have their planes of foliation in all positions regardless of the bedding of the schist. If the schistic bedding controlled the foliation of the gneiss immediately below it would be able to control that of the gneiss bodily enclosed."

This is by no means a logical inference, even if the premise were altogether sound, as it is not. It very commonly happens in conglomerates which have been subjected to pressure, that the enclosed pebbles or boulders, being much harder or more resistant than the matrix, do not yield while the matrix becomes intensely sheared and schistose, and even flows around the pebbles leaving a triangular space, often filled with infiltrated quartz, in the lee or wake of the pebble. Thus pebbles are arranged with their long axes approximately parallel to the planes of schistosity, without reference to any foliated structure that may exist in them; except in so far that the foliated structure is usually a factor in determining the position of the long axes. The pebbles (none of them gneiss to my own knowledge) existed as such in the conglomerates of the Keewatin, at a time when the Laurentian granite gneiss below was in a magmatic condition. The "schistic bedding" did not altogether control the foliation of the gneiss. The confines of the areas of schists are usually parallel to the cleavage of the schists; and it is only where such cleavage confines have determined a plane of flow in the crystallizing magma that the foliation of the gneiss is parallel to the cleavage of the schists. This is the common case. But frequently the schists have been shattered and then the foliation of the gneiss is as often as not transverse to the cleavage of the schists.

8. Prof. W. says: "The foliation of the gneisses diminishes as the distance from the schists increases." I find the reverse to be very distinctly the case in the northern portion of the Rainy Lake region, where a broad zone of rudely foliated syenitic gneiss very constantly intervenes between the base of the Keewatin series and the more evenly foliated biotite gneisses; so that no such general rule as the above can be laid down; and Prof. W's. inference as to the foliation being inversely as the amount of alteration, together with the various corallaries in the same paragraph, have again only an imaginary not a logical connection with the facts.

9. Prof. W. says: "The adjustment of planes of foliation to foreign fragments as seen in the wrappings of their folia about masses of schist reveals the tendency of the foliation to assume relations to external material conditions."

This is a very good answer to the objection in paragraph two which I have quoted above. For, the great belts of schistose rocks, like that of the Lake of the Woods, are just as truly foreign fragments in the gneiss, only on a grand scale, as are the smaller inclusions along the shattered confines of those belts. The limits of these schist belts are, as I have stated, usually schist planes and because of "the tendency of the foliation to assume relations to external material conditions" due to differential pressure and consequent flow against these limiting schist planes, it cannot be urged as Prof. W. urges that "no reason can be given for supposing subsequent foliation would so closely follow the schistic sedimentation etc."

By the way, Prof. W. is strangely silent as to how these "foreign fragments" became imersed in the gneiss."

10. Prof. W. says : " Injected veins do not prove the igneous origin of the whole gneissic mass." Taken in connection with the inclusion of the innumerable more or less angular fragments of the overlaying schist in the gneiss, near the contact, and often at considerable distances from it, and also in connection with the excessive metamorphism of the schists at the contact, such 'veins' certainly do prove the igneous origin of the whole igneous mass. "Nor" he continues, "do they prove a completely igneous condition of any part of it—but only a softened state, which, as we know, might be produced at a temperature far below that of igneous fluidity."

We know nothing of the kind. We have yet to learn that rock forming crystals, or an aggregate of such crystals, may be *softened* by any temperature so that they will flow without losing their crystallinity. Rocks or rock forming crystals may be crushed to any grade of fineness and made to flow in a solid condition by intense shearing or friction of the constituent parts one upon another, and so become very schistose, and have new minerals developed from the decomposition of the original constituents; but it is a fallacious notion that rocks may be softened in any other sense, so as to flow and still retain the individuality of their constituent crystals. When that individuality is lost at high temperatures, whether the result be a state of "igneous fluidity" or a thickly viscid, or even colloidal state by reason of the pressure, the only term we have for the change is fusion, or hydro-thermal fusion; and we have a magma, which, on recrystallizing, gives rise to a new rock devoid of the evidence of shearing which is so common in the schists.

11. Prof. W. says: "The foliation often seen in veins * * may in many cases sustain a relation to the earlier sedimentation planes of the closely contiguous rock with which the vein is in continuity."

There is precisely the same proof that the granite gneiss has passed through a magmatic condition in which every trace of sedimentation must necessarily have been obliterated, as holds in the case of ordinary granite of Devonian or any other post-Archæan age. Any injection that could take place with the retention of traces of sedimentation would necessarily shew the evidence of the shearing and deformation, and not possess the structure of granites as the veins in question do.

"If vein foliation were quite independent of a previous bedded condition of the matter—as is doubtless the case in foliated veins of igneous origin, etc."

How does Prof. W. distinguish between foliated veins of igneous origin and veins of foliated granite which penetrate and cut the schists? Precisely those characters which determined a vein to be of igneous origin, loudly asserted the origin of the veins of Laurentian gneiss.

12. "It is admitted that the gneiss during the period of its metamorphosia was probably in a pasty condition though we have no proof that the blocks of schist were very far transported in it. Some limited, deeper seated portions may have approached a state of igneous fluidity."

This admission practically allows my whole contention if the word "pasty" be properly defined. The meanings it may have are limited in number. It may mean (1) a mechanical mixture of rock matter, as such, and water, in which any crystalline constituents of the rock still retain their crystalline individuality however much comminuted. (2) A thickly viscid solution of rock matter in a small portion of water which could only take place at very high temperatures, and in which the constituents of the rock have lost their individuality and have merged into a common magma, which process is termed hydro-thermal fusion or aqueo-igneous fusion, or (3) absolutely dry fusion, which many facts warrant us in believing, is very rare in nature. There is no evidence whatever that granites or granite gneisses ever crystallized from such a mechanical paste as (1), and its existence at great depths, under high pressure and temperatures is directly at variance with our knowledge or deductions as to the probable behavior of matter under such conditions. These rocks must therefore on Prof. W's. admission have crystallized from a magma; and as we have abundant evidence of small quantities of water in the rocks themselves, we are forced to recognize some sort of hydro-thermal fusion. The sooner the well defined line which exists in nature between rock metamorphism and fusion is recognized by geologists, and the former understood to stop where the latter begins, the better for the progress of investigation in Archæan geology.

Another admission whereby Prof. W. places himself at one with myself is his statement that "we are at liberty to assume for portions of the gneisses any degree of fluidity which observed phenomena seem to indicate; and yet, for the great body of the gneisses recognize such a history as is indicated most plainly by the general tenor of the most accessible facts."

The facts which prove the fluidity thus admitted are for the most part observed at the top of the Laurentian, and it is admitted that the conditions inducing fusion were more intense in still deeper portions, although with increasing pressure the fluidity was perhaps less. At great depths the absence of brecciated fragments of the overlying schists, and of injected sheets and dikes renders the intrusive character of the gneiss less apparent; but the absolute identity of the rock with rocks known to be irruptive, and the unbroken continuity of the deep portions with the intrusive portions at the contact with the overlying schists, is sufficient proof that the admission which Prof. W. makes for portions of the mass is applicable to the whole.

13. Prof. W. says: "Some of the difficulties experienced by geologists, especially German geologists and their followers, in admitting a former sedimentary condition of most gneisses and granites arises, probably, from too narrow a conception of geological history."

As to the difficulties alluded to I have, I think, made it sufficiently clear that I experience none in admitting the possibility of a former sedimentary condition for the Laurentian gneiss, and in one of my later papers I have advanced considerations in favor of probability of such a view. The only difficulty I experience is, as I have stated, in accepting the metamorphic theory in its application to rocks which are plainly irruptive, whatever may have been their condition prior to the fusion which enabled them to become irruptive. As to the class of geologists who are alleged to experience such difficulties, and to the narrowness of conception with which they are alleged to be afflicted, I may say for myself, that while I admire greatly the truly scientific spirit of German research and find it, so far as I know it suggestive of the broadest principles, I am neither a German geologist, nor a follower of German geologists, nor one of those who believe that wisdom will die with German geologists. If I must be placed with any school of geology, I stand as a humble disciple of the glorious school of British geology, whose founder was the immortal Hutton, the teacher of the broadest conception of geological history ever penned: "In the economy of the world I can find no traces of a beginning, no prospect of an end." With this conception, modified only by cosmical considerations, the discovary of the younger age of the Laurentian granite gneisses, relatively to the overlying schists of the upper Archæan, is in entire harmony; and completes the proof of those great cycles in the evolution of the earth's crust which the genius of Hutton first descried.

THE NEWARK SYSTEM.

BY ISRAEL C. RUSSELL.

While writing a review of the Triassic and Jurassic systems of North America I have recently had occasion to re-examine the literature relating to the red sandstone and associated shale and conglomerate along the Atlantic coast which are commonly referred to as New Red Sandstone, Triassic, Jura-Trias, etc.

The distribution of these rocks is well known; they occur about the bay of Fundy, in the Connecticut valley, and in detached areas from southern New York to South Carolina, and include the Richmond coal-field and the coal bearing strata on Deep river and Dan river in North Carolina.

The terranes here designated have been referred to many horizons in the geological column varying from the Silurian to the Jurassic, as is indicated in the following table in which the opinions of various geologists respecting their European equivalents, are briefly designated:

The rocks referred to in the table are a unit in American geology and form a well defined system which is limited above and below by great unconformities. Fossils occur in abundance at certain localities but as yet have not been found at enough horizons in the various areas to establish subordinate divisions. This has been attempted, however, and not only have numerous subdivisions been proposed but various fossiliferous layers have been correlated on the strength, in some instances, of a very few fossils, with various terranes in Europe. At other times

Names and correlations applied to the whole or portions of the Newark System.

Date	NAME USED.	AUTHOR.	PLACE OF PUBLICATION.
1817	Old Red Sandstone....	Maclure, W......	Am. Philo. Soc. Phila., Trans. Vol. 1, n. s, p. 20, and map.
1820	Old Red Sandstone....	Nuttall, F.......	Acad. Nat. Sci., Phila., Jour. Vol. 2, p. 37
1832	Old Red Sandstone and Coal formation......	Hitchcock, E...	Am. Jour. Sci. [1] Vol. 6, pl. op. 86.
1824	Freestone and Coal formation of Orange and Chatham [N. C.]	Olmsted, D......	Rep. Geol. North Carolina, p. 12.
1833	New Red Sandstone....	Hitchcock, E....	Rep. Geol. Massachusetts, p. 206.
1835	Carboniferous	Taylor, R. C.....	Geol. Soc. Pa. Trans., Vol. 1, p, 294.
1836	Lias [?]	Redfield, J. H...	Lyc. Nat. Hist. N. Y., Ann. Vol. 41.
1839	Middle Secondary Strata..............	Rogers, H. D....	Third Annual Rep. Geol. Pa., p. 12.
1839	Middle Secondary Strata..................	Rogers, W. B. ..	Geol. of Virginia, p. 74.
1842	Secondary Formation	Percival, T. G...	Rep. Geol. Connecticut.
1842	Keuper	Rogers, W. B....	Amer. Jour. Sci. [1] Vol. 43, p. 175.
1843	New Red Sandstone....	Mather, W. W.	Rep. Geol. of New York, part iv, p 293.
1843	Old Red Sandstone and Coal Measures.........	Cozzens, I.	Geol. Hist. of Manhattan, p. 43.
1843	Oolite....................	Rogers, W. B ...	Amer. Assoc. Geol. Nat., Trans., p. 298.
1844	New Red Sandstone....	Silliman, B.......	" " " Proc., pp. 14, 15.
1847	Triassic or Jurassic	Bunsbury C. J. F	Quar. Jour. Geol. Soc., Lond., v. 3, p. 288.
1847	Permian or Triassic....	Lyell, C...........	" " " " " " 275.
1847	Inferior Oolite?	Lyell, C...........	" " " " " " 278-280
1849	Keuper or Lias..........	Marcou, J.	Geol. Soc. France, Bull., Vol. 6, p. 575.
1850	Silurian...................	Jackson, C. T...	Am. Jour. Sci. [1] Vol. 3, p. 335.
1851	New Red Sandstone....	Agassiz, L........	Am. Assoc. Adv. Sci., Proc., Vol. 5, p. 46.
1851	Post Permian.	Redfield, W. C...	" " " " " " p. 45.
1853	New Red Sandstone or Keuper..................	Marcou, J.......	Geol. Map of North America.
1854	Jurassic..................	Rogers, W. B....	Boston Soc. Nat. Hist. Proc., v. 5, p. 14.
1855	Near the Lias of Europe..................	Jackson, C. T....	Am. Jour. Sci [1] Vol. 5, p. 186.
1856	Trias or New Red Sandstone............	Hitchcock, E....	Outlines of Geol. of the Globe, p. 96.
1856	Oolitic	Hitchcock, E....	" " " " Map.
1856	Newark Group	Redfield, W. C...	Am. Jour. Sci. [1] Vol. 22, p. 357.
1856	Triassic and Jurassic...	Dana, J. D........	" " " " " p. 357,
185	Trias and Permian	Emmons, E......	Geol. Rep. North Carolina, p. 273.
1856	Jurassic	Rogers, H. D....	Geol. Map of U. S., Johnson's Phys. Atlas.
1857	Keuper	Heer, O...........	Geol. of North Am. by J. Marcou, p. 16.
1857	Chatham Series........	Emmons, E......	Am. Geol., Pt. vi. p. 19.
1857	Keuper........	Lyell, C	Cited by J. Marcou in Geol. of N. Am. p. 16
1858	Lias	Agassiz, L........	" " " " " p. 15
1858	Mesozoic Red Sand-		

Date.	NAME USED.	AUTHOR.	PLACE OF PUBLICATION.
	stone	Rogers, H.D.	Geol. of Pennsylvania, 4 to Vol. 2, p. 667.
1858	Refers various portion of the system to Trias, Keuper and Jurassic	Marcou, J.	Geol. of North Am. pp. 10-13 and Map.
1859	Between the New Red Sandstone and the Oolite	Agassiz, L.	Am. Assoc. Adv. Sci. Proc., Vol. 4, p. 276.
1860	Mesozoic or New Red Sandstone	Tyson, P. T.	First Rep. on Agr. Chem., Maryland, map
1864	Trias	Hall, J. and W. E. Logan	Geol. Map of Canada, [etc.]
1866	Richmond Coalfield	Daddow, S. H. and Bannon, B	Coal, Iron and Oil, p. 395.
1866	Jurassic	Lyell, C.	Elem. of Geol., 6 ed., p. 451.
1868	Triassic formation also Triassic or Red Sandstone Age	Cook, G. H.	Geol. of New Jersey, p. 173.
1869	Triassic Period	Dana, J. D.	Manual of Geol., p. 411.
1871	Trias	Lyell, C.	Students' Elem. of Geol., p. 361.
1875	Triassic	Kerr, W. C.	Rep. Geol. of North Carolina, p. 116.
1878	Mesozoic Formation	Heinrich, O. J.	Amer. Inst. Min. Eng., Tran. v. 6, p. 227.
1878	Trias or New Red sandstone	Dawson, J. W.	Acadian Geol., 3d ed. p. 86.
1878	Triassic	Russel, I. C.	N. Y. Acad. Sci., Ann, Vol. 1, p. 220.
1878	Jura-Trias	LeConte, J.	Elem. of Geol., p. 439.
1879	Triassico-Jurassic	Dana. J. D.	Amer. Jour. Sci., [3] v. 17, p. 330.
1879	Jurasso-Trassic	Rogers, W. B.	Macfarlane's Railway Guide, p. 180.
1879	Amer. New Red sandstone	Frazer, P.	Amer. Nat., v. , p. 284.
1879	Rhaetic or Younger	Fontaine, W.M.	Amer. Jour. Sci., [3] Vol. 17, p. 39.
1882	Triassic	Geikie, A.	Text Book of Geol., p. 770.
1883	Older Mesozoic	Fontaine, W.M.	Monograph, No. vi, U. S. Geol. Survey.
1883	Rhaetic	Fontaine, W.M.	" " " " "
1883	Triassic	Davis, W. M.	Mus., Comp. Zool., Bull., Vol. 7, No. 9.
1884	Jurasso-Triassic	McGee, W. J.	5th Ann. Rep., U. S. Geol. Surv., pl. 2.
1884	Lower Jurassic passing downward into Triassic	Hotchkis, Jed.	[Reprint of Roger's Ann. Rep., etc. of Virginia.] Map.
1885	Triassic or Mesozoic	Lesley, J. P.	Geol. Atlas of Pennsylvania, v. x. p. vii.
1886	Tria-Jurassic	Chapin, J. H.	Meriden Sci. Assoc., Proc., Vol. 2, p. 23.
1886	Triassic	Hitchcock C. H.	Am. Ins. Min. Eng., Trans., Vol. 15, pl. op. p. 486.
1887	Trias	Emeson, B. K.	Gazetteer of Hampshire E. Mass., p. 18.
1888	Triassic	Newberry, J. S.	Monograph, No. xiv, U. S. Geol. Survey.

mere lithological resemblances to rocks in distant countries have been used as a basis for correlation. The futility of these attempts is indicated by the confusion of names and of opinions that has arisen. Judging from the relations of this system to associated terranes as well as from the most recent investigations of its fossils, it seems evident that as a whole it may reasonably be correlated in a general way, with the Jurassic and Triassic systems of Europe. To attempt a more minute correlation at the present time does not seem warranted.

The desirability of a commonly acceptable name for this system is sufficiently obvious, if for no other reason than convenience in discussing its relation to other terranes. The question is, what name shall be used? The diversity of opinion regarding its relation to European rocks renders it evident that a name implying correlation will not meet with general acceptance. More than this, to express my own opinion, it does not seem desirable that widely separated terranes should be considered as strictly synchronous on the strength of palæontological evidence simply.

The first consideration that should guide a geologist in selecting a name for a series of rocks should evidently be to avoid all terms which imply a greater knowledge of the relations of the rocks or of their constancy in lithological or other characters, than is warranted by the facts in hand. A name which simply indicates the object referred to has great advantages in a rapidly advancing science like geology. The length of a name, its euphony, etc., also claim consideration.

On examining the table given above it will be seen that with the exception of names used to designate special areas as the "Richmond coalfield" or the "Freestone and coal formation of Orange and Chatham," for example, only one name has been advanced which does not imply correlation. The name referred to is the "Newark Group" proposed by W. C. Redfield in 1856.

In giving this name the following language was used:*—"I propose the latter designation [Newark group] as a convenient name for these rocks [the red sandstones extending from New Jersey to Virginia] and to those of the Connecticut valley, with which they are thoroughly identified by footprints and other fossils, and I would include also, the contemporaneous sandstones of Virginia and North Carolina."

The term "*group*" having been used by the International Congress of Geologists to denote a larger division than Redfield included under it, the word "*system*" may be substituted for it with propriety. I propose, therefore, that the name Newark system be used to designate the rocks of the Atlantic slope referred to above.

By adopting a name which does not imply correlation it is not intended to throw doubt on any of the classifications that have been made, but the scarcity of fossils, particularly of invertebrates, in the Newark system as well as the great diversity of opinions regarding its position in geological history, demands the adoption of a name which does not imply more than is definitely known concerning it.

* Amer. Jour. Sci., 2d ser., vol. 22, 1856, p. 357; and also in Proc. Amer. Assoc. Adv. Sci., vol. 10. Albany meeting, 1856, p. 181.

In giving the Newark system a specific name all expression of relationships with other terranes in this country implied in the names heretofore in common use, is avoided. Certain portions of this system may be more or less definitely correlated with portions of the Red Beds of the Rocky Mountain region, but to say that the Newark system as a whole is synchronous with the Red Beds, or with the Red Beds and the intimately associated Jurassic rocks, is to carry inference far in advance of observation.

I also claim an absolute divorce of the rocks of the Newark system from the copper-bearing rocks of Lake Superior, and from the red sandstone of Maine and New Brunswick with which they have sometimes been correlated. Whether the rocks just referred to are closely related in age to the Newark system or not is immaterial at present, as they are mentioned simply as examples of what is not included under the name here proposed.

MR. FORSTER ON EARTHQUAKES.*

BY R. D. SALISBURY.

Somewhat more than a year ago Mr. W. G. Forster, manager and electrician to the Eastern Telegraph Company, Zante, issued a somewhat lengthy paper (68 pp.) on Seismology, which seems not to have attracted that attention to which it is entitled. Some of the foreign periodicals spoke slightingly of the paper, though failing, at the same time, to give an adequate idea of its contents. This was perhaps not to be wondered at, since that portion of the paper which is of especial interest—the record of Mr. Forster's own observations—is prefaced by a lengthy discussion concerning the theory of earthquakes, which seems not to have found much favor, and which has perhaps deterred reviewers from a complete perusal of the paper. The facts which Mr. Forster records, are however, of so much importance, that it seems fitting to give them wide circulation through the columns of an American journal.

Located in the midst of a region where seismic disturbances are frequent and often severe, and holding an official position

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* Seismology. A paper on earthquakes in general, together with a new theory of their origin, developed by the introduction of submarine telegraphy. London, 1887.

which gives him exceptional opportunities for observation, it is not strange that Mr. Forster is able to contribute some facts of great importance to the theory of earthquakes. Some of these facts, so far as possible in the words of the author, are here reproduced. That the language in which they are recorded may be the better understood, the hypothesis which they are thought by the author to support, may be briefly indicated by a few citations.

The irregularities of the bed of the Mediterranean are, as is well known, very considerable. "In many parts a difference of depth equal to 2,000 feet has been found between the bow and stern soundings." * * "We know of mushroom-shaped mountain ranges, abrupt and precipitous table-lands, immense marginal shelves and overhanging cliffs, many of which do not form part and parcel of the earth's upper crust, but are divided from it by beds of firm ooze or clay. Now, all these idiosyncrasies of the surface must become eventually levelled down. We know, by soundings, that many of these tottering masses are hanging over precipices from 3,000 to 5,000 feet in depth, and that the erosion of the water at the base of the inverted cone-shaped rocks, eventually, causes them to slip over in this very natural course of levelling down." After referring to like irregularities of bottom in other seas, Mr. Forster further says: "We know that the form of these (submarine elevations) is precisely inverse to our terrestrial mountain peaks and sharply pointed ranges, and we also know that both mechanical and chemical action erode them at their base, then loosen them, and finally hurl them over to the abysses below." The same idea is still further emphasized by the following: "From the few instances which have been obtained by soundings, we have actual proof afforded us that the sinuosities of this (sub-marine) surface are most remarkable and erratic, and that they receive vast deposits, produced by the various existing currnets, and that their bases (that is, the bases of the sub-marine elevations and ledges,) suffer erosion, or become honey-combed, as it were, in the lapse of geological time; that also they eventually fall over, are levelled down and become homogeneous masses. All this is exhaustively proven by the known condition of the central beds of our ocean." In these unstable elevations the author thinks we have "the true and only reason for seismic disturbances. * * * The steeper the angle of these irregularities of the oceans' beds, the more frequent are the earthquake shocks."

It is not the purpose of this notice to discuss the hypothesis advanced, but from these citations it is clear that Mr. Forster believes earthquakes to be due to the toppling over of unstable sub-marine mountains, or to landslides from their precipitous slopes. Landslides from the steep slopes of islands or the mainland, would of course produce the same result.

In support of this hypothesis the following facts are given; and it is these which give especial importance to the paper under review:

1. On the 26th day of October, 1873, a very violent shock of earthquake took place in Zante. "At the moment the shock occurred the cable between Zante and Trepito, the landing place opposite, broke, and the distance of the break was found to be seven miles from the Zante office.

"When this cable was repaired some time afterwards, it was discovered that the break had occurred in a depth of about 2,000 feet of water, where about 1,400 feet originally existed, and it was impossible to haul in the broken end, firmly jammed down by the mass which had fallen over and upon it; in fact, nearly a mile of the cable had to be abandoned for this reason, and a fresh piece of that length laid instead.

2. "In the year 1878" a violent shock of earthquake was felt in Messina, extending from the Gulf of Calamata to Navarino, and slightly felt in Crete and in Zante. At the same time that the shock occurred the cable between Zante and Canea broke at a distance of 137 miles from the former island and 101 from Canea. It was a peculiar break and all my tests taken to localize the fault failed to alter the distance; yet when the repairing ship tested from the Cretan end the distance appeared to be 139 and 99 knots respectively. * * * In the end it turned out that the cable had been broken in two different places, * * * at the moment the ground fell away, and for a distance of about two miles; and so irregular and uneven was the bottom then found to be, (between the two breaks) that a detour was made and the cable lengthened by five or six miles, to avoid any further chances of breakage."

3. On the 28th of March, 1885, "a prolonged shock came

rolling up to Zante from the south, lasting nearly forty seconds. It began with a very slight force, gradually increasing to a fairly smart shock, and then died away. * * * Soon after this we observed that the hitherto perfect cable between Zante and the island of Crete appeared to be faulty, thus interfering with the work, and when the next morning a clerk proceeded to the Canea cable-house to arrange for my tests, I found that, although not entirely broken, it had been very seriously damaged." The sea bottom where this injury to the cable occurred is exceedingly irregular. Outside Sapienza, to the north, the sea has an average depth of only 700 feet, but a little to the westward "it suddenly falls into 4,000, and even into 10,000 feet." * * * "For a space of about 150 square miles there appears to be a vast depression, averaging 9,000 feet in depth, rising abruptly and precipitously towards the coast line. It was in the center of this depression that our repairing ship found the extraordinary difference of 1,500 feet between the bow and stern soundings." In this instance Mr. Forster thinks that "a considerable mass of matter had fallen directly upon it, (the cable) as the subsidence came shelving down from some 2,000 feet into a depth of 8,000, and had crushed it without actually fracturing it."

4. "On December 7th, 1885, a long undulating shock, of slight intensity, was felt in Zante and its direction was decidedly from the west northwest. Just after the shock our Zante-Corfu cable, which passes along the channel dividing Zante from Cephalonia and thence out to the westward of the latter island, was found to be faulty, the fault being within one mile of the Zante shore, off Cape Krionaro, in a depth of only about 300 feet of water. The cable was not entirely broken, but either badly crushed or strained by an uprising, or more probably by a subsidence of the bottom in our old earthquake ground, in the channel between the northwest of Zante and the southeast of Cephalonia. It eventually, however, gave out, as in the previous cases, and it was found advisable, on repairing it, to lay in a new shore end of one knot, up to and beyond the fracture. Whilst waiting for the arrival of our repairing ship I examined the cable from a boat with the aid of a sea telescope, as it lay on the bottom of the sea, the water being very clear, and I followed it for a distance of about 400 or 500 yards from the

shore, ere the depth of water prevented my further examination. I was very surprised to see that a short way out the cable had been lifted clear away from its original bed, which, owing to the bottom being of smooth limestone and for some distance out quite as level as a street pavement, showed the impress of its own weight, which had been made during the fifteen years it had lain there undisturbed, and quite two feet west of its new position, about 300 yards from the coast, in thirty-six feet of water; the cable looked as if it had been bent downwards, but it was not possible to verify this; however, it was most interesting to observe the extraordinary condition of the level limestone rock at this point. Everybody knows the peculiar appearance a large pane of glass has when fractured. In the center there is a hole of varying size, whilst the cracks radiate from that center in all directions. So it was here with the rocky bottom, and *exactly in the place where the cable originally lay*, a large hole of some two feet in diameter, in which no bottom at sixty feet could be found, now existed, and the rock all round was fractured as just described."

5. On the 15th day of August, 1886, there was a severe earthquake shock, the exact centrum of which "was in the sea, twenty-three miles from the port of Zante, between the island of Strophades and the Gulf of Arcadia. The concussion caused by the vast subsidence seemed to be felt the most severely between Trepito Point, opposite Zante, and the island of Sapienza, to the south. It reached Zante with a long, swaying motion, increasing to a maximum after fifteen seconds, and dying away at the end of forty seconds from its first commencement. Zante divided the waves of vibration, part of them travelling along the sea by the northern channel and reproducing a corresponding echo in Patras, Missolongi and that neighborhood, whilst other waves passed to the west of Zante, in the direction of Corfu. * * * To the south the shock seemed to have been somewhat arrested by the rocky island of Sapienza, and the line of mountains behind Filiatra also reduced its intensity before reaching Calamata. The flat island of Strophades, only a few feet above the level of the sea, felt the shock with terrific force. * * * At the moment the shock occurred one of the employes in the Zante telegraph office was in the act of receiving a message from Candia by the Zante-Cretan cable, and

of course, the fright made him rush out of the office with the others, for safety; seeing, however, that the house was totally undamaged, the staff soon returned, and on examining the band still running from the Morse instrument, it was seen that the signals went wrong and ceased entirely at the moment of the shock. I was immediately advised of this by telephone, and before almost the lamps and other suspended articles had ceased swaying I had the cable end on my testing apparatus and localized a dead break at the distance already named, which was equal to 25.5 cable knots, or twenty-three miles from this, the port of Zante. All this was absolutely defined within a few moments of the shock's commencement. * * *

"On proceeding to grapple for the broken ends, the repairing ship found that to the south of the break the bottom suddenly increased in depth from 4,500 to 5,800 feet, and slightly to the westward nearly 7,000 feet were found. The fault (break in the cable) came in from a depth of 5,800 feet." Concerning this break it is further stated "that for a length of six miles north and south, and directly along the cable's course, the whole of this level bottom (on which the cable had lain)had either slid over into a greater depth or had sunk by its weight over some cavernous spaces. I am more inclined to favor the opinion, that towards the westward this bank, 4,500 feet in depth had originally almost as precipitous a slope into deep water as it has to the south, off Proti, (where the depth suddenly increased from 4,500 to 10,000 feet) and that the cable was lying within a few inches of the actual margin of this bank, which fell over toward the west into very deep water." Mr. Forster further reasons that "not a shadow of doubt exists that this landslip broke the cable, because it was firmly jammed down for a considerable length and could not possibly be extracted, whilst the broken end to the south came in freely, as it lay hanging over the precipice at the point of subsidence; and that this landslip was the *cause* of the earthquake is also *absolutely irrefutable*, because the cable broke *exactly* when the shock took place, being dragged down by the mass of matter, or crushed by the weight in falling."

Whatever may be thought of the hypothesis which is invoked to explain the above phenomena, the phenomena themselves are striking enough. Since the publication of his paper Mr. Forster has received appropriations from at least one of the scientific bodies in England, which will enable him to carry on still more accurate and extended observations hereafter. "A new era in seismic history began with the introduction of sub-marine telegraphy." Mr. Forster has taken advantage of the possibilities of this new era, and it is to be hoped that those similarly situated will follow his commendable example.

THE ORIGINAL LOCALITY OF THE GRYPHÆA PITCHERI, MORTON.

By Jules Marcou.

Professor Robert T. Hill, of the University of Texas, in *Bulletin U. S. Geol. Survey*, No. 45, "The present condition of Knowledge of the Geology of Texas," Washington, 1887, (issued only in November, 1888,) says, at p. 46, "Dr. Samuel George Morton was the first to make allusion to the Cretaceous strata of Texas. He describes, from 'the Calcareous platform of Red river,' the fossil *Gryphæa Pitcheri*, now accepted as the most characteristic fossil of the typical Texas Cretaceous. This locality, we can only surmise, was the same as that now called the Staked Plains (Llano Estacado) region of Texas. The specimens were collected by army officers."

In his celebrated "Synopsis of the organic remains of the Cretaceous group of the United States," Philadelphia, 1834, Dr. Morton says, at p. 55: "I received this fossil (*Gryphæa pitcheri*,) together with some others of great interest, from my friend, Z. Pitcher, M. D., of the United States army, who obtained it from the plain of the Kiameshia, in Arkansas. I have seen others from the fall of the Verdigris river, in the same territory."

As far back as 1860 I published a letter from Dr. Pitcher, in my "Lettres sur les Roches du Jura et leur distribution géographique dans les deux hémisphères," p. 291, Paris, which seems to have escaped professor Hill's notice, and which is so little known among American geologists, that it is best to have it reprinted. I shall give it without the suppression of the beginning, for it is the only document we possess, from the first geological explorer of that part of the Indian Territory called territory of the Choctaw nation, directly west of the state of Arkansas.

Having learned through my friend Capt. A. W. Whipple, (since Major-General) that Dr. Pitcher was living at Detroit, where Whipple was then detailed on the Great Lakes surveys, I sent him a copy of my "Geology of North America," containing excellent figures and descriptions of the *Gryphæa pitcheri*, found by me on an affluent of the False Washita river, during our explorations and surveys, under command of Lieutenant A. W. Whipple, for a Pacific railroad by the 35th parallel, asking his opinion, and also to tell me the exact locality where he first found his *Gryphæa pitcheri*. Here is the correspondence:

DETROIT, Mich. Oct. 14, 1859.

Professor Jules Marcou, University of Zurich, Switzerland.

My Dear Marcou: * * * The enclosed letter from our friend Dr. Pitcher will give you truly the chief cause of my delay in writing; for often and often I have thought—well in a day or two I shall get an answer to your queries of April 5th and then I shall have something interesting to communicate. The Dr. has promised often and to-day I get his letter. * * *

I remain, my dear Marcou, sincerely your friend

A. W. WHIPPLE,
U. S. Topographical Engineer.

DETROIT, October 12th, 1859.

Capt. A. W. Whipple, U. S. Topographical Engineer.

Dear Sir: Your note of the 2nd of May was left at my residence during my absence in the South, and with it a letter from your friend professor Marcou. My return, though not long delayed, brought with it so many professional engagements, that I was obliged temporarily to lay it aside, where it was forgotten. I hope this negligence of mine will not have effected you in the estimation of that distinguished savant.

"The Kiamechia" is a small stream which empties into the Red river a few miles above Fort Towson. My little fossil which has acquired so much consequence from the discussions into which it has been drawn by scientific names, was picked up on the plains drained by this little rivulet, through which our troops were marking out a road from Fort Smith to Fort Towson, in 1833.

Having a few years before this, in company with a detachment of troops, descended the Alabama and ascended the Red river to Nachitoches, I was observant of the geology of their banks, and on my return to Philadelphia, gave notice to my valued friend Morton, that the formations related to the Mauvaises Terres, were traceable from Mount Vernon by the route I had just passed over and from the Red river to Nebraska. What little knowledge I then had of Nebraska had been obtained from officers of the 6th

U. S. Infantry, who many years before had been on detached service from Council Bluffs.

I write this history to show that I have been a geological observer for a long series of years and to furnish a reason for my sending the fossils obtained on the march from Fort Gibson, *via* Fort Smith to Fort Towson, to my particular friend Dr. Morton.

During the time I was a student of Natural History, more attention was given to the lithological character of rocks than at present or since their fossil contents have been so carefully studied. For that reason I could sooner trust myself in giving an opinion of the character of a given formation from its mineral constituents, than to express one based upon such a critical knowledge of paleontology as is requisite to enable one to distinguish the species of a genus, as nearly related as those of the genus *Gryphæa*. For this reason also I should feel strongly inclined to adopt the opinions of a geologist who formed his judgments in the field, rather than to accept the opinion of a cabinet student, however profound he may be.

Trusting in the ability of professor Marcou to defend his own opinions, I think it is only necessary for me, who have never assumed the responsibilities of authorship in geology, to express my concurrence in them as regards the existence of the Jurassic formation described in the *Geology of North America*.

With respectful consideration, I am very truly yours,

Z. PITCHER.

P. S.—The only map in my possession which shows the course of the Kiamechia, is the one contained in Major Emory's *Report on the United States and Mexican boundary, vol.* I, where it is spelled *Kimichi.*

From this important letter of Dr. Pitcher, it results that not only the locality where the *Gryphæa pitcheri* Morton, came from, was not the Llano Estacado, but also, that it is not even comprised in the state of Texas; being in the Indian Territory, in the district attributed to the Choctaw nation; very near the western boundary of the state of Arkansas. In the maps published lately by the office of the Engineer Corps, war department, that small stream is called *Kiamishi*, *Kiamashi* and even *Kianashi*.

In 1853, I came upon that *Gryphæa pitcheri*, not far west from its original area, at Fort Washita; and farther west up the Washita river, at Comet creek of Lieutenant Whipple's topographical map (Pacific railroad explorations) by 99° longitude and 35°, 50′ of latitude. I saw it also, a few miles north on the banks of the Canadian river, at the great bend of that river. Those two last localities are the most northern and western points where, until now, the *Gryphæa pitcheri* is known to exist with certainty.

Dr. J. S. Newberry, geologist to the Colorado exploring expedition, under command of Lieut. J. C. Ives, 1857-58, gave in his "Geological Report," Washington, 1861, at p. 85, the *Gryphœa pitcheri*, as found by him in his section of the cliffs called "mesa wall, Moquis village;" in his No. 12 of the group of strata and in the succeeding number 13, he mentions another variety of that species under the name *Gryphœa pitcheri* var. *navia*. At p. 94, Dr. Newberry gives the *Gryphœa pitcheri* not the variety, as found by him near Fort Defiance, in the "Canonita Bonita." At p. 97, at Covéro, he says: "The greenish shales, enclosed in the yellow sandstones, contain a large number of *Gryphœa pitcheri*" and finally, at p. 154, he mentions the *Gryphœa pitcheri* var. *navia* found by him on the banks of Pecos river.

In the chapter XI, Paleontology p. 120, Dr. Newberry refers to Morton's *synopsis* for the *Gryphœa*, found by him a few miles east of Fort Defiance, near Covero, banks of the Pecos east of Albuquerque; and he adds: "This is the typical form of the species as given by Morton." Farther on, he refers the *Gryphœa* found by him at the Moqui villages, east of Fort Defiance and on the Pecos, to the *Gryphœa pitcheri* var. *navia* Hall, Pacific R. R. Repts., vol. III ; Geol. Rept. p. 500. Pl. I, figs. 7-10. "This shell should perhaps be considered specifically distinct from the preceding (*G. pitcheri*) * * * these shells should be carefully scrutinized when used as palæontological evidence, and deductions made from them should be given their proper subordinate value ;" thus depreciating as much as he could the value of the genus *Gryphœa*; but taking care not to give a single figure or a single word of description of what he calls *Gryphœa pitcheri* and *Gryphœa pitcheri* var. *navia*.

Sixteen years later, in 1876, Dr. Newberry published his "Report on the exploring expedition from Santa Fe to junction of Grand and Green rivers in 1859" under the command of Capt. J. N. Macomb. At p. 33, he mentions twice the *Gryphœa pitcheri*, as found by him in the valley of the Red fork of the Canadian river. He repeats at p. 52 that he found the *Gryphœa pitcheri* near Galisteo at Capt. Pope's artesian well. At p. 104 he indicates in his section of the valley of the Rito del Sierra Abajo, of the San Juan river, the *Grpyhœa pitcheri* as the only fossil found there. Dr. Newberry, farther on at p. 115, declares that in the Naciniento mountains he found the *Gryphœa* *pitcheri* filling up the rocks in association with *Ostrea congesta* and *Inoceramus problematicus*; an association absolutely impossible. In this second book, as well as in the first, there is neither a single figure of *Gryphæa pitcheri*, nor a word of description; and it is difficult to make out what he means by *Gryphæa pitcheri.*

Dr. Newberry has failed completely to sustain in any way his determination of the *Gryphæa* found by him from the upper Canadian river country, to the Moquis pueblos and the Rio San Juan country, as belonging truly to the *Gryphæa pitcheri* of the Kiamisha river, of the Fort Washita and Comet creek, four and eight hundred miles away from the region explored by him.

Since his two explorations, several geologists have gone over the same roads that he did, and no one has found the *Gryphæa pitcheri*—which according to his phraseology is there in "large numbers," filling up the rocks—in any of the localities indicated by Dr. Newberry. But even more, one of these explorers, appointed by Lieut. Geo. M. Wheeler, on the special and very strong recommendation of Dr. Newberry, did all he could to sustain Newberry's singularly incorrect classification, and did go so far as to color the geological map of a "Part of North Central New Mexico" between Santa Fe, Galisteo and Las Vegas, according to Dr. Newberry's recommendation, making the Jurassic and the Trias "a linear outcrop," unique in geological maps all the world over. And even such an uncompromising sustainer as professor J. J. Stevenson is, in his report (Geographical Surv. west of 100th meridian, vol. III, Supplement, Geology, 1881, Washington) does not once mention having met with a single specimen of *Gryphæa pitcheri* anywhere on the Upper Canadian river or round Galisteo.

Having explored New Mexico five and six years before Dr. Newberry, and being the first to have recognized that the *Gryphæa pitcheri* characterizes the Neocomian in Texas, I can say that I did not find that fossil anywhere in New Mexico. The Neocomian does not exist in Central New Mexico, and certainly not between Galisteo and Pecos; the Upper Cretaceous or Chalk formation lies there in discordance of stratification over Jurassic rocks of Canon Blanco and Cuesta, equivalent and the continuation of the Jurassic formation of the Tucumcari area of Texas.

It is plain that Dr. Newberry took the *Gryphœa dilatata* var. *tucumcarii* or more exactly the *Gryphœa tucumcarii* Marcou—for it is truly a species of the group of the *Gryphœa dilatata* type of the European Oxfordian—for a *Gryphœa pitcheri*, at least in several instances; for he may have referred other species also to *G. pitcheri*, which are neither *G. pitcheri*, nor *G. tucumcarii*. Without seeing his specimens it is impossible to know what his *Gryphœa* of New Mexico are.

The object of Dr. Newberry in quoting so often the *Gryphœa pitcheri* in New Mexico, was perhaps to sustain his conclusion that the "Jurassic rocks do not occur on any part of the route followed by Mr. Marcou, and where he claims to have discovered them." (*Explor. Exped. Sante Fe to Green river*, p. 142.)

Lately, November 18, 1888, the University of Texas School of Geology, has issued a "Circular No. 1," in which we read: "The reaffirmation of the age of the Tucumcarii section along the northwest corner of Texas to be uppermost Jurassic, as originally described by Marcou." It seems that professor Robert T. Hill is the first geologist, since my exploration of the Tucumcarii area, more than thirty-five years ago, who has gone over the ground where I first discovered and described the Jurassic system in North America; and I shall wait until he has published his observations there, before writing another paper on the *Gryphœa tucumcarii*, as a suite and complement to the present paper on the *Gryphœa pitcheri*.

Cambridge, 6 December, 1888.

EDITORIAL COMMENT.

REJOINDER TO DR. LAWSON.

Attention is directed to an interesting communication in the present number of the GEOLOGIST from the able pen of Dr. Lawson. It is written in reply to some condensed criticisms of the theory of the eruptive nature and origin of the great Archæan masses of granitic and gneissic rocks occurring northwest of lake Superior. The criticisms were embodied in the inferences based by the writer on three months' field-study of Archæan rocks in that region, and were directed specifically to

Dr. Lawson's lately published conclusions, because these appertained, as it seemed, to a region possessing very similar characters. Dr. Lawson's reply to these criticisms will probably contribute something to a convergence of general opinion toward the views which he *opposes*. He has brought no new evidence to sustain his inferences; and it is therefore unnecessary to restate my disagreements. Having presented nothing but iterations of former utterances, involving a number of personal contradictions of my statements, joined to a few principles which approach the character of paradoxes, the candid reader, if sufficiently interested may re-examine the original publication of each of us; while those less interested must conclude that the igneous theory of gneisses has been completely exhausted of arguments by Dr. Lawson's first essay.

My former and only contention, it will be noted, was for the original sedimentary condition of the great granitic and gneissic masses—and I cited foliation, among other evidences, as an indication of this. The metamorphism of the original sediments I contemplated in a large way, and suggested, as others have done, that it seems to have reached, many times a state of plasticity, or even semifluidity—reminding the reader that such state would be reached, as geologists now well understand, at a temperature comparatively low—from 700° to 1000° Fah. Yet Dr. Lawson has the originality to declare that "we know nothing of the kind;" and to make this appear, proceeds to disprove something not asserted. In the end, Dr. Lawson makes it appear that he has come almost to my position; for he expresses himself thus: "I experience no difficulty in admitting the possibility of a former sedimentary condition of the gneiss." Then wrapping himself in the "glory" and "immortality" of the "British school of geologists," he disappears from the scene. It is to be hoped Dr. Lawson will interview some other adherents of the "British school." Among these, Sir Andrew Ramsay will tell him that it is impossible to work among the old rocks of Anglesea without being impressed with the idea that the *granite and its veins* "are merely the result of *a more thorough metamorphosis* than was attained in the production of the associated gneiss; that is to say, that *absolute fusion* of portions of the strata occurred under such conditions of depth beneath the surface, that a reconsolidation of the fused portions produced granite."* Jukes will tell him of the Leinster sections which show mica schist on a ridge of granite "which seems to have eaten its way upwards through whatever lay above it," in which case, and others similar, "there could be little doubt of the granite being a metamorphic rock.†" Dr. James Geikie will tell him respecting the gray granites of the southern uplands of Scotland, that "they have resulted from the alteration *in situ* of certain bedded deposites."‡ It is hoped the volume of testimony offered by the "British school" will complete Dr. Lawson's conversion to the sedimentary theory, so that when he reappears on the scene, he will feel justified in substituting "probability" for "possibility." When he reaches that point, no difference will separate us, except as to the meaning which should be attached to "metamorphism." Dr. Lawson says, it is very important for geologists to arrest its action before the softened state of the original sediments is reached. This is a question which he will have to settle with the authorities, and not with me. Dr. T. S. Hunt says, that granite is only the result of an extreme stage of metamorphism; the process which at certain stages only gave rise to gneiss, when carried a step further, went to the length of *fusing* the rocks it affected. § Professor Prestwich of the "British school," thinks that "granite is only *an extreme phase of metamorphism*, and has been formed by the *refusion* of the older sedimentary strata." "Granite may be considered as the same rock, but in a stage of metamorphism more advanced than gneiss *and schists*."‖

The question of the sedimentary origin of the granitic and gneissic masses must be argued on broad and various grounds, among which the existence of conglomeritic gneisses, brought to notice in the present number of the GEOLOGIST, is one of the more novel and convincing. On a different occasion the present writer may undertake a more complete discussion. A. W.

ANOTHER OLD CHANNEL OF THE NIAGARA RIVER.

Dr. J. T. Scovell of Terre Haute, Indiana, writes us that he has established the existence of an old and gravel-filled channel

**Memoirs, Geological Survey*, vol. iii, 2d. ed. p. 243, 1881.

† Jukes' *Student's Manual*, 3d ed, 1872, pp. 146, 242, 366.

‡ *Geol. Mag.*, vol. viii, p. 529, 1866.

§ *Survey of Canada* for 1863, p. 267.

‖ *Geology, Chemical, Physical and Stratigraphical*, vol. i, pp. 433, 435. See also, p. 415.

stretching from the Falls to St. David's. This must be distinguished from the old channel from the Whirlpool to St. David's. Dr. Scovell's observations were made in 1886. He was led to the study as a sequel to extended investigations in the old channels of the Wabash and other streams which preceded it, in Vigo county, Indiana. The old Niagara channel here referred to was "a little more than a mile wide" and its presence is indicated by wells sunk in the sand which now fills it. The village of Clifton, on the Canadian side, lies on the east of it. "The rock, which at Clifton Station rises 150 feet above the brink of the falls, represents the east bank of the old river." This account is accompanied by a carefully drawn map of the entire region.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Recherches sur les Poissons Paleozoiques de Belgique—Poissons du Famennieu par M. Lohest. Analyse par J. Fraipont.

Until recently the Devonian strata of Belgium have been supposed almost entirely destitute of ichthyic remains. During the last five years, however, M. Max Lohest, assistant professor of geology in the University of Liege, has managed to obtain from these same strata a very liberal collection of fossil ganoid fishes. The descriptions of these fossils and the conclusions to be drawn from their discovery and character form the subject of an interesting memoir recently issued by the Geological Society of Belgium.

M. Lohest describes ten new species of ganoid fishes, one species representing at the same time a new genus. In the memoir ten carefully prepared plates illustrate the new species and the richness of M. Lohest's discoveries is apparent when we note that all the (Belgic) species previously known are figured upon a single plate accompanying—the eleventh. Many years ago, Agassiz, in his famous study of the fossil fishes of central Europe, happened upon a few imperfect, large, thin scales. Upon this imperfect and scant material he nevertheless ventured to base the genus *Phyllolepis*. M. Lohest has discovered material by which he is able not only to confirm the insight of his great predecessor, but also to enlarge the genus by the addition of two new species.

A new genus of Lepidosteids is also described—*Pentagonolepis*—which offers a new type of ganoid scales. The scales are pentagonal and may be c nsidered as showing a transitional phase between purely cycloidal and purely ganoidal forms.

As a result of his investigations and a comparative study of the Devonian of western Europe, M. Lohest concludes that the Belgic beds belong to the same horizon as certain parts of the Old Red (Devonian) sandstone of Scotland. It is well known that the Old Red of Scotland and the Devonshire formations of England present such different characteristics alike petrographic and paleontologic, that in Great Britain no synchronism whatever between these deposits can be affirmed. But, M. Lohest assures us, this synchronism is now rendered possible by the discovery in Belgium of an ichthyic fauna comparable to that of the Old Red mingled with a molluscan fauna analogous to that found in Devonshire.

Our author also discusses the mooted question whether the Old Red sandstones were deposited in salt water or in fresh. "With good reason he affirms that the presence in fresh water of our modern ganoids whose affinities with their paleozoic predecessors are so close, does not necessarily imply for the former an identical habitat. All our fresh-water fauna had probably, more or less remotely, an origin marine." But M. Lohest argues that the correlation of the different strata mentioned above by which correlation mollusca, certainly marine, are associated with those ancient ganoids makes a fresh water habitat for the latter extremely improbable.

By his comparative study of the British and Belgic Devonian, M. Lohest is led to propose an explanation of the want of concordance in certain types of fishes occupying successive deposits in the Belgian formation.

He suggests that to assume an alternation of deposits as between Scotland and Belgium explains the difficulty. The Scotch formations biologically fill the hiatus between the older and later deposits on the continent; as if by successive changes in level the ganoid and dipnoid fauna had migrated first from Belgium to Scotland and then back again to Belgium.

A second brochure by the same author, (M. Lohest,) issued at the same time and place as the memoir just considered, announces the discovery of what is esteemed "the most ancient amphibian known" to science. A fragmentary skeleton from the upper Devonian is figured and briefly described.

The Iron Ores of the Penokee-Gogebic Series of Michigan and Wisconsin —With Plate. BY C. R. VAN HISE. (From the American Journal of Science for January, 1889.) The author treats first of the series of rocks in which the iron ores occur—a series running across the country in a direction approximately east and west, from the vicinity of Numakagon lake, Wis., to Gogebic lake, Mich., a distance of more than 80 miles. The series has been tilted to the north at an angle of 60° to 80°, rests on a complex of granites, gneiss and green schists, and is overlain by eruptives of the Keweenaw series. There are four members to the Penokee-Gogebic series,—*first*, cherty limestone,—*second*, feldspathic quartz-slate,—*third*, non-fragmental sediments 800 feet thick and known as the iron-bearing member,—*fourth*, a series of greywackes, greywacke-slates, and mica-schists and slates, in the aggregate several times thicker than the other three members combined.

The iron-bearing formation is traversed by dykes of greenstones or other more or less altered phases of the original basic eruptives. The original rock series, as has been said, dips to the north; the dykes dip to the south, and the angle between the dykes and the original beds of stratification is such that *if the stratified rocks were placed again in a horizontal position the dykes would be vertical.* The ore-bodies rest upon a foot-wall of tilted quartzite and lie in the apices of the V-shaped troughs formed by the quartzite and the intersecting dykes. The iron ore is a soft, red, often porous, somewhat hydrated hematite, more or less manganiferous. The position and shape of the ore deposits preclude the possibility of original sedimentation in place, as well as the possibility of their having been derived by oxidation from iron carbonate in place. There is an abunbance of iron carbonate in the iron-bearing formation but it is for the most part a lean ore containing a large amount of silica. Iron carbonate was doubtless the source from which the hematite was derived, and the author shows how concentration from the siliceous carbonate may have occurred.

Indeed in some parts of the series the process of concentration may be observed in all its various phases and stages. Narrow seams and crevices in the cherty carbonate are often found filled with a rich hematite.

"Along the seams waters bearing iron in solution have passed. These waters have particle by particle dissolved out the chert and replaced it with iron oxide, and where once was lean sideritic chert is rich ore. A part of the iron oxide is due to the oxidation in place of iron carbonate, but the larger part has come from a greater or less distance there to be deposited. The seams of iron oxide at this point are but a few in thickness, but it is probable that the series of changes which have here taken place on a small scale, will upon a larger scale explain the concentration of workable ore-deposits."

The possible mode of concentration of hematite in the apices of the troughs already referred to is given at some length, with a very full and clear statement of the physical and chemical processes involved.

The Great Lake Basins of the St. Lawrence, pp. 247-287. By A. T. Drummond. (From the "Canadian Record of Science," January, 1889.) With a sketch map of the lake region. This paper is a careful examination of the hypsometric and geological features of the basins of the great lakes with a view to reaching inferences touching their origin, age and vicissitudes. The topography of the lake bottoms is studied from the maps of the United States and Canadian surveys and soundings; and this, joined to the existing topography of the land and the geological structure, points out certain conclusions here set forth. The substance of these is as follows: Glaciers had little effect in the creation of the lake-basins or even in shaping their present general outlines. The superficial deposits as others have maintained are less the product of glacier erosion than of secular disintegration since Carboniferous times. Lake Superior dates from Cambrian, Kewenian and Huronian times and as was first shown by Dr. Houghton, is in part at least, a synclinal trough; though volcanic action has had much to do with its origin and the shaping of its coasts. Its early outlet was through Whitefish Bay, as long ago indicated by A. Winchell. Lakes

Michigan, Huron and Ontario were originally the bed of a preglacial river which first crossed the Ontario peninsula along the Niagara escarpment, and was afterward diverted to a course by way of Long Point on lake Erie and the Dundas valley (as already shown by Spencer.) Each of the basins —Michigan, Huron, Erie and Ontario—began as two or three smaller lakes. Lakes Erie and St. Clair are the most recent, and were, not long since, united. While the author minifies the action of glaciers he magnifies that of fractures, faults and changes of relative levels.

Northwest Kansas: *Its Topography, Geology, Climate and Resources*, by Robert Hay, F.G.S.A. This memoir appears to be extracted from the "Sixth Biennial Report of the Kansas State Board of Agriculture," pp. 91-116. It is a well digested and valuable exhibit of the features of the state in the particulars and within the limits mentioned. It is noteworthy that this, like so many similar memoirs in various parts of the country, is the outcome of intelligence and enterprise controlled by the agricultural interest. Every survey of natural resources ought to be conducted with due regard to that interest; but on the other hand, that interest is recreant to itself when it prescribes narrow, unenlightened and miscalled "practical" limits to the researches of the geologist. This memoir is illustrated by profiles and a geologic section, and by numerous scenic photo-engravings. The usual blemishes of public documents printed under contract are seen in the absence of the proof-reader's finishing touches. It may be to the same cause that we are to ascribe the disregard of established usage in the printing, capitalizing and italicizing of the few technical names employed. We are aware that the stock compositors use their own sweet will in dispensing with typographic discriminations and emphasis; but all evidences of either ignorance or neglect present a bad appearance in a western publication.

Les minéraux des roches: By LEVY and LACROIX. 334, pp. 8vo; 12,fr 50. Paris, Baudry and Co., This new and advanced work on microscopic petrography is primarily devoted to the determination of minerals of very small demensions by means of mineralogical and chemical tests in connection with the microscope, and secondarily to a summary description of the different minerals by the application of the new methods. In their researches in optical mineralogy the authors have carried to a greater degree of exact application the laws of polarized light and its modifications by minute crystals when placed on the stage between crossed Nicols, than has been done in any similar work. The different crystal systems are illustrated in great fulness, as they exhibit their characters and extinctions in parallel light, and to these actual observations are applied the theories of mathematical determinations. A similar exemplification is made of the use of convergent light, of refraction, and of polychroism. Another chapter presents a résumé of the more recent methods of micro-chemistry to the qualitative analysis of minerals. Here are summarized, and sometimes modified and improved, the processes of Boricky, Fouqué, Behren s, Haushofer, Streng, Klément and Renard; closing with a table of the principal micro-chemical reactions.

If one gives this work no more than a casual glance he is impressed with the exactness of the science of microscopic petrography, and with the patient and long labor that the authors have expended on the study of minerals in thin sections. No young man can enter upon and prosecute this study as a pastime. He who carries it to completion receives one of the most severe of mental trainings, and he gets an insight into some of the exact methods of nature as inspiring to the devout worker as those of astronomy. This work will contribute, as remarked by M. F. Fouqué, very largely to the extension of the science of the rocks. It is by works of this kind that micrographic methods will finally win the place that is due them in the University programs and in the instruction given in the higher schools. It is a companion, although later to appear, and a natural complement, of *Mineralogie Micrographic*, by Fouqué and Lévy published in 1879.

Discovery of the Ventral Structure of Taxocrinus and Haplocrinus, and Consequent Modifications in the classification of the Crinoidea. By CHARLES WACHSMUTH AND FRANK SPRINGER. From the Proc. Acad. Nat. Sci., Philadelphia, November 27, 1883. This contribution to crinoid morphology may justly be regarded as one of the most important ever chronicled; and its effect upon the present systematic arrangement of the crinoids will be to demand a complete reclassification of the order. The memoir is the ultimatum of a long and heated controversy between the authors and Dr. P. Herbert Carpenter, the eminent English authority on Crinoids. Both found themselves partly in the right; partly in error. But it is indeed gratifying to learn that the views of each are now practically in harmony; and that the final result of the discussion, extending over a long period of years, has been to place the classification of the Crinoidea upon a firmer and more rational basis than even the most sanguine could anticipate a decade ago.

The immediate occasion for the present publication was the discovery of the non-existence of a central plate in the ventral side of *Haplocrinus*; and of the presence of an open mouth in *Taxocrinus*. The so-called central plate in *Haplocrinus* is now proved satisfactorily to be a linguiform extension of the posterior interradial—or as it must now be denominated the posterior oral—instead of being completely separated suturally, as suggested in the Revision of the Palæocrinoidea, part iii. Another structural feature in the calyx of *Haplocrinus*, as disclosed by the present investigation, is the location of the anal opening.

The presence, in *Taxocrinus*, and probably in the Ichthyocrinidæ generally, of an open mouth, surrounded by irregular plates, in number and arrangement similar to the hitherto known "central" and four "proximal" plates, presents suggestions of much significance as effecting the entire classification of the crinoids. The import of the recent discovery is: (1) that structurally the older and later crinoids are not separated as widely as heretofore regarded; (2) that there is no substantiation, as Messrs. Wachsmuth and Springer supposed, for considering the universal presence of interradials in the older crinoids; nor for regarding the mouth in all paleozoic crinoids as closed; (3) that the distinction which Dr. Carpenter considered of the utmost importance as a classificatory criterion—the asymmetry imparted by anal structures—is far from being a constant character, numerous exceptions occurring among the older as well as the recent crinoids; (4) that the various structural features upon which were based the great divisions of the crinoids, as presented in part iii of the Revision, form good distinctive characters; and Messrs. Wachsmuth and Springer propose four great groups into which the *Crinoidea* may be divided, irrespective of age. These well defined primary divisions of the *Crinoidea* are *Camarata*; *Inadunata*, including *Larviformia* and *Fistulata*; *Articulata*, comprising also the *Ichthyocrinidæ;* and *Canaliculata*, which includes most of the mesozoic and recent forms. The paper is illustrated by a plate of 21 figures.

Crotalocrinus: Its Structure and Zoological Position. By Charles Wachsmuth and Frank Springer. From Proc. Acad. Nat. Sci., Phila, November 27, 1888. Another problematic question has been solved in the elucidation of the real structure of a form which has until now been an enigma to paleontologists. In the Revision of the Palaeocrinoidea *Crotalocrinus*, together with *Ichthyocrinidæ*, was placed among the Articulata; but it appears that the basis for such reference was the figures and descriptions of Angelin, now known to be for the most part erroneous. Recently the authors had the opportunity for a critical examination of some excellent material from Sweden and England. It was immediately noticed that in the construction of the calyx this form resembled closely some of the *Platycrinidæ*, and particularly *Marsupiocrinus*. This fact together with various other considerations now places *Crotalocrinus*, and also *Enallocrinus*, among the Camarata. One of the most remarkable characters of this genus is the peculiar net-like arms. But it is now understood that the retiary radial appendages are only highly differentiated arms, which dichotomize frequently, the branches being connected laterally by small processes projecting from each joint, the whole forming an expansion not unlike the fronds of certain Bryozoa. In *Enallocrinus* which is referred also to the same family, the lateral projections of the arm joints are not united, and the arm branches remain free. The presence of hydrospires in the Crotalocrinidæ has not met with the approbation of Dr. Carpenter, who has denied their existence in this family. Messrs. Wachsmuth and Springer, however, have found in the Swedish specimens organs apparently of identical structure and similar position as the hydrospires in the blastoid genus *Orophocrinus*. These structures are entirely covered by the vault, affording conclusive evidence that they could not have been muscle plates, which necessarily should be exposed externally. This paper is accompanied by two heliotype plates. Without question this method is by far the most satisfactory for the reproduction of structural details, but it is quite manifest, that with the plates in question sufficient care was not taken with the negatives and consequently some of the figures are not quite as distinct as others.

Preliminary report of the Dakota School of Mines upon the Geology, Mineral Resources and Mills of the Black Hills of Dakota. Rapid City, Dakota. Transmitted to the Board of Trustees by Franklin R. Carpenter, Dean of the school, November 5, 1888. 8vo. 171 pp. This is a valuable document; indeed one whose scope and scientific as well as practical value do great credit to the enterprising Territory and reflects honor on the authors. It consists of three parts:

(1) Notes on the geology of the Black Hills, by Prof. Carpenter;

(2) Notes on gold mining in the Black Hills, by H. O. Hofman, and

(3) Upon the mineral resources of the Black Hills, by Prof. Carpenter. Each part deserves more extended notice than we can give at this time. The report itself which claims only to be a preliminary one, lacks the maps which were planned to illustrate it. But it is to be hoped that means will be provided by the Legislature to carry on and to finish a work which has been so well begun.

(1) The Archæan rocks are said to embrace two groups, a western one of schists and an eastern one of slates, both containing quartzytes and "great beds of conglomerates." Although the author does not mention it, this agrees with observations made in Manitoba and Minnesota where the Kewatin, a formation essentially of schists, is unconformable below the Animike, a great group of slates and iron-bearing quartzytes. In the same manner the Black Hills' slates carry siliceous iron ore in the northeastern portion of the Hills. In discussing possible equivalents of these series with formations in other parts of the United States, while not accepting unqualifiedly the opinions of Prof. W. O. Crosby, that they are the representatives of the Montalban and the Taconian, he quotes favorably from Mr. Crosby's paper, but with the cautionary remark that the Taconian may have to be removed from the Archæan owing to the recent discovery by Mr. Walcott, of primordial fossils in what has been supposed to be its lowest member.

Prof. Carpenter includes under the term Potsdam both the remarkable quartzytes of the southern portion of the Hills and the nearly horizontal sandstones and conglomerates, and separates it, i. e., both these, from what he has grouped as Archæan, by a general and conspicuous unconformity. He does not however make it plain that there is a conformity of stratification between the quartzyte and the sandstone. There are "interbedded quartzytes" in the upper member, and so there are, to a limited extent, in what may be supposed to be its equivalent along the bluffs of the Mississippi. But there is, besides, throughout Wisconsin and Minnesota, a great unconformable lower quartzyte, and these have in like manner both been styled Potsdam. This great quartzyte exists in southeastern Dakota and it is very reasonable to suppose that its equivalent is also found in the red quartzyte of the southern part of the Hills. Again this lower quartzyte in its manner of occurrence in northern Minnesota lies with *apparent* concordance of stratification on the slates and gray quartzytes of the Animike in some places, and in others it lies unconformably on the older rocks. Its positions in Minnesota accord with the hypothesis that is advanced by Prof. Carpenter that it was deposited during a time of gradual submergence of the pre-existing land. This great quartzyte, which is undoubtedly a part of the primordial, is apparently the equivalent of the "Red Sandrock" and the Granular Quartz of Vermont. It remains to be seen not only whether the lower quartzyte of the Black Hills may not be the equivalent of the top layers of the tilted quartzytes that carry the siliceous hematites there, as mentioned by Prof. Carpenter, and so be a part of his "slate series," but whether they may not show as in southwestern Minnesota and in Vermont, a true primoidal fauna. This would further confirm their supposed equivalence with the primordial Taconian and would also indicate the propriety, even the necessity, of removing the whole "slate series" from the Archæan.

Prof. Carpenter discards the idea that the granites of the Black Hills are of eruptive origin. "They seem to be true veins of the type known as segregated veins—different from the true fissure veins in that they are parallel to the apparent bedding. Usually they are distinctly lens-shaped," but some of them extend for thousands of feet. Their width varies from a few inches to over 100 feet.

(2) Prof. Hofman's report gives the details of the processes of treatment employed in the Black Hills with low-grade auriferous rock. All the mills, except the Caledonia, are constructed and operated practically on the same model—the Homestake—and are also under the management of the same superintendent. Including the Caledonia there are seven mills in operation, and they "drop 640 stamps." After crushing, the ore is subjected, in the Homestake mills, to the battery amalgamation process. This begins in the mortar where mercury is added at intervals and continues till the amalgam reaches the apron plates where it is collected daily. A compromise is made between the two extreme methods of milling gold ore, that which mills large amounts and extracts carelessly as much gold as can be got in the hasty process, and that which extracts as much as possible at the expense of capacity. The amalgamation in these mills is carried on both outside and inside the battery. Within the small area of about 6,000 by 1,600 feet $2,271,341.14 were produced in 1887 from rock averaging $4.00 per ton in free gold. The report enters into the details of construction and operation of each of the mills, and describes the complement of men, accessories and products.

In conclusion Prof. Hofman calls attention to the simplicity and effectiveness of the methods for extracting the free gold, and the waste that ensues in not extracting that which is involved with the sulphurets. This is allowed to disappear with the tailings, without any effort to secure it. He considers these tailings quite rich enough to repay working, as 3 per cent assays $24.00 per ton. In the not very distant future, as the free gold becomes less and less in proportion to the sulphurets as the mines are worked deeper, the question of extracting the gold from the sulphurets will become one of practical and imperative importance.

(3) Prof. Carpenter closes the report with a chapter on the character, occurrence and extent of the mineral resources of the Black Hills, treating of gold, copper, nickel, tin, phosphates, and the various materials useful for construction. We believe this chapter contains the first systematic

presentation of stanniferous mining in America, excepting perhaps some preliminary announcements of the same by Prof. Carpenter before the Am. Inst. of Mining Engineers.

The metalliferous deposits of the Black Hills belong to many different classes, none of which he regards true fissure veins. The gold deposits are primarily of the Archæan age and yield mainly an auriferous pyrite. Sometimes the lodes are of lenticular shape, forming independent members of the slate and schist series, and share in all their folds and contortions, having a columnar cleavage like them coincident with the bedding. From these have been produced placer deposits both of tin and gold. Some of these are of the age of the Potsdam and some are Quaternary. The latter yield yet some gold, but their richer parts, like the Deadwood gulch, are practically exhausted. The existence of gold in the Potsdam placer proves that the Archæan was auriferous when it was submerged by the encroaching Potsdam sea. The subsequent laccolitic intrusion of felsite, below the Potsdam in some places and above it in others, corresponding to the laccolites of trachyte and other acid eruptives such as those described by Mr. Gilbert in the Henry mountains, is another instance in which the acid eruptive was not able for some reason to reach the surface, and is perfectly comparable, both in age and lithology to some of the felsytes found on the north shore of lake Superior.* The rock was gold-bearing before the advent of the porphyry. Its effect seems to have been to concentrate the gold and to render it more free-milling.

The tin deposits were discovered in 1877 by professor Richard Pearce, from samples of black sand sent to him from the Black Hills. He found it to be cassiterite. Since then the known area of tin ore has been constantly expanding, but principally since 1883 under the instigation of major A. J. Simmons who employed Prof. W. P. Blake to investigate the find.† Tin is now found throughout the area surrounding Harney's peak, and in the granite areas extending south and west of Custer City, as well as in the small Archæan area west of Deadwood, a part of which extends into Wyoming. Gold and tin associated in pyrite, are here found in veins of coarse granite. These are not intrusive but segregated veins lens-shaped and parallel with the bedding of the schists.

RECENT PUBLICATIONS.

1. *State and Government reports.*

Royal society of Canada, Proceedings and Transactions, vol. v, contains, with other papers, the following: On a specimen of Canada native platinum from British Columbia, by Hoffmann; Microscopic petrography of the drift of central Ontario, by Coleman; The faults and foldings of the Pictou coal field; Note on fossil woods and other plant remains, from the Cretaceous and Laramie formations of the western territories of

*Compare: *Some thoughts on eruptive rocks, with special reference to those of Minnesota*, N. H. Winchell. Proc. A. A. A. S. Cleveland. 1888.

†Am. Jour. Sci. Sep. 1883.

Canada, by Sir William Dawson (noticed in the GEOLOGIST vol. i, p. 195); Notes on the Physiography and Geology of Aroostook county, Maine, by Bailey; The correlation of the Animikie and Huronian rocks of Lake Superior, by McKellar; The geography and geology of Baffin land, by Boas; Glacial erosion in Norway and high latitudes, by Spencer; (reviewed in the GEOLOGIST, vol. ii, p. 432;) On the theory of glacial motion, by Spencer; the petroleum field of Ontario, by Bell; Illustrations of the fauna of the St. John group, by Matthew, Quarto volume. Two plates of fossils.

Kentucky geological survey. Report on Geological and economic features of the Jackson purchase region, embracing the counties of Ballard, Calloway, Fulton, Graves, Hickman, McCracken and Marshall. By R. H. Loughridge, Roy. 8vo. 357 pp.

Some New York minerals and their localities. By F. L. Nason. Bulletin No. 4 of the *New York State Museum.* Aug. 1888.

Contributions to Canadian palæontology, Vol. 1. By J. F. Whiteaves, pp. 91 to 149. *Canadian Geological Survey.*

Ores of North Carolina, being Chap. 11, 2nd vol. *Geological Survey of North Carolina.*

Production of gold and silver in the United States. *Report of the Director of the Mint*, for 1887. Jas. P. Kimball, 8vo. 375 pp.

The *Proceedings of the U. S. Nat. Museum*, 1888, contain the following papers by F. H. Knowlton, Asst. Curator. (1) New species of fossil wood (Araucarioxylon arizonicum) from Arizona and New Mexico. (2) Description of two species of Palmoxylon—one new—from Louisana. The following are by Leo Lesquereux. (1) List of fossil plants collected by Mr. I. C. Russell at Black creek, near Gadsden, Ala. with descriptions of several new species. (2) Recent determination of fossil plants from Kentucky, Louisiana, Oregon, California, Alaska, Greenland, etc., with descriptions of new species; also the following by Lester F. Ward. The paleontologic history of the genus Platanus.

Pennsylvania geological survey, Annual report, 1886, J. P. Lesley. Part iv; Paint, iron ore, limestone, serpentine; with an atlas volume; pp. 1331—1618, 8vo.

Coal. By Chas. A. Ashburner. Abstracted from the "Mineral resources of the United States," calendar year 1887. *U. S. Geol. Sur.*

Forty-first annual report of the Trustees of the State Museum of Natural History, for 1887, 8 vo. 390 pp. xv. plates, Albany, N. Y.

Chemical report of the coals, soils, clays, petroleum, mineral waters etc., etc. of Kentucky. By Robert Peter, M. D. vol. A. Part iii, of the geological survey of Kentucky. Royal 8vo. 171, pp.

Report of the State of Illinois Historical Library and Natural History Museum. By Josua Lindahl, Curator. An administrative report of seven octavo pages.

Reports on the geology of Henry, Shelby, Oldham and Mason counties, Kentucky. By W. M. Linney. With colored county maps. Roy. 8vo. each county report paged independently. *Ken. Geol. Sur.*

Final Report of the State Geologist, vol. 1. Topography, Magnetism, Climate. By Geo. H. Cook. 439 pp. Roy. 8vo. One general state map and one relief map of the state showing elevations above the sea by different shades of color. *Geol. Sur. of New Jersey.*

2. *Proceedings of scientific societies.*

The Journal of the Elisha Mitchell Scientific Society of North Carolina contains: Of the three Crystallographic Axes, W. B. Phillips; Chlorination of Auriferous Sulphides, E. A. Thies; Mica Mining in North Carolina. W. B. Phillips; The change in Superphosphates when they are applied to the soil, H. B. Battle.

Twenty-second report of the Trustees of the *Peabody Museum of Harvard University.* Report of the Curator, F. W. Putnam. 60 pp. 8vo.

3. *Papers in scientific journals.*

American Naturalist Nov. No. Cretaceous Floras of the northwest Territories of Canada. WILLIAM DAWSON. On the Glacial Drift and Loess of a portion of the Northern-Central Basin of Iowa. CLEMENT S. WEBSTER. *Dec. No.* Surface Geology of Burlington, Iowa. CHARLES R. KEYES. The Evolution of Mammallian Molars to and from the Tritubercular Type. HENRY F. OSBORN. The Artiodactyla. E. D. COPE.

Amer. Jour. Sci. Jan. No. Description of a new mineral beryllonite. DANA and WELLS. The iron ores of the Penokee-Gogebic series of Michigan and Wisconsin. C. R. VAN HISE. A quartz keratophyre from Pigeon point, and Irving's augite-syenites. W. S. BAYLEY. On the occurrence of hanksite in California. HENRY G. HANKS. Sperrylite, a new mineral. H. L. WELLS. On the crystalline form of sperrylite. S. L. PENFIELD.

Canadian Record of Science, vol. iii, No. 5. The Great Lake basins of the St. Lawrence. A. T. DRUMMOND. Note on Balanus hameri in the Pleistocene at Rivière Beaudette. SIR WM. DAWSON. Modern concretions from the Ste. Lawrence. REV. PROF. KAVANAGH; with remarks on cylinders found in the Potsdam sandstone. On the classification of the Cambrian rocks in Acadia. G. F. MATTHEW, Montreal. Published by the Natural History Society.

4. *Excerpts and individual publications.*

Date of the publication of the report upon the geology of Vermont. By C. H. Hitchcock. *Proc. Bos. Soc. Nat. Hist..* (Replies to the strictures of Mr. Marcou.)

Inorganic coal and limestone, in an electro-chemical world. By T. S. Emery. 8vo. 139 pp. seven plates. Philadelphia.

The Ivorydale well in Mill creek valley and an ancient channel of the Ohio river at Cincinnati. By Prof. Jos. F. James. *Jour. Cin. Soc. Nat. Hist.*

The Structure and Development of the Visual Area in the Trilobite, Phacops rana, Green. By J. M. Clarke. *Journal of Morphology, vol. ii. No. 2.*

The life history of Niagara. By Dr. Julius Pohlman. *Trans. Am. Inst. Min. Eng.*

Cement rock and gypsum deposits in Buffalo. By Julius Pohlman. *Trans. Am. Inst. Min. Eng.*

Fossil plants collected at Golden, Colo. Dr. Leo Lesquereux. *Bul. Mus. Comp. Zool.* Geol. Ser. vol. ii.

On three geological excursions made during the months of October and November, 1887, into the Southern Counties of Maryland. Discovery of Fossil-bearing Cretaceous Strata in Ann Arundel and Prince George counties, Maryland. Last two by W. B. Clark. *Johns Hopkins University Circulars*, 1888.

A new Ammonite which throws additional light upon the geological position of the Alpine Rhætic. By W. B. Clark. *Am. Jour. Sci.* Feb. 1888.

Some recent aspects of scientific education especially as influenced by the study of the natural sciences. Inaugural address by Prof. Robt. T. Hill, Austin, Texas, 1888.

Bulletin of the Museum of comparative Zoology at Harvard College. Geol. Ser. Vol. ii. With map and 2 plates. pp. 41. On the geology of the Cambrian district of Bristol county, Mass. By N. S. Shaler.

On the geology of Great Barrington, Mass. By Dr. Alexis A. Julien. *Trans. N. Y. Acad. Sci.*, V., 1887.

On the Eozoic and Paleozoic rocks of the Atlantic coast of Canada, in comparison with those of western Europe and of the interior of America. By Sir J. Wm. Dawson. *Quart. Jour. Geol. Soc.* November, 1888.

On Cretaceous plants from Fort McNeill, Vancouver Island. Sir W. Dawson. *Trans. Roy. Soc. Canada.* 1888.

5. *Foreign publications.*

Foldtani Kozlony, for August to October, 1888, contains, Spuren einstiger Gletscher auf der nordseite der hohen Tatra. By Dr. Samuel Roth. Die Action der Eiszeit in Ungarn. By Dr. J. von Szabo. Krystallographische Untersuchungen. By Karl Zimanyi. Budapest, 1888.

Annual Report of the Department of Mines, New South Wales, 1887. Sydney, pp. 216.

The invertebrate fauna of the Hawkesbury-Wianamatta series of New South Wales. By Robert Etheridge, Jr., pp. 21, 2 plates. *Mem. Geol. Sur.* of *New South Wales.* Sydney, 1888.

Uber die geologischer Verhältnisse der Gegend nordwestlich vom Achen-see mit besonderer Rücksichtigung der Bivalven und Gasteropoden des unteren Lias. By W. B. Clark.

Department of Mines, Sydney. Report (1887) contains the following:— Mineral Products of New South Wales. By Harrie Wood. Notes on the Geology of New South Wales. By C. S. Wilkinson. Description of the seams of coal worked in New South Wales. By John MacKenzie.

Congrés géologique international, London 1888. Résumés des rapports des sous-comités Americains. Rédigé par le Prof. Persifor Frazer; traduit de l'Anglais par le Prof. G. Dewalque.

CORRESPONDENCE.

On Glacial Erosion: by Prof. J. W. Spencer, M.A., Ph.D., F.G.S.— This paper is a reply to the courteous review of "Glacial Erosion in Norway and High Latitudes," which appeared in the American Geologist of Dec. 1888. A reply to the questions there asked may remove some doubts from the minds of those who do not repose in complaisance with one or the other of the schools of surface geology. In this paper, I shall fortify myself with the observations of early glacialists, who made their studies in the Alps, when the glaciers were advancing down the valleys, a condition which only a very few of our oldest men have seen—phenomena not commonly known to the working glacialists of America, as their papers are difficult of access.

My reviewer says that Dr. A. Geikie* visited one of the regions described by me and came to "contrary results." My paper was first published as "Notes on the Erosive Power of Glaciers, etc," in the Geological Magazine of London, and was not an attempt at a monograph. I shall here show how Dr. Geikie's and my own conclusions do not reflect on either of us as observers. I had his paper with me in the field. Here is what Dr. Geikie says upon the glacier in question—that at head of Holands fjord, just inside of the Arctic circle. "But the feature which most interested us was the relation of this large glacier of Fondalen to the moraine deposits of the locality. The high terrace so marked along the sides of the Holands fjord enters this valley, and extends on the mountain sides, as far, at least, as the foot of the glacier. Hence the gravelly plain and the moraine mounds that separate the glacier from the fjord are overlooked on either side by a raised sea-beach. In examining attentively the nature of the material of which the mounds nearest the glacier were composed, we were struck with the difference between it and the loose, coarse character of the ordinary moraine rubbish, and its resemblance to the upper boulder clay of Scotland. The glacier is pushing a great nose of ice into and over these mounds, so that freshly exposed sections are abundant. The deposit is a loose sandy clay or earth full of stones, among which the percentage of striated specimens is not large. The larger blocks of gneiss and schist appeared to us not to occur in the clay, but to be tumbled down upon it from the surface of the glacier. We had hardly begun to look over the surface of the clay ere we found fragments of shells, and in the course of a few minutes we picked up several handfuls, chiefly of broken *pieces of Cyprina islandica*, but including also single valves of *Astarte compressa*, etc. We even took out two or three fragments which were sticking in the end of the glacier. * * * We were looking not merely upon ordinary moraine heaps—the detritus carried down on the surface of the ice and discharged upon the bottom of the valley. The glacier was engaged in ploughing up the marine sediments which had been formerly deposited upon the submerged floor of the valley, and on heaps of earth and clay now torn up were thrown the gravel and blocks brought down by the present glacier."

*Geological Sketches, by A. Geikie.

Having been brought up in America under the constant assertions, plausibly maintained, that the glaciers were great diggers, the proof of which I failed to see in the Alps, where I saw no glaciers pushing against their moraines, and with the above quoted description by Dr. Geikie before me, I was dazed by what I saw in Norway. At first I fully concurred with Dr. Geikie, and had the glacier shrunken back 200 feet before my arrival, I could have added nothing to the knowledge of the dynamics of this glacier. I will repeat what I saw, and have figured: **"Svartisen glacier, at the head of Holands fjord, descends to within sixty feet of the sea, where it ends in a morainic lake of considerable size, the northern side of which is filled with the glacier. The water of the lake rises, in part, to the level of the ice, or over it, where the waves of the lake are depositing sand upon its surface. The glacier being unable to advance, the lateral pressure has forced up an anticlinal ridge, or rather dome in the ice, to a hight of fifteen feet, along whose axis there has been a fracture and fault. Upon this uplifted dome rests the undisturbed sand stratified in perfect conformity to the surface, which was formerly just below the surface of the lake. As the ice about the line of fracture melts, the sand falls over and leaves a sand cone, of which there were examples —one at the end of the lake, and two in the centre—but the nuclei of the mounds were of solid ice. By this lifting process, pockets of loose clayey sand were thrown on top of the morainic matter, producing thus the appearance of having been ploughed up by the glacier to even several yards beyond its termination, which has not been the case."

Had these evanescent domes not been there I should have reported the ploughing action of the glacier, and Dr. Geikie does not report having seen them. The shells had been brought into the disturbed boulderless part of the moraine by the action of the waves of the lake upon the marine deposits described by Dr. Geikie.

In many places in Norway I have seen glaciers advancing against both rock and morainic barriers, and when the ice is high enough it simply flows over upon itself. It is a question of physics which will yield—the huge mass of earth and rock or the semiplastic ice of the tongue which ought to form the plough-share of the glacier. The surprise at finding the above and previously undescribed results made me careful not to underrate the amount of ploughing that might have occured here.

If the Norwegian snow-fields, which are the largest in Europe, are too insignificant to build up by inductive reasoning the theory of glacial geology, how much more so are the snow-fields of the Alps. Still I will be rash enough to appeal to the Alps of forty-five years ago or more, when the glaciers were yet advancing against their moraines, and to the names of Forbes, Collomb and Charles Martins, and even to that of Charpentier, to show the harmony of my conclusions with those of other observers who have had my own favorable opportunities for investigation, and not to speculation of what glaciers can do, or ought to do, unless supported by observed facts.

**Glacial Erosion in Norway and High Latitudes by J. W. Spencer, Am. Nat. 1888.

Forbes† describes the glacier of Brenva and others as flowing over their moraines. Certainly none knew better the movement of glaciers than Forbes, for although combatted, there has been no advance in the knowledge of the causes of their flow beyond his own plastic theory, except to support his views.

Collomb‡ "(who was with Agassiz) said that the Aar glacier(the basis of Agassiz's work) pushed against its moraines, scarcely deranging, and slid over without excavating them. He also says that the glaciers of the Rhone, Allée Blanche, and those about Zermatt and Chamouni did not penetrate the soil, although affecting the surface of a meadow very slightly. Charpentier made similar observations, and generalizes thus: "When a glacier reaches the bottom of a large valley, so that it can expand freely on all sides, it ceases to dig and to raise the flat earth which it meets, especially if it be deprived of vegetable soil, and gravelly enough not to retain the water which it absorbes."§

Dr. Charles Martins ‡‡ speaking with equal authority, says: "Un glacier ne pénétre pas dans terrain meuble a la manière d'un soc de churrue qui entame le soc et l' affouille. Il agit comme grande polissoir qui le nivelle dans surfaces néglées."

In the region of lake Geneva and in Val d' Aosta, where the ancient glaciers were at least from 2200 to 2700 feet thick the older subjacent gravels were not disturbed as has often been shown by the Swiss school of glacialists. This shows that the action of the great ancient glaciers upon subjacent gravels was one in kind with that of the modern living glaciers. If we ignore those phenomena, we must pass into the field of speculation which admits of no proof. The ploughshare of the glacier cannot be the bottom but the snout, as the pressure of the mass is a great leveller.

We know but little of the action of glaciers under partial flotation when they are projecting into the sea, (but here I am willing provisionally to allow, if necessary, a different action from that of land glaciers,) which are the only ones that are known to have the phenomenal velocity; and these are gathered from great basins, whose aggregate discharge through a single channel must produce an accelerated velocity greatly in excess of that of the parts.

My reviewer asks if the boulders, which I have described as causing the subjacent parts of the glacier to be channelled, when these come in contact with the bed-rocks, owing to the adhesion of the stones to the rock from friction, may not have melted through the ice? Go and see; for I have seen them in so many stages of contact and enclosure in the ice as to preclude the idea that the channellings were due to the melting of the ice owing to the greater conductivity of heat by the stone, for the enclosed stones have the same temperature as the enclosing ice; and any increase of heat in the caverns, visited, under the ice affected the body of the

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†Travels in the Alps, by J. D. Forbes, 1843.

‡Cit. by Sir R. I. Murchison, Add. Roy. Geog. Soc., 1864.

§Essai sur Les Glaciers etc., by J. de Charpentier, 1841

‡‡Revue de Deux Mondes, March, 1864, p. 87.

glacier, through the mass of bed rock as quickly as through the more recently and only partly exposed stone.

Whatever bias of an anti-glacial character I may show it is the result of the evidence of field observations against the widely disseminated speculations and dogmatic teachings of glacialists, whose theories have in the language of my reviewer, become "tyrannical."

My conclusions as to the power of glaciers to erode are in harmony with those of the majority of European geologists, who have had the best opportunities of studying living glaciers. Despite the "tyrannical theories", modern research is constantly showing that the patent rights of the glaciers have been and are being infringed by other agents. Thus Mr. Hugh Miller,¶ a glacialist, states that "in mere indiscriminateness of composition (which is the character most emphasized) the till is not to be distinguished from the boulder-clay formed under berg or raft-ice, such as the highest marine clays of the Norwegian coasts." The same is true for the marine boulder-clay of the St. Lawrence valley. Mr. E. Whymper, and Prof. T. Bonney,¶¶ and others regard glaciers and snow-fields as having, comparatively a protecting influence. All of these observations and conclusions show that glacial geology is still a debatable field, and not settled as our glacial friends would wish.

Advices from the village of Kerschkaranza, in the Kola peninsula, on the White Sea, state that on January 5 a curious and destructive phenomenon occurred there. At 4 a. m. the inhabitants were awakened by a peculiar, dull, heavy detonation, like that of distant artillery.

Piled up to a hight of several hundred feet, the ice in consequence, no doubt of the enormous ocean pressure without was seen to begin moving from the north-west towards the shore. The gigantic ice-wall moved irresistibly forward, and soon reached the shore and the village, which it completely buried, the ice extending a mile inland. The forward movement of the ice lasted four hours.*

Dr. Percy Mathews, for several years medical officer of the Hudson's Bay Company, at York Factory has furnished me with the following facts relating to the action of the ice at the mouth of Hayes river as it empties into Hudson's bay. The mouth of the river is about twenty feet deep. In it the ground-ice charged with mud, forms to a thickness of four feet. After the surface ice, which is sometimes seven feet thick in the channel of the river, is broken up, the ground-ice rises and is carried out, bearing its load, by a considerable current. Owing to ice-jams in the river, the ice is forced over the low shores, polishing stones, frozen in the soil and is itself sometimes grooved. It also digs and scours out the channel. The stones, brought down by the river-ice, have often a weight of twenty or thirty, and occasionally of over a hundred tons. In one case a six-ton anchor, frozen in the soil, had its shaft, nine inches in diameter, planed off as if it had been so much wood. As the spring tides rise here to 27 feet, they aid largely in piling up the ice; and when the packs of ice meet, much of their mass is crushed into fragments.

¶Geol. Mag. 1888, p. 273.
¶¶Geol. Mag. 1888, p. 548.
*"Nature", June 28, 1888, p. 205.

These observations on the joint action of river-ice and coast ice, on a very gently shelving shore, are worthy of record, as we have so few observations, compared with the vast area of high latitudes, wherein the coast-ice is playing a most important part as a geological agent.

The observations in Lapland, first cited, are of extraordinary interest; as herein is an agent, capable of effecting a greater amount of surface erosion, than ice in any other form; and the catastrophe at Kerschkaranza, seems to be more phenomenal than even those recorded by Sir George Nares, off the Grinnell coast; but this is probably owing to our ignorance of the uninhabited ice-bound coasts of arctic lands.

University of Georgia, Athens, Ga., Dec. 26, 1888. J. W. SPENCER.

TWO SYSTEMS CONFOUNDED IN THE HURONIAN. In the *Quarterly Journal of the Geological Society* for February 1, 1888, appears an important communication from professor T. G. Bonney which I have only recently found time to read with due attention. I wish now to make a note upon it. The communication is entitled, "Notes on a part of the Huronian series in the neighborhood of Sudbury, (Canada)." Professor Bonney, passing off the gneisses of recognized Laurentian age, begins his investigations on rocks supposed to be Huronian, and extends his studies westward more than fifty-nine miles beyond Sudbury—though most of his studies lie within two miles of Sudbury. The first rock encountered "is mainly composed of quartz and feldspar, with but little mica, though occasional thinnish bands of a fissile mica-schist occur. It is much jointed, and appears to have a flaggy bedding, reminding me," he says, "in its general aspect, of parts of the Highland 'eastern gneiss' in Glen Docherty, (that is where the crushing is less conspicuous) or of the schistose series on the south side of Perth Nobla, Anglesey". This zone is less than a mile wide, when "outcrops of a rock distinctly fragmental are exposed". A dark quartzose rock is observed west of Sudbury, and this grows more coarsely fragmental—the "fragments now showing very distinctly on a weathered surface, by a slight bleaching, some looking rather like a felsite, others like a holocrystalline (?gneissose) rock." Next comes a coarse breccia, looking rather like an agglomerate—the matrix a more or less fine-grained quartzite. Then follows a quartzite without fragments, and then another group of fragmental rocks, slightly reddish-gray, resembling a microgranulite with dark green spots, and these include "gneissose and schistose rocks, and a greenstone, or possibly chlorite schist." Professor Bonney erroneously, I suspect, suggests that these may be Logan's "slate conglomerate," though he leaves the matter undecided. This belt of eastern (or lower) "Huronian" rocks is obviously distinct, he says, from the Laurentian; by which I understand that the mica-schists mentioned are sufficiently distinct from the older gneisses. These older Huronian "rocks are seen under the microscope to consist chiefly of quartz, feldspar and a brownish mica." "The rock certainly exhibits a fragmental structure with secondary reconstruction."

After this, but still within two miles of Sudbury, the character of the geology plainly changes. The rocks are grouped as **A.** Quartzites—ordinary, conspicuously fragmental, and fine-grained-schistose; B. Agglomeratic or conglomeratic rocks. These are carefully described, but there is no occasion here for reproducing the descriptions. The quartzites possess few peculiarities. The breccias are various, but predominantly quartzose, and generally with a matrix containing quartz and feldspar. Some of these are suspected to be igneous in origin, and one seems to possess the characters of a volcanic ash. Among all the rocks described, I find no description answering the characters of the great "Plummer argillites" or "slate conglomerates" of Logan, and I am uncertain whether this member of the Huronian passed under professor Bonney's observation.

The author naturally conceived the view common to the Canadian geologist (but erroneous as I think) that the Huronian embraces the entire complex of beds to the "Laurentian gneiss." Evidently, in passing off the gneisses, he arrived at the usual belt of crystalline schists—the "Vermilion group" of the Minnesota Survey. In proceeding from these, a transition was observed toward less crystalline rocks, and in the midst of these was the condition which I have designated "nascent mica schist" in which the mica folia are exceedingly minute. Still beyond, the mica is still less conspicuous, the quartz and feldspar more soiled and much mingled with particles of "dust." This is my graywackenitic rock—though not well constituted graywacke. It escapes clearly from the group of crystalline schists. In northeastern Minnesota, this is succeeded by sundry conditions of earthy schists—argillitic, sericitic, chloritic, jaspilitic and hæmatitic. All these are wanting in the vicinity of the Thessalon, Missasagui and Blind rivers, as also the greywackenitic and crystalline-schistic rocks. It may be they are wanting in the vicinity of Sudbury. In the valley of the Thessalon, some twenty miles from its mouth, the dark, siliceous argillites appear, which lie near the bottom of the proper Huronian series. I take the liberty to say "proper" Huronian, because I find these recognized Huronian rocks, northwest of lake Superior, succeeded downwards by a break which makes them necessarily the lower limit of a system.* I do not regard therefore, as Huronian, the series of rocks succeeding the Plummer argillites (Animike slates) downward, though the Canadian geologists may so regard them. I entertain a suspicion that most of the rocks investigated by professor Bonney belong to the lower series. Even among these, as I have just stated, are two groups, before we reach the "Laurentian gneiss." Of these two, the upper sub-Huronian group, is embraced under Dr. Lawson's term "Kewatin," but is not co-extensive with it. The lower is the "Vermilion group" of the Minnesota Survey, to which Dr. Lawson applied also the designation "Couchiching group."

Now professor Bonney notes the evidence of rocks of widely different age within the compass of the series pointed out by the Canadian geologists as "Huronian." His conclusions are in part as follows:

"Among the rocks in this region at present referred to the Huronian, two groups may be distinguished, depending on the degree of alteration observed." "This distinction must indicate either (*a*) that selective meta-

* This is a stratigraphic unconformity which I have described in *American Geologist* Jan., 1888, and more in detail in the *XVIth Annual Report Minnesota Geological Survey*, pp. 256-259, 264, 323.

morphism has produced marked effects * * * (*b*) that we are dealing with a series of great thickness, the deposition of which occupied a very long time, so that the lower beds are more altered than the higher, or (*c*) that under the name of Huronian two different series are included." He concludes: "I incline to the latter opinion, viz, that the two distinct groups, of which, one at any rate, is pre-Cambrian, are included under the name Huronian."

This conclusion accords with my own convictions. Even if professor Bonney's studies did not extend to the "slate conglomerate" (Animike), he encountered two systems of rocks—the crystalline schists below, and probably the earthy schists above—the iron-bearing schists of Marquette and of Vermilion lake. If his studies embraced the Animike slates, they extended to a system stratigraphically discordant with the iron-bearing schists, and therefore, beyond question, a system of much more recent origin. Geologists who embrace under the single designation "Huronian," the entire complex of rocks from the top of the Animike slates to the "Laurentian gneiss," confound three separate systems under a single term. There "*is* a Huronian System," but not so large a one as this.

Ann Arbor, Feb. 1, 1889. ALEXANDER WINCHELL.

Artesian Well, Woodhaven, L. I., N. Y. In the August, 1888, number of the AMERICAN GEOLOGIST the writer gave an unfinished report of the boring at the Woodhaven well on the south side of Long Island, promising to furnish fuller data when the work was completed. The boring went on until the rock *in situ* was reached at a depth of 556 feet. The gneiss rock was also penetrated to the depth of 15 feet when the work of boring was abandoned owing to the filling in of the bore by the fine micaceous sand overlying the rock. The well was not a success, as water is not found in any great quantity below the level of the ocean. The boring is valuable, however, in a scientific point of view, as showing the nature and depth of the superficial deposits on the south side of Long Island, as this is the only place, we believe, where the rock *in situ* has been reached south of the terminal moraine.

Woodhaven is situated about a mile from Jamaica Bay and not long ago the tides would wash up, through the old river channels, as far as the village, yet strange to say, not a single shell, or other marine matter has been found as far as we can detect in the borings which have taken place. Even on Barnum's Island, only two miles from the ocean, down to the depth of over 400 feet, nothing marine was found except a small fragment of a crinoidal stem, probably washed in from some older palæozoic formation. Mr. E. Lewis, in his "Ups and Downs of the Long Island Coast" thinks that the surface beds to a depth of 180 feet are post-glacial, while all below them are pre-glacial, but really there is nothing in the specimens before us by which their age can be determined, unless some of the lower clays should prove to be, when properly analyzed, Cretaceous.

Down to 298 feet the material is very much like the glacial detritus spread out over the island in general. The lower beds of clay show fine rootlets and other vegetable matter, but it would not be safe to infer from this that they *grew* where found, for the pieces of carbonized wood found in the same deposits were evidently drifted in, as this drift wood is found at various depths all over the south side of the island.

This little isle by the sea still remains a geological puzzle. Stratified beds are found 260 feet above the level of the ocean as well as 500 feet below it. At Calvary Cemetery the rock was struck at a depth of 182 feet in the glaciated part of the island. In the unglaciated part, as at Woodhaven not more than three miles south of the former place, the rock is eroded to the extent of over five hundred feet.

The following gives the results of the boring at Woodhaven:

1 to 113 feet.	Reddish sand and gravel.
113 " 120 "	Sand and coarse gravel.
120 " 132 "	Pepper and salt sand.
132 " 144 "	Reddish sand.
144 " 213 "	Reddish sand and gravel.
213 " 218 "	Tough whitish clay.
218 " 246 "	Reddish sand.
246 " 298 "	Clay containing pebbles.
298 " 315 "	Light bluish clay.
315 " 358 "	Clay with rootlets.
358 " 375 "	Fine sand and clay.
375 " 385 "	Clay, wood and vegetable matter.
385 " 417 "	Grayish sand.
417 " 419 "	Light bluish clay.
419 " 430 "	Sandy clay.
430 " 433 "	Bluish clay.
433 " 436 "	White clay.
436 " 443 "	Light gray sand.
443 " 456 "	Dark gray sand.
456 " 460 "	Coarse white beach sand.
460 " 475 "	Clay, pebbles and fine beach sand intercalated.
475 " 480 "	Clean gravel.
480 " 500 "	Sand and gravel.
500 " 510 "	Quartz gravel and sand.
510 " 515 "	Grayish sand.
515 " 518 "	Clay or marl?
518 " 540 "	Dark clay.
540 " 556 to rock.	Gray, micaceous sand probably ground out of the underlying gneiss rock.

JOHN BRYSON.

1309 Baxter Ave., Louisville, Kentucky.

PERSONAL AND SCIENTIFIC NEWS.

AT THE "DRANE COLLIERY," CLEARFIELD COUNTY, PENNSYLVANIA, electric motors are in use for operating coal-cutters. Electricity seems to possess many advantages over compressed air as a means of applying power in coal mines. The machinery is more readily handled, and the cost of equipment and maintenance is very greatly reduced.

THE MCAULEY PROCESS OF BURNING PULVERIZED FUEL, a process invented by J. G. McAuley of Lansing, Michigan, is likely to work something of a revolution in the consumption of fuel. A very good description of the process is given in "*Science*" for December 28th, 1888. A test trial of the process was made at the works of the Warren Iron and Steel Co., at Warren, Ohio, some time ago and was attended with the most satisfactory results. Two puddling-furnaces were charged with iron, and pulverized coal to the amount of 12,260 pounds was used in putting it through the puddling process. The fuel cost $5.43. By the old method the process would have required an amount of coal worth $16.50, or about three times what is needed by the McAuley method. Moreover there is a saving in iron by the McAuley method that more than pays for the fuel.

PROFESSOR MEEK, OF COE COLLEGE, CEDAR RAPIDS, IOWA, a former pupil of President Jordan, is at work on the native fishes of Iowa, and has already made considerable progress.

PROF. F. H. SNOW, OF THE KANSAS STATE UNIVERSITY recently made careful examination of the rocks now being mined for nickel in Logan county, Kansas. According to his report there is an entire absence of crystalline rocks. The so-called "nickel ore" is the prevailing fragmental rock of the Tertiary age, the characteristic conglomerate or pudding-stone which overlies the eroded surface of the Niobrara limestones and shales. The color of this rock at the "mines" is darker than that of the ordinary conglomerate, but it is unmistakably the same kind of rock. A chemical analysis of specimens of these rocks by Prof. E. H. S. Bailey reveals the presence of nickel and cobalt in very small quantities. A special examination of one specimen said to be among the richest, showed not more than one third of one per cent of cobalt and one-tenth of one per cent of nickel. The specimens examined were of his own selection.

Prof. Snow explains the presence of nickel in this rock by referring it to meteoric origin, from dust that fell into the old Tertiary ocean, in the same manner as it now falls into the Atlantic ocean, as revealed by the dredgings of the Challenger expedition.

DR. HALSTEAD has resigned the professorship of Botany in the Iowa Agricultural College to take a position in connection with the Agricultural Experiment Station at Rutger's College, New Brunswick, N. J.

MR. CHAS. A. HELVIE of the State University at Bloomington, Indiana, will spend a portion of the summer of 1889 in collecting marine invertebrates at Wood's Holl, Mass., and offers to supply zoölogical laboratories throughout the country at very reasonable rates. Mr. Helvie will work in connection with Dr. J. S. Kingsley.

TO OUR SUBSCRIBERS.

All subscriptions, except those which have been directed to be renewed for the coming year, expired with the December number. Owing to the fact that a few, who ordered the GEOLOGIST at the beginning of the year, have not yet paid the subscription price, although several times requested by special bills, we have determined to discontinue sending to all such as do not signify to us their desire for renewal, and to require payment in advance of all parties that are now delinquent for the year 1888.

Any old subscriber who sends us a new name with the subscription price for 1889 ($3.50) is entitled to the GEOLOGIST for 1889 at one-half the regular rate.

Sample copies will be furnished for 20 cents each. The numbers for 1888 (two volumes) will be supplied at $2.75, and to new subscribers for 1889, who remit to us in advance, at $2.00.

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G. W. FEATHERSTONHAUGH.

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MEMOIR OF MR. G. W. FEATHERSTONHAUGH.

By J. D. Featherstonhaugh.

The subject of this brief memoir was born in the city of London, England, in the year 1780 a short time after the sudden death of his father, at the early age of twenty-three. He was descended from that branch of the family then represented by Sir Matthew of Featherstonhaugh Castle, Northumberland.

The young and widowed mother fled from the violence and danger of the Lord George Gordon riots, to her property in Yorkshire, with her nervous system impaired, and her eyesight so seriously affected, that she gradually became totally blind, and remained so until her death at the ripe age of eighty-seven.

At an early age he was placed at Stepney Hall, where he remained until fitted for one of the universities. Attaining his majority, the love of travel seized upon him, and despite the difficulties and dangers of almost constant warfare, he went abroad, residing in different countries for several years, with occasional visits home, laying the foundation of those extensive philological attainments which distinguished him in after life.

The American Union was then a new country and nation, paving the way to political eminence, and offering the observer a wide contrast to the governments of the old continent. Arriving here with letters to the most eminent citizens, the young traveler, a classical scholar, and fluently speaking several languages, soon acquired the friendship of the cultured men of the day, and being of striking personal appearance, measuring more than six feet in hight, with courteous manner and an accomplished musician, gained a ready admission to the somewhat exclusive society of that period.

As the time approached for his return home, in paying some farewell visits to his hospitable friends in the neighborhood of Philadelphia, by a providential mistake in his road he became instrumental in saving the life, perhaps, of a young lady, endangered by a vicious horse. This lady was the granddaughter of Robert, third proprietor of the Livingstone manor and daughter of Mr. James Duane, first mayor of New York appointed by governor Clinton, and an intimate friend of general Washington. The lady was beautiful and accomplished; the intimacy thus established led on to mutual affection and marriage.

A large residence was erected, almost in the then wilderness on the patent known as Duanesburgh in the neighborhood of their kinsman, general North, of revolutionary distinction where the subject of our memoir devoted himself to the interests of agriculture, importing largely from the best blooded stock abroad. He served for some time as corresponding secretary of the board of agriculture of the state of New York, the patroon, Stephen Van Rensselaer being president, and was the active spirit of that useful institution, and the one upon whom the compilation of its memoirs and the other literary work chiefly fell.[1]

When the construction of the Erie canal, which had overshadowed all their schemes of internal improvement, was completed, reviving his old idea,[2] he vigorously agitated in

[1] "Mr. Featherstonhaugh from the committee appointed to propose the most important measures necessary to be adopted at the present session of this board, and to whom was likewise referred the subject of rules or orders for the government of this board, in the transaction of business, reported as follows:"—*Memoirs of the board of agriculture of the State of New York, Vol. 1st. page 11.*

"George W. Featherstonhaugh, corresponding secretary for the United States and foreign nations," *Ibid page 46.*

the public journals a system of railways in the Mohawk valley. It was accordingly announced in November, 1825, that an application would be made to the next legislature for an act to incorporate a company to construct a rail-road from Schenectady to the Hudson river at Albany or Troy as should be deemed most advisable.

After untold difficulties from prejudices, want of comprehension on the part of rural legislators, and vested interests in horse-flesh and stages, a charter was procured on the 27th of March, 1826,[3] for the proposed road between the cities of Albany and Schenectady, a distance of sixteen miles, presenting gradients more difficult for the experience of that day to overcome, than are elsewhere to be found in the 500 miles from New York to lake Erie. In the interest of the rail-road he visited England to inspect the roads that were beginning to be operated there, and to consult with engineers who had some experience as to the most feasible plans.

The rail-road being at length an established fact, and public opinion having been drawn to its support by his indefatigable pen, he returned with zest to his agricultural labors. But the death of his two daughters within a few days of each other, from diphtheria, and the loss of his sorrowing wife, made his home desolate. He was ordered to seek a milder climate, and closing his house, which was shortly afterwards destroyed by fire, never revisited the place, or resumed the agricultural pursuits to which he had given so many years of his life, and sacrificed a large part of his fortune.

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[2] "We find that in 1812 a pamphlet was published for the purpose of explaining the superior advantage of rail-ways and steam carriages over canal navigation. * * * * Mr. Stevens of New Jersey endeavored to persuade all who were engaged in public improvement, that railroads were cheaper and more effective, as well as far more rapid in transit, than was possible to be obtained by water. Mr. Featherstonhaugh of Schenectady (county) also about the same time put in a plea for rail-roads." *Origin and progress of the Mohawk and Hudson rail-road.* Munson, Albany, page 4. G. W. Featherstonhaugh in a letter to the mayor, said that transportation of property from Albany to Schenectady was seldom effected in less than two and sometimes three days. By rail-road the communication between the same would be safely made, in winter and summer, in three hours, at no greater cost than by canal, paying for sixteen instead of twenty-eight miles. He regarded this experiment as a test whether this economical mode of transportation would succeed in this country." *Ibid.* p. 7.

[3] "Stephen Van Rensselaer, known as the old Patroon, and G. W. Featherstonhaugh were the only persons named as directors in the charter. This seems therefore to have been the first charter of what became a successful passenger rail-road in this country." *Ibid.* p. 7.

As it was impossible for one of his active temperament to exist without some congenial work, on regaining his health, he established a monthly journal of geology in the city of Philadelphia, delivering lectures in the meanwhile to excite public interest, and at various intervals publishing classical translations, books of travel and much of Italian literature.

Geological knowledge was gradually extending itself, and the government at Washington was becoming alive to its importance. The federal senate, composed of men of culture and liberality, passed a bill authorizing geological surveys in the territories, and confirmed the appointment of Mr. Featherstonhaugh as United States geologist. In this capacity he made several journeys in the wilderness beyond the limits of civilization, exposed to difficulties, dangers and hardship always.

At length the longing for the home of his youth, his duty to his old blind mother, the desire for rest and the society of his old geological friends, Dr. Buckland and Sir Roderick Murchison, determined him to return to his native land, and he took leave, as he thought, for the last time of a country where so much hard work had been done for its agriculture, geology and means of internal communication.

Although more than sixty years old, rest was not yet to come. Lord Palmerston was then in power, with his hands so full of European difficulties that he dreaded any complication of American affairs. The question of the boundary line between Canada and the United States was then hotly and dangerously agitated. An indiscretion on either side might lead on to deplorable results. Armed parties of citizens were taking possession of strategic points and building defences. Peace could not be long preserved under these circumstances. Indeed it was not a disavowed plan of belligerent politicians to drive their respective governments into hostilities.

Mr. Featherstonhaugh, whose acquaintance with the public men and the geography of America was exceeded by none, and always having cherished his allegiance to his native country, was called upon for advice and information by the English foreign office. The first essential point was to withdraw the subject entirely from the mere politician, and place it in the hands of the wiser and more responsible statesmen of the respective governments. The conference resulted in a commission, whose duty it should be to review the controversy of more than fifty years, to make a minute personal examination of the territory in dispute, to establish barometrical altitudes, and fix the latitude and longitude of prominent points. A similar commission was appointed by the United States.

Accordingly Colonel Z. Mudge, of high astronomical reputation, and Mr. Featherstonhaugh were appointed her Majesty's commissioners for the disputed boundary in North America. These gentlemen entered upon their duties at once, and after a thorough examination, traversing the wilderness on foot and in canoes, presented to the houses of parliament a substantially accurate map with an accompanying report, embracing the subject in all its historical and existent details. Not long after this Commissioner Featherstonhaugh, when called upon to speak of the subject at a numerously attended public dinner, outlined an equitable compromise, which was eventually agreed upon by Mr. Webster and Lord Ashburton, and finally ratified by the United States senate.

Subsequently to this happy and rational termination of the irritating controversy, Mr. Featherstonhaugh was appointed by the English government to the responsible office of consul for the Department of the Seine, France, where he resided with his family until the time of his decease, having married Charlotte, youngest daughter of Bernard Carter, a well-known Virginia gentleman.

It was during his residence at Hâvre that he was called upon to be the effective agent in accomplishing the escape of Louis Philippe and the queen from the imminent dangers of the revolution of 1848. The plan was arranged that an English gentleman should escort the Duchess of Orleans to the frontiers of Belgium, with a passport made out as if for his own wife and children. Or failing that, assist the others in the king's flight, as he was cautiously making for the sea-coast, near Hâvre. The Duchess and her children happily escaped by other means, and all efforts were concentrated on the safety of the king. At length reaching the coast in a sorry plight from the tempestuous weather, the royal party crossed in a ferry-boat to Hâvre, in a drenching rain, and Mr. Smith in a dreadnaught coat and a southwester hat assumed to be on a visit to his nephew, the English consul.

Arriving at Hâvre the travellers were received by the consul, who, locking arms with his new-found uncle, marched the party off into the darkness followed by a curious and somewhat suspicious crowd. There were several English steamers along the wharves, blowing off their steam furiously and making a noisy demonstration of immediate departure. In a remote and obscure corner was a small but swift boat moored by a single hawser, with fires banked and no lights or men visible. This steamer was commanded by a captain Paul of the Royal navy, a man short of stature but fearless and determined as a giant, with the least possible respect for a six-footer of the gens d' armes, on the deck of his own vessel in a heavy sea.

As the king was being led away from the steamers that were noisily preparing to depart, and which were closely watched by the police, Madame Moussé, an attaché of the custom-house, and an amateur detective, planted herself directly before the party, and suspiciously peering into the king's face, forced an introduction from the consul. "*Mon oncle Monsieur Smith, Madame Moussé!*" "*Ah!*" replied the wide-awake woman, in the most significant manner, "*Il me parait, Monsieur le Consul, que votre oncle n'est plus agé que vous.*"

This was a declaration of war and quick action was necessary. Madame Moussé was ruthlessly brushed aside, and before her cries could bring assistance, the king and his party were rushed into the cabin of the silent steamer moored in the dark, and the captain brandishing an axe, was shouting to the mob to keep off his gangway, in the most energetic nautical style, not a word of which did his listeners understand.

As the consul reappeared from the cabin and stepped on the quai, a rush was made for the boat, in the midst of which the steam shrieked at its best, the wind blew a hurricane, the waves thundered on the pier, the axe fell on the hawser, and under cover of the fearful din and darkness, the tight little steamer stole out into the tempestuous sea.

Subsequently the consul was presented by the king, as a memorial of the event, with a massive gold box, superbly chased, with his monogram and date of escape set in diamonds of great value, and he was specially invited by the family to attend the obsequies of the deceased monarch.

In the performance of his duties and in the exercise of hospitality, preserving his physical and mental powers to the last his years lengthened out to the venerable age of eighty-six. Speaking the French language perfectly, and familiar with its literature from his youth up, he was the friend and correspondent of the eminent men of France,, and his funeral was attended by many of them. A French journal in an obituary notice, uses the following language: "He was borne to his grave by six consuls of the English department, preceded by the clergy of the church of England. The principal authorities, civil and military, followed, together with the officers of the English vessels in the port. An eloquent eulogy was delivered at the grave, commemorating the eminent qualities and high character which had distinguished the honorable dead."

Sir Roderick Murchison soon afterwards published in the London *Times* a worthy tribute to his life and memory.

It is impossible at the present time to give a complete list of the geological papers and volumes of Mr. Featherstonhaugh. There may be some of his unpublished maps and manuscripts in the archives of the government at Washington. His principal published works relating to the Northwest are the well known "Report of a geological reconnoissance made in 1835 from the seat of government by the way of Green bay and the Wisconsin territory to the Coteau des Prairies, an elevated ridge dividing the Missouri from the St. Peter's river," printed by order of the Senate in 1836. Another work of two volumes, based on the same journey, was published in London in 1847, entitled "A canoe voyage up the Minnay Sotar." The work of the preceding year (1834) was published by the Government under the title "Geological report of an examination made in 1834 of the elevated country between the Missouri and Red rivers." [i. e. the region of the Ozark mountains, N. H. W.] In the transactions of the Geological Society of Pennsylvania, 1835, vol. 1, is a paper by Mr. Featherstonhaugh entitled: "Account of the travertine deposited by the waters of the sweet springs in Alleghany county, in the State of Virginia, and of an ancient travertine discovered in the adjacent hills." It is not known whether there is extant a single copy of the geological journal which he established at Philadelphia. Mr. Featherstonhaugh's son, Mr. J. D. Featherstonhaugh resides at Duanesburgh, near Schenectady, New York, and his grandson, Dr. Thomas Featherstonhaugh is a prominent physician of Albany, New York. [Ed.]

ORISKANY DRIFT NEAR WASHINGTON, D. C.

BY COOPER CURTICE.

The Potomac formation near Washington is made up in part of rounded, apparently water worn cobbles and boulders which are sandstones of various degrees of induration and fineness. These sandstones range in size from mere pebbles to boulders a foot or two in diameter. From their rounded contours they are supposed to have been transported by water or ice for some distance. As the nearest known rock like them is in the Shenandoah valley on the western side of the Blue Ridge some seventy miles to the westward, it is also supposed that they have been transported thence along the valley of the Potomac either by the currents or by floating ice.

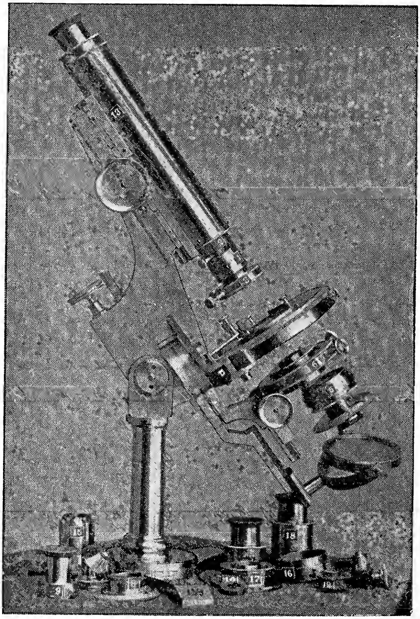
On a visit with friends to the Mecca of all loyal Americans, Mount Vernon, Virginia, during the spring of 1886, it was my good fortune to find within a rod or two of the tomb an angular fragment of rock which bore an unmistakable Oriskany fauna. The guard was near and the rock is probably there yet as he seemed to think I wanted it for a souvenir; a search through the stone heaps in the ravines yielded other fossiliferous pieces, however, and partially appeased me for the loss of the coveted fragment. A few days later I went to a point about a mile below Alexandria and was rewarded by finding quite an addition to those species already found. Since then I occasionally find fragments of fossils in the cobbles used in paving many of the gutters and car tracks throughout this city.

Mr. R. R. Gurley, of the National Museum, has lately identified the fossils found and kindly furnished me with a list.

They are as follows:

	Mount Vernon.	Alexandria.
Und't coral		"
Orthis hipparionyx Vanuxem,		"
Spirifera arenosa Conrad,	"	"
Cyrtina rostrata Hall,		"
Leptæna flabellites Conrad,		"
Rensslaeria marylandica Hall,	"	"
" suessana Hall,		"
Megambonia lamellosa Hall,	"	"
Avicula textilis var. arenaria Hall,	"	
Und't lamellibranch (2 sp)	"	"
Platyceras? (1 sp)	"	
Homalonotus	"	"
	7	10

The interest of this discovery lies in the determination of the horizon to which these loose drift stones of the Potomac formation once belonged. The only statement that I have seen regarding their supposed age is that by Rogers in the Geology of Virginia in which it is asserted that they are of Potsdam age. This determination must have been made from the resemblance of these stones to the strata of a formation in



First Lithological Microscope of American Manufacture,

W. H. BULLOCH,

Chicago.

the Shenandoah valley which Prof. Rogers supposed to be Potsdam.

AMERICAN PETROGRAPHICAL MICROSCOPES.

By N. H. Winchell.

Three American firms now advertise petrographical microscopes made in this country.[1] That which gave microscopical petrography its first important impulse in America was the publication in 1876 by the U. S. government of the work of Zirkel on the eruptive rocks collected under Mr. Clarence King by the *survey of the fortieth parallel.* This was written and engraved if not printed in Europe. On the distribution of this beautiful quarto volume (Vol. VI of Mr. King's report), a comparatively new geological domain was revealed to the American student. He was not backward in entering upon its exploration. Soon afterward the pioneer of American publications in microscopic petrography appeared as a chapter in one of the final volumes of the New Hampshire geological survey prepared by Dr. Geo. W. Hawes under the direction of Prof. C. H. Hitchcock. There began with this to be a demand for American-made petrographical microscopes. Several foreign instruments were in use in the laboratories of American students. The cheaper grades were found to be defective and the higher class instruments were too expensive. Several styles were announced in England before any attempt was made in America. The first English work designed for student's use was that of Mr. Frank Rutley (*The Study of Rocks,* published in London in 1879) and it called attention by special description to an English-made microscope, manufactured by Watson, Pall Mall, London.

When the examination of the crystalline rocks was begun by the Minnesota geological survey in 1878, it was essential that this method of research should be resorted to. The first instrument owned by the survey was a Tolles *Student's Stand,* remodeled for petrography in New York under the special direction of Prof. A. A. Julien of the Columbia College School of Mines. As this lacked some of the appliances needed, resort was had to American makers, but none would undertake to construct a microscope adapted for petrographical research

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[1] W. H. Bulloch, 99 W. Monroe St., Chicago, Ill.; Jas W. Queen & Co., 924 Chestnut St., Philadelphia, Pa.; and the Bausch-Lomb Optical Company, Rochester, N. Y.

except Mr. W. H. Bulloch, of Chicago. With a true American pride Mr. Bulloch responded with promptness, and in August 1880 he sent to the University of Minnesota the first made American petrographical microscope. This instrument was furnished with the apparatus arranged in the manner then prevalent,and it is illustrated by the preceding plate which was made from a photograph taken when it was first finished. This instrument is accompanied by the following appliances, the numbers corresponding to the parts so designated in the plate, and described by Mr. Bulloch.

No. 1, nose-piece containing Klein's quartz plate and Nicol prism. No. 2, Nicol prism. No. 3, centering nose-piece. No. 4, lower part of substage, containing prism which swings to one side. No. 6, centering substage. No. 8, lower part of goniometer. No. 9, upper Nicol prism. No. 10, plate of calc-spar cut perpendicular to the axis. No. 12, Hemisphere for use with convergent polarized light for showing crosses. No. 13, scale inside of tube. No. 15, extra nose piece. No. 16, supplementary substage.

This microscope was exhibited at the Detroit meeting of the American Society of Microscopists, August 17, 1880,[2] and is now owned by Dr. Edson Basten, of the Chicago College of Pharmacy, 3330 S. Park Ave., Chicago. Mr. Bulloch thereafter illustrated and announced in his circular this lithological microscope. Its price was $125. He subsequently made a more elaborate instrument for Mr. J. H. Caswell, of New York, author of the chapter on the microscopic petrography of the Black Hills of Dakota, published in Newton and Janney's report on the geology of the Black Hills in 1881. The most elaborate and costly lithological microscope yet made by Mr. Bulloch was for Mr. F. E. Tyler, of Kansas City, Mo., at a cost of $300. This is shown in the cut on the following page. In the summer of 1880 Mr. Bulloch also altered two instruments made before by him, so as to adapt them for lithological work, for Prof. R. D. Irving, of Madison, Wisconsin.

Shortly after the enterprise of Mr. Bulloch, in the spring of 1881, the "Acme lithological microscope" was made and advertised by Mr. John W. Sidle, at Lancaster, Pa. The agency of the Acme microscopes passed to James W. Queen & Co., of Philadelphia, in November, 1881, and that firm has since continued their manufacture and sale, but without much effort to extend the lithological model.

This microscope is of the usual style in its rotating stage

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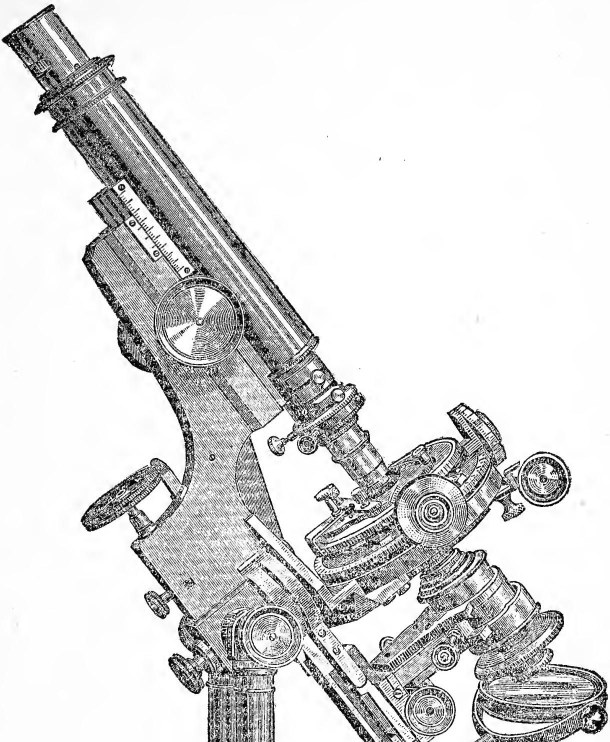
[2]See their proceedings, Aug. 19, 1880, p. 12.



MR. F. E. TYLER.

and revolving swinging polarizer. It is furnished with two analyzers, one to be used at the upper end of the tube with a graduated rim and indicator, and the other placed in a sliding brass box which enters the body of the tube just above the objective. A Klein quartz plate is mounted in a similar way and slides in another slot just below in the nose-piece. The eye-piece is furnished with crossed spider-lines, and receives at the upper end a circular calc-spar plate for stauroscopic examination. This instrument is illustrated by the figure 5. Its cost with two objectives is $125.

The Bausch-Lomb Optical Company, Rochester, N. Y., introduced the third lithological model in December, 1887. This was designed and con-

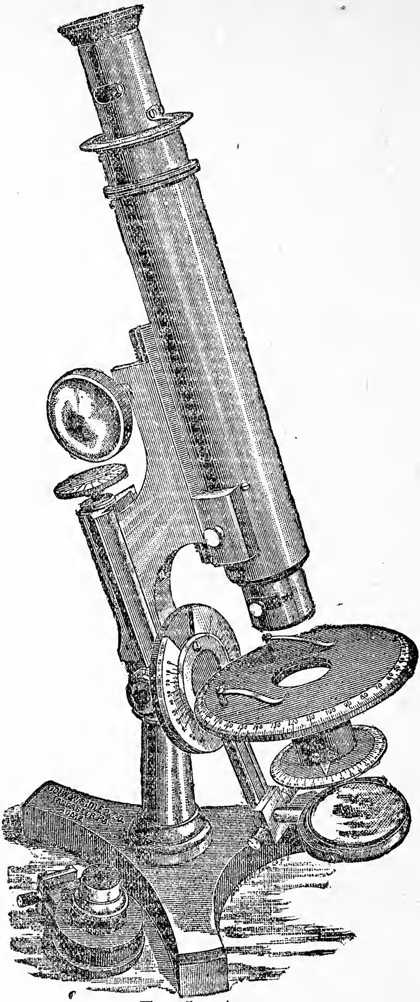


FIG. 5. ACME.

structed under the direction of Prof. Geo. H. Williams, of Johns Hopkins University, and was described by him in the *Am. Jour. Sci.*, February, 1888. It is illustrated by the adjoining figure, one-third its actual size. It was first exhibited and described by him at the winter meeting (Dec. 1887) of the *Society of Naturalists*, at New Haven, Ct. Following is his description.[3]

Coming now to the peculiarly petrographical features, we have the lower Nicol-prism or polarizer enclosed in a cylindrical metal box, both ends of which are protected by glass. This box is capable of a complete revolution, and is provided with a graduated silvered circle and index. It is held by a cylindrical frame in which it may be raised or depressed at will by a rack and pinion movement. This frame is attached to the under side of the stage by a swinging arm, so that the whole polarizing apparatus may be thrown to one side, if desired. A strong compound lens may be screwed upon the upper end of the polarizer whenever strong illumination or converged polarized light is needed.

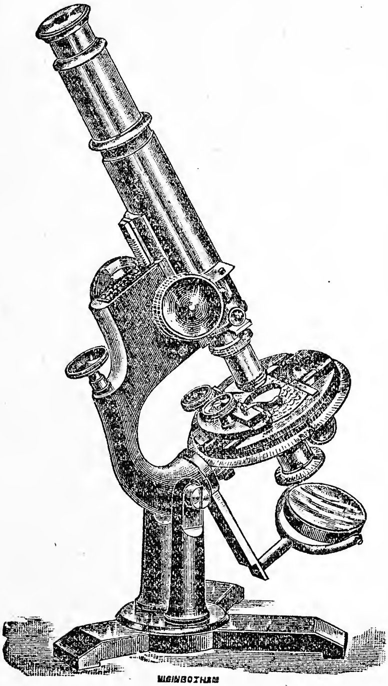


FIG. 6. BAUSCH-LOMB LITHOLOGICAL STAND.

The circular stage (9.5 cm. in diameter) is provided with a beveled silvered edge, graduated to degrees. Upon this is mounted for smooth and concentric revolution the admirable mechanical stage known to the manufacturer's catalogue as No. 1052. This carries an index for reading the graduated circle, and is also provided with silvered graduations for its two rectangular movements, whereby any point in a section can be readily located. The upper sliding bar which carries the object has been shortened so as to be only flush with the revolving stage when pushed to its extreme limit on either side. With this, square or short rectangular glasses must be

[3] Am. Journal of Science. February, 1888. p. 116

used for mounting which will avoid any interference with the revolution of the stage.

Into the nose-piece, just above the objective, is an opening intended to receive the four following accessories, each mounted in a separate brass frame: (1) a Bertrand lens for magnifying the interference figures; (2) a quarter-undulation mica-plate; (3) a quartz wedge; (4) a Klein quartz-plate or a gypsum plate with red of the first order.

The centering of the various objectives is secured by two screws having motions at right angles to each other.

The upper Nicol-prism or analyzer is inserted in the tube in order to avoid the diminishing of the size of the field which is unavoidable when the prism is placed over the ocular as a cap. To accomplish this and at the same time to keep the tube dust-tight the Nicol is enclosed in one side of a double chambered box. The other side is left vacant and the box may be slid to and fro according as ordinary or polarized light is desired. A metal sheath protects this box from above.

The microscope, as here described, in a case with a single eye-piece but without objectives, may be obtained for $108.00. With two eye-pieces (one with cross hairs and the other with micrometer) and two objectives (¾ and 1 - 5 inch) its cost is $135.00. The cost of a solid brass stand is about $25 00 more.

The demand in the United States for microscopes adapted for the examination of minerals in thin sections is rapidly extending. This is due to the, hitherto, small amount of attention that has been given to this science in America and the awakening that has marked the past ten years. It is also due, in a large measure, to the prevalence of the Archæan rocks in those regions of the country where the advanced schools of science are found. This brings the science of microscopic petrography prominently before both the student and the teaching geologist, and they find material ready at hand with which to work. It remains yet to see a first-class petrographic microscope of American manufacture. Those above described are adapted to ordinary use and the necessities of the instructional laboratory. They do not embrace the extended apparatus for nice distinctions, and for elaborate research, seen in some of those of European make, like that of the *Grand Modele* of Nachet.

ON THE RELATION OF THE DEVONIAN FAUNAS OF IOWA.

By H. S. Williams.

The two papers of professor Calvin, which were published in the *Bulletin from the Laboratories of Natural History of the State University of Iowa,* November, 1888, Vol. 1, No. I,[1]

[1] Some geological problems in Muscatine County, Iowa. With special reference to the rectification of the supposed Kinderhook near

are striking illustrations of the value of palæontologic evidence in determining equivalency of strata.

In the first paper the author has succeeded in distinguishing the "yellow sandstone" at Pine creek, which lies above the Hamilton limestone, from the "yellow sandstone" of Burlington, which lies at the base of the Burlington group of the lower Carboniferous. These two sandstones were called equivalents of the "Chemung" by Hall in 1858 and when, in 1861, the "Kinderhook group" was defined by Meek and Worthen to include the "Goniatite beds" of Rockford, Indiana, and the "yellow sandstones" of Burlington, with their equivalents, which had been previously referred to the "Chemung," it was not strange that a student of the fossils, recognizing the Devonian relations of the fauna of Pine creek, should conclude that the term "Kinderhook," as used by Meek and Worthen, and White, should include all of the rocks of the Mississippi valley that had previously been called "Chemung."

This mistake I made in an article "On a remarkable fauna at the base of the Chemung group in New York." [2]

It is gratifying to learn that professor Calvin has since obtained palæontologic evidence to convince him that the "yellow sandstone" at Pine creek, Muscatine Co., Iowa, which was called "Chemung" and "Kinderhook," is really below the Burlington "yellow sandstone," which he had regarded as equivalent, and, therefore, that it is not equivalent to Meek and Worthen's "Kinderhook group."

Without visiting Iowa, and purely from a study of the fossils and structure of the "Rockford shales" of the northern counties of Iowa, I was led to identify their fauna with one occuring above the typical Hamilton fauna of the East, as is shown in the paper above referred to; and, although I have not yet had an opportunity to examine the stratigraphy, my knowledge of the fossils leads me to believe that the fauna of the "Rockford shales" follows that of the "yellow sandstone" of Muscatine county, described by professor Calvin.

The fauna of this "yellow sandstone" is probably closely related to that of the "calcareo-siliceous sandstone" under-

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the mouth of Pine creek, pp. 7-18.

Notes on the synonymy, characters, and distribution of Spirifera parryana Hall, pp. 19-28.

[2] Amer. Jour. Sci., Vol. XXV, pp. 97-104, 1883.

lying the Rockford shales at Rockford, Iowa, and recognized in Beaver Creek and Nora Springs, by Clement L. Webster. (See, "A description of Rockford Shales of Iowa," Proc. Davenport Acad. Nat. Sci., Vol. V, p. 103, and note at bottom of pp. 103 and 104). Specimens of the fossil called *Spirifera disjuncta* Sow. by Mr. Webster, have been kindly sent for examination by him, and I find them, not *Spirifera disjuncta*, but presenting the characters of the *Spirifera mesostrialis* Hall, of the Ithaca sandstone at the base of the Chemung group of New York, and also answering so closely to the descriptions of the *Spirifera parryana* Hall, of the "yellow sandstone" of Muscatine county, as to make it probable that *S. parryana* is but a western variety of *S. mesostrialis* of New York, in the same way that *Orthis iowensis* is but a western variety of the *Orthis impressa* of the New York faunas, both of which are but varieties of the European *Orthis striatula* Schlotheim.

The zone in which *Spirifera mesostrialis* and *Cryptonella eudora* are characteristic in New York sections, is followed by the zone holding the fauna with *Orthis impressa*, *Productella dissimilis* Hall, and *Rhynchonella pugnus* Martin, of the geological reports of Illinois, (or=*Rhynchonella alta*, of Calvin).

Judging, therefore, from the order of succession of the faunas, which is beyond dispute in the Devonian of New York state and the Appalachians, it appears probable that the Devonian fauna of Rockford, Iowa, and the northern counties of Iowa, represents a large stage of the middle Devonian, or an early stage of the upper Devonian of the New York sections. If the fauna of the "yellow sandstones" of Muscatine county, Iowa, were in the rocks of the Appalachian Devonian, we should unmistakably place it at the base of the "Chemung Period," in what is locally called the "Ithaca group," and using the same standards, the Rockford shale fauna of Iowa would be placed a little higher up, in the Ithaca group. Both would be decidedly in the lower part of the upper Devonian, entirely below the first appearance of the lowest representative of typical Chemung faunas.

The discovery of the clue to the order of sequence of the Iowa faunas was first announced in my paper above cited, and had I then known the stratigraphy of the Iowa Devonian as well as professor Calvin appeared to know it when he wrote his article of June, 1883, I could have added, that the place in the series for *Spirifer parryana* fauna to appear, is between the *Spirifera pennata* fauna of the typical Hamilton limestones, and the fauna with *Spirifera whitneyi* and *Spirifera hungerfordi*.

But the confusion as to which rocks really belong to the "Kinderhook group" of Meek and Worthen, a confusion which, it now appears, professor Calvin shared with some of us who lived outside of Iowa, made it impossible to place confidence in the strictness of reference for the fossils reported. The representatives of "*S. whitneyi*" and "*S. hungerfordi*," wherever they are recognizable, from the Ural mountains, from Russia, from Germany, from Northern France, from Spain, from Belgium, from England, and from New York and along the Appalachian, are always associated with species found at the close of the middle or base of the upper Devonian. The Russian, German, and French geologists more generally regard this fauna as the first fauna of the upper Devonian, to which the name "*Frasnien*" is quite commonly applied. The English, on account of the great disturbance of the rocks during and after the Devonian, have no satisfactory means of determining the precise sequence of faunas, and it is also probable that the South Devonshire limestones were continuous, without change, till after the stage represented in other regions by the earlier part of the upper Devonian deposits.

The homotaxial relation of the Rockford shale fauna, and that of the "yellow sandstones" of Muscatine Co., Iowa, if the species have been correctly reported, is with the faunas of the "Ithaca group" of New York and the East, and of the "Frasnien Etage" of the northern part of Europe and Asia, and not with strictly middle Devonian faunas in any region where continuous sections have enabled the geologists to determine accurately their sequence. March 9, 1889.

PRELIMINARY DESCRIPTION OF NEW LOWER SILURIAN SPONGES.

By E. O. Ulrich.

This paper may well begin with an apology for the scantiness of the descriptions and the lack of sufficient illustrations. It is hoped, however, that the critic will be lenient and bear in mind that so little is known of palæozoic sponges (Lower Silurian ones in particular) that almost any contribution to our knowledge of them is welcome. The imperfections will prove the most serious to the systematist, but for the needs of the collector and of those who desire to use these fossils as paleontological evidence in the determination of strata, it is believed these descriptions will suffice, temporarily. The systematist also should not forget that among Silurian sponges the minute characters upon which his classification is founded are so seldom preserved in a recognizable condition that often the heart grows weary waiting for the resurrection of the specimens which, if placed in the proper hands, might be made to throw light into the dark recesses of our classifications. It is almost needless for me to say that had such specimens been at my command I would most surely have fulfilled all the requirements of scientific publication by describing and figuring their minute characters in detail. To offer illustrations now, when the structure is only *conjectured*, might serve but to mislead.

The amateur and mere collector rarely searches for unnamed fossils, especially if they belong to so unprepossessing a class as the sponges. He must have a *name* for his specimens or they go into his unclassified drawer which too frequently merges into his trash box. And how often does not that "trash box" contain the very specimen for which we have searched so diligently.

It is, therefore, partly to satisfy and incite him, partly to make these fossils available for stratigraphical determination, and partly my desire to add a little to the literature of a subject so generally shunned by American paleontologists that induces me to present the following.

A few remarks upon the systematic position of the proposed new genera may prove of value.

The new genus *Rauffella*, named in honor of Dr. H. Rauff, the distinguished collaborator of Dr. Karl Zittel on fossil sponges, is proposed for the reception of two remarkable sponges. At first I believed their spicules to be of only the uniaxial type and the genus probably a member of the *Monactinellidæ*. A later study, however, proved the results of the first to be erroneous, and that, instead of being of the uniaxial type, the spicules of the outer layer at any rate are really peculiarly modified hexacts, as shown in figures 2 and 4 of the accompanying cut. In figure 2 we have an arrangement somewhat like that usual among the *Dictyospongidæ*, and it is as an abnormal type of that hexactinellid family that I regard *Rauffella*. I am not certain that *R. palmipes* ought to be considered as congeneric with *R. filosa*, the *form* of the sponge being very different in the two species. That they belong to the same family is scarcely to be questioned.

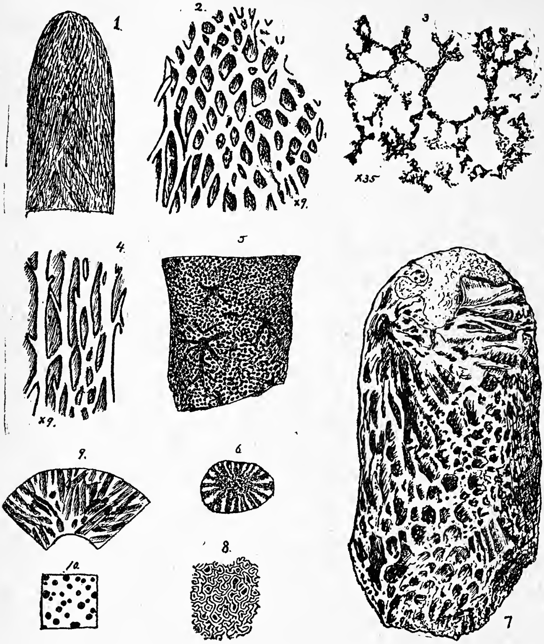
The position of *Leptopoterion*, in the absence of a definite knowledge of the spicular structure, is somewhat doubtful. The general aspect, however, is suggestive of the *Hexactinellidæ*, and indicates a relationship to the *Dictyospongidæ* on the one hand and, perhaps less strongly, the *Receptaculitidæ* on the other. The peculiar bodies which in one of my earlier papers were named *Lepidolites* and are now classed provisionally in the latter family, may be more closely related than would at first appear.

Heterospongia and *Saccospongia*, together with *Dystactospongia* S. A. Miller, and *Strotospongia*, a new genus described in my report on fossil sponges for vol. VIII Ill. Geol. Survey reports, (now in press) constitute a natural group of sponges, having, I believe, rather close relations to *Calcispongiæ* of the type of *Corynella* Zittel. *Streptospongia* and *Cylindrocœlia* are difficult to place. If I should hazard an opinion it would be that both belong to the *Calcispongiæ*, the former near *Dystactospongia*, the latter, perhaps, near *Myrmecium* Goldf. (Zittel).

RAUFFELLA n. gen.

Sponges free (?), forming hollow cylindrical stems, or radially arranged leaves. Wall exceedingly thin, composed of two distinct layers of spicule-tissue. Inner layer minutely porous, the pores irregularly distributed, of unequal size, the larger ones rounded, the smaller ones much more numerous and mostly of irregularly angular outline; spicular tissue separating pores thin, the nature of its elements undetermined. Outer layer consisting of a network of large spicules, apparently of a curiously modified hexactinellid type. Usually they appear as irregularly coalescing thread-like striæ lining the surface in a longitudinal direction, with more slender connecting filaments traversing the narrow intervening spaces at more or less acute angles leaving acutely elliptical depressed spaces. At other times the striæ cross eaeh other diagonally, producing appearance not much unlike that of the ordinary arrangement of the spicules in the *Dictyospongidæ.*

Type, *R. filosa*, n. sp.



EXPLANATION.

Fig. 1. Upper extremity of specimen of *Rauffella filosa* Ulrich, of the natural size.

Figs. 2 and 4. Small portions of fig. 1, x 9, showing the irregular character of the superficial network.

Fig. 3. Thin section of *Rauffella palmipes* Ul., x 35, showing the porous character of the inner layer of the sponge. The spicules were not determined and no attempt was made to represent them in this hasty sketch.

Fig. 5. Portion of an example of *Heterospongia knotti* Ul.; of the natural size.

Fig. 6. Transverse section of a calcareous specimen referred with doubt to *Heterospongia subramosa* Ul. nat. size.

Fig. 7. Example of Saccospongia rudis, Ul.; of the natural size. This figure was inverted by the engraver, its upper extremity, where a

small portion of the dermal layer is represented, being really the basal part of the sponge.

Fig. 8 represents a small portion of a transverse fracture of the specimen of *Streptospongia labyrinthica* described; nat. size.

Fig. 9, portion of the fractured smaller end of the type specimen of *Cylindrocœlia elongata* Ul., showing thickness of sponge wall and radiating canals.

Fig. 10. Outer surface of same, showing distribution of canal apertures when the dermal layer is removed. Both of the natural size.

RAUFFELLA FILOSA, n. sp.

Sponge forming a straight or slightly curved hollow cylindrical stem, 10 to 15 mm. in diameter. The largest fragment seen is 90 mm. in length. One of the ends (whether the upper or lower one has not been determined) is rounded off somewhat like the tip of a finger. The other, probably, was open. Sponge wall less than 0.5 mm. in thickness. Outer surface generally appearing to the naked eye as strongly striated longitudinally. Under a good pocket lens numerous connecting filaments are noticeable forming with the stronger threads an irregular, narrow-meshed network. Nearly every specimen, however, exhibits on limited portions of the surface a comparatively regular arrangement of the spicular tissue in diagonally intersecting lines. Here the hexactinellid character of the spicules is determined, there being, apparently, four rays spread horizontally and one extending downward into the inner tissue, while the sixth is not developed. The spicules are joined together by a union of the horizontal rays of each with those of four other spicules in such a manner that a network with rhomboidal meshes is formed. Similar but smaller spicules are developed in the interspaces. This regular arrangement of the spicules is but rarely met with, the surface appearing, as already stated, usually to be striated in a longitudinal direction mainly. On an average eleven of the striæ occur in 5mm. transversely.

Inner layer of sponge tissue exceedingly thin and minutely porous. Its structure has not been determined, the finer details having been obliterated during the process of fossilization.

This sponge cannot be confounded with any other fossil known to me from Cambrian or Silurian rocks, its finger-like form and the strong thread-like striations of the surface giving it a very characteristic and easily recognized aspect.

Formation and locality: Fragments are not uncommon in the Trenton shales at Minneapolis, St. Paul, Fountain and other localities in Minnesota.

RAUFFELLA PALMIPES, n. sp.

Sponges rather large, originally probably of inverted pear-shaped outline, consisting of five bi- or tri-furcating compressed lobes springing from a short stem, united at the center and arranged in a radial manner. In the fossil state they present varied forms corresponding with the degree and direction of the compression they have suffered. This is much less than might be expected of so frail an organism, and I can account for the comparatively good preservation of the shape only by supposing the lower extremity of the stem to have been open, thus permitting the material that made up the strata (mud, fragments of shells, bryozoa, etc.) to enter freely into the internal cavity. Generally, the cavity is entirely filled with material of the same nature as the surrounding matrix. In a few cases free communication must have been interrupted causing a lobe to remain empty and now to appear much more compressed than usual. On account of the friable nature of the shales in which they are found, most of the specimens are mere fragments. Still after a careful search the author succeeded in securing three nearly complete examples. Two of these are compressed obliquely with the stem on one side, and look very much like the webbed foot of a bird. The specific name was suggested by this fancied resemblance. The third is compressed vertically and shows the radial arrangement and bifurcation of the compressed lobes very satisfactorily. As near as can be determined the original dimensions of a specimen of medium size were about as follows: hight, 90 mm.; greatest width, 80 mm.; diameter of stem, 15 mm.; thickness of lobe, 8 mm.; thickness of walls of sponge, 0.5 mm. or less.

The spicules of the inner layer, owing to alteration and replacement by calcite, have not been determined. A thin section, however, shows that it was minutely porous, the tissue separating the pores thin, and the pores of variable size, the larger ones of rounded form, the smaller ones more or less angular. The surface, as in *R. filosa*, is striated, only the striæ are much finer and more irregular. The appearance of the surface is to be described as hirsute rather than filose.

Formation and locality: Trenton shales, near Minneapolis, Minn.

LEPTOPOTERION MAMMIFERUM, n. gen. et. sp.

Sponge free, obconical, about 70 mm. high and 40 mm. wide at the top. At intervals of about 9 mm. the sides are marked with shallow transverse constrictions, giving the sponge, particularly the lower half, an annulated appearance. The basal portion, which is 14 mm. in diameter at the first constriction and 8 mm. high, seems to have formed a nearly hemispherical termination. The second annulation shows seven very faintly defined broad elevations; the third, eight a little more distinct; the fourth, nine, each about 9 mm. in diameter and 15 mm. high; the fifth ten, and the sixth eleven; the seventh is incomplete. The mammillations of each row alternate in position with those of the preceding and succeeding series. Those of the rows above the fourth annulation become narrower gradually, those of the seventh being elliptical in outline, averaging 5.5 mm. in width by 9.5 mm. in length, with a hight varying between 1.5 and 2.0 mm.

Sponge-wall exceeding thin, the thickness being less than 0.5 mm. In the only example seen the minute details of its structure have been almost obliterated by replacement with iron pyrites. The outer surface, where best preserved, is finely reticulated, being traversed by lines and series of points ranged in very regular diagonally intersecting, tranverse and longitudinal directions. Measuring diagonally, 14 lines were counted in 5 mm. When a little worn the diagonal lines become fainter but the longitudinal ones proportionately more conspicuous. There is some evidence to show that this network was formed of overlapping hexactinellid spicules having the six rays spread in one plane.

Formation and locality: Middle beds of the Cincinnati group. The type and only specimen seen was collected some years ago in the quarries on Roh's hill, Cincinnati, O., by Mr. Charles Schuchert, now of Albany, N. Y. It is now in the author's cabinet.

HETEROSPONGIA, n. gen.

Sponges consisting of sublobate or irregularly divided, compressed branches. Entire surface exhibiting the mouths of branching and more or less tortuous canals, which begin near the center, where they are nearly vertical, and proceed toward all portions of the surface in a curved direction. A limited number of "oscula" distinguished from the ordinary canals by being larger and surrounded by radiating channels, occasionally present.

Sponge skeleton between the canals of variable thickness, sometimes appearing nearly solid, at other times composed of loosely interwoven spicule fibers. None of the specimens show the spicules in a satisfactory manner. From the traces seen it would appear that they are mostly very small and of the three-rayed type. Type: *H. subramosa*, n. sp.

[1] This genus is related to the *Dystactospongia* S. A. Miller, differing from species of that genus chiefly in the erect and subramose habit of growth. The four or five species of Miller's genus known to me are all parasitic or form amorphous masses.

HETEROSPONGIA SUBRAMOSA. n. sp,

Sponge subramose, occasionally palmate; branches more or less flattened, from 9 to 13 mm. thick, and 11 to 30 mm. wide. The largest specimen seen is 65 mm. high and 45 mm. wide. Surface generally even, exhibiting the rather irregularly distributed canal apertures. These are generally of very unequal sizes, though on limited portions of the surface, both their distribution and size may be fairly regular. The average diameter of an aperture is nearly 0.7 mm., with about 5 in 5 mm. The width of the interspaces between the canal mouths is equally variable, the extremes being 0.2 and 1.2 mm. The sponge skeleton is composed of more or less loosely interwoven spicule-fibres, but in the usual state of preservation the inter-canal spaces appear quite solid and structureless. In none of the specimens are the spicules sufficiently well preserved to make their determination a matter beyond dispute.

Formation and locality: Upper and perhaps middle beds of the Cincinnati group. The best specimens come from

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[1] This generic and four specific names (*subramosa*, *knotti*, *aspera* and *nodulosa*), were proposed in my Catalogue of Cincinnati group fossils, published in 1880. Being unaccompanied by either descriptions or figures, these species cannot be considered as established. The publication of mere ms. names is no more binding to the author of such names than to other authors who may have no means of learning what the names apply to. This being the first adequate publication of the genus and species, their date of publication is necessarily the same as that of this issue of the "GEOLOGIST." The same is to be said of *Streptospongia* and its species *labyrinthica*.

Marion and Lincoln counties in Kentucky. At those localities the original material of the sponges, in common with that of the associated fossils, has been replaced by silica. In two fragments, one from the tops of the Cincinnati hills, the other from Spring Valley, Minn., both doubtfully referred to the species, the skeleton consists of crystalline calcite. These preserve the canals very well but the minute characters of the spicule-fiber are entirely obliterated.

HETEROSPONGIA KNOTTI, n. sp.

Sponges subramose; branches strong, more or less flattened, 8 to 20 mm. thick, and 18 to 30 mm. wide. Surface even or with irregular swellings. Canal apertures small, sub-equal, mostly round, averaging 0.35 mm. in diameter; arranged in rather irregular rows with 6 to 8 in 5 mm. Partitions between canal mouths of variable thickness, composed of rather compactly interwoven spicule-fibers. Where best preserved the angles of junction are prominent. The most distinctive feature of the species is found in the oscula which are scattered over the surface at intervals of from 8 to 20 mm. These are nearly circular, about 1.5 mm. in diameter and generally surrounded by a variable number of radiating channels.

Compared with *H. subramosa* this species will be found to differ in having smaller and more closely arranged canals and "oscula." The latter are absent in that species.

The specific name is given in honor of Mr. W. T. Knott, of Lebanon, Kentucky, who found the specimens in the upper beds of the Cincinnati group near Lebanon and kindly presented them to the author for description. I am also indebted to this gentleman for hospitable entertainment.

HETEROSPONGIA ASPERA, n. sp.

Sponges of very irregular growth, forming thick, shapeless fronds, or strongly nodulated, lobate or subramose, elongate masses, several inches in length. When in a good state of preservation the surface is remarkably rough, the inter-canal spaces being comparatively thin and set at close intervals with sharp prominences. The canal apertures are of irregular form, often sub-quadrate, and average about 0.5 mm. in diameter, with 7 or 8 in 5 mm. They are more regularly arranged and of more nearly equal size than usual. The nodulated examples frequently present areas over which their mouths are disposed in a radial manner, bnt there is no "osculum" at the center of these areas. Again, over limited spaces canal apertures may be wanting.

In the number of canals in a given space this species agrees very nearly with *H. knotti*. Still, the more irregular growth, remarkably rough surface, and absence of oscula serve very well in distinguishing them.

Formation and locality: Upper beds of the Cincinnati group, in Marion and Lincoln counties, Kentucky.

SACCOSPONGIA, n. gen.

Sponges simple, of sub-cylindrical or oval form, with a central cloacal cavity extending through the sponge from its summit to the base. Walls moderately thick, very porous, being traversed by large, tortuous, branching canals, intercommunicating freely with each other. Minute characters of skeleton, robably similar to that of *Heterospongia* and *Dystactospongia*. A dermal layer of compact structure is developed over at least the basal portion.

Type: *S. rudis*, n. sp.

This genus is believed to differ from *Heterospongia* and *Dystactospongia* mainly in its mode of growth and in possessing a cloacal cavity.

SACCOSPONGIA RUDIS, n. sp.

Sponge of sub-ovate form, or with the sides parallel and the two extremities rounded, the upper, however, slightly truncate. A rather small but nearly complete example is 65 mm. long by 30 mm. wide. The cloaca, about 18 mm. in diameter, extends downward apparently to the base. Outer surface roughly and very irregularly pitted, or lined with tortuous ridges. The latter occur on the lower portion of the sponge mainly. Channels between the ridges porous, the openings small, sub-circular or transversely elongated, and often ranged in series. Canal openings oblique, very unequal, their width varying between the extremes of 1 and 3 mm. Walls separating canals porous, usually 0.5 or 0.6 mm. thick. A thin dermal layer, seemingly composed of very minute and closely interwoven spicules, covers a portion of the base of one of the examples.

All the specimens have been distorted through compression, and much of the variation of form noticed is obviously due to that cause.

Formation and locality: In the siliceous beds at the top of the Trenton, near Lexington and Frankfort, Kentucky. The remarkable *Brachiospongia* is from the same horizon. I am indebted to Mr. Moritz Fischer, of the geological survey of Kentucky, for specimens of this species.

SACCOSPONGIA DANVILLENSIS, n. sp.

Sponge small, sub-cylindrical, 7 to 12 mm. in diameter; occasionally exhibiting a tendency to bifurcate. Wall varying in thickness from 1 to 4 mm. Cloacal cavity variable, sometimes small, at other times comparatively large. Outer surface rough, in the worn or greatly compressed condition appearing as though traversed by small interrupted longitudinal ridges. Canal-apertures more or less oblique, small, averaging about 0.6 mm. in diameter, and from 3 to 5 in the space of 3 mm.

This species resembles *Heterospongia* but an examination of the fractured ends of the examples revealed the presence of a cloacal cavity. It is a smaller sponge than *S. rudis*, from which it is distinguished further by its smaller canals.

Formation and locality: From the siliceous beds at the top of the Trenton, at localities in Boyle, Mercer, Franklin and Fayette counties, Kentucky.

DYSTACTOSPONGIA MINIMA, n. sp.

This name is proposed for a small parasitic sponge apparently congeneric with *D. insolens* S. A. Miller. It forms thin crusts or small irregular masses upon bryozoa and other foreign bodies. The largest seen is about 15 mm. wide and 5 mm. high at the center. The canals are much smaller than in any of the other species and the partitions exceedingly thin. About 5 canals occur in 2 mm. The whole skeleton is usually replaced by a brown oxide of iron.

It is doubtful whether the specimens catalogued by me under the name *Streptospongia confusa* Ulrich (Catal. foss. Cin. gr. 1880) are specifically distinct from Miller's *D. insolens*. (Jour. Cin. Soc. Nat. Hist. vol. v, 1882). The typical examples of his species are large amorphous masses, while the specimens named by me as above are small and generally attached to ramose or frondescent bryozoa. Mr. Miller believes them to be distinct but I am very much inclined to doubt the propriety of separating them as I have failed to note any difference in the size and arrangement of the canals between those of the large and small examples. On the other hand, the specimens now named *D. minima* differ decidedly from that species in those respects, the canals being scarcely more than one third as large.

Formation and locality: The best specimens of *D. minima* seen were found at a fine locality for bryozoa near Hanover, a small village in Butler county, Ohio. *D. insolens*, so far as known, is restricted to the middle beds of the group.

STREPTOSPONGIA LABYRINTHICA, n. gen. et. sp.

The specimen upon which this genus and species are founded is a fragment of a massive sponge. It is siliceous, over 50 mm. long, 30 mm. high, and 25 mm. wide, and broken so as to show longitudinal and transverse sections. In the latter the sponge appears composed of labyrinthically intertwining vertical laminæ, nearly constantly 0.3 mm. thick, separated by tortuous and almost linear interspaces, with here and there an irregular angular open space not noticed to exceed 1 mm. in length. The vertical fracture shows that this remarkable intertwining is largely produced by connecting processes on the sides of the laminæ. These are usually rounded in cross-section and occur at frequent but irregular intervals, while they are also of very unequal size, some being very small and others more than 1 mm. in diameter. Numerous small punctures also may be detected scattered among the connecting projections.

Spicular structure entirely destroyed.

The systematic position of this genus is very uncertain, but the fossil is so remarkable that the propriety of naming it is believed to be beyond question. The sponge is not likely to be confounded with any other known to me and it is to be hoped that collectors will search for other specimens. The only one seen was found in the bed of a creek near Lebanon, Kentucky, in the banks of which the upper beds of the Cincinnati group were exposed.

HINDIA PARVA, n. sp.

Sponges free, globular in form, with an even rounded surface. Specimens vary between 5 and 10 mm. in diameter, but in a large proportion of the specimens seen the diameter varies but little from 7 or 8 mm.

The radiating canals are a little smaller than in the common *H. spheroidalis* Duncan, of the Niagara, being, as a rule, not over 0.27 mm. in diameter. *H. inæqualis* Ulrich, from the lower or sponge beds of the Trenton limestone at Dixon, Illinois, is larger and has, as its name may indicate, radiating canals of very unequal size.

This species (*H. parva*) has been known to me for nearly ten years as one of the most persistent fossils of the upper or Galena beds of the Trenton group in the western states. I met with it first at several localities in central Kentucky, and since have found it holding about the same horizon in Tennessee, Minnesota and Wisconsin. Though a common fossil, good specimens are rare.

Occasionally we meet with specimens of this or a closely related species in the middle beds of the Cincinnati group. These are a little larger than the Trenton form, the specimens averaging about 10 mm. in diameter. This supposed variety of *H. parva* has been found on the hills about Cincinnati Ohio, at Colby and McKinney's in central Kentucky, and at Savannah, Ill. Formerly I supposed it might be identical with Miller and Dyer's *Microspongia gregaria* (Jour. Cin- Soc. Nat. Hist. vol. i, p. 37, 1878) but its internal structure is clearly the same as that of *Hindia*. Those authors say of their species that its structure is " fibrous or minutely porous, and very compact," and that sections reveal " needle-shaped bodies " supposed by them to be the spicules. From this it is evident that either they are mistaken in their diagnosis or they had a very different sponge before them.

Seven specimens of another supposed variety of *H. parva* were collected from the upper beds of the Cincinnati group near Middleton, Ohio. These have the same internal structure but are unusually small, the diameters of the smallest and largest specimens being respectively 3 and 5 mm.

CYLINDROCŒLIA, n. gen.

Sponges free, cylindrical or nearly so, with the lower end tapering rapidly to a point, or truncate. A central cloaca extends throughout at least the sub-cylindrical portion. It is of tubular or very elongate conical form, widening gradually upwards. Walls thick, traversed by irregularly disposed radiating canals. Very few of these penetrate the thin and compact dermal layer which covers both the inner and outer surfaces. When the dermal layer is worn away their sub-circular mouths appear. Skeleton, apparently very finely porous. The specimens are too much altered to admit of determining its elemental components.

Type: *C. endoceroidea*, n. sp.

Sponges of this genus are liable to confusion with slightly tapering forms of *Orthoceras* and *Endoceras*. The absence of septa and presence of canals should, of course, distinguish them at once.

The specimens of two of the species are now siliceous, that being the usual conditions of the fossils associated with them in their respective beds. In these the canal system is preserved in a satisfactory manner, but it is very difficult, if not impossible, to make out the minute details of structure. Those of the other two species now consist of rather coarsely crystalline calcite in which even the canals are not readily determinable, much less the spicule fibers. Under these adverse circumstances the systematic position of *Cylindrocœlia* cannot be established with any degree of certainty, and my reference of the genus to the *Calcispongiæ* is, therefore, only provisional.

CYLINDROCŒLIA ENDOCEROIDEA. n. sp.

Of this species my collection affords but a single partly silicified example which I found at High Bridge, Ky., in the Birdseye limestone which at that locality forms the top of the Kentucky river gorge. It is incomplete at the lower end, tapers slowly, 170 mm. long, 45 mm. in diameter at the upper end, and 32 mm. at the lower extremity. At the lower end the cloaca is about 10 mm. in diameter and the sponge wall varies in thickness between 9 and 13 mm. The specimen is broken across at a point about 80 mm. from the top. Here the cloaca is 17 mm. in diameter and the wall about 12 mm. thick. At the upper extremity the wall is much thinner and is now narrowly rounded. Originally it may have formed a sharp edge. On one side the outer surface exhibits obscure transverse undulations.

Where the outer surface appears best preserved but few canal apertures are shown, but where the surface is ground or a fragment chipped away and moisture applied, a much larger number are disclosed. From this it is evident that a thin dermal layer was stretched over the surface through which but few of the canals penetrated. A similar layer was developed on the inner or cloacal surface.

Canals numerous, sub-circular in cross-section, of variable size, the largest about 1.5 mm. the smallest less than

0.5 mm. in diameter; averaging about thirty in a space 10 mm. square. Their course is nearly always straight but the angle at which they pass through the sponge wa greatly. Occasionally they may divide.

A careless observer might mistake this sponge for the shell of an *Endoceras* or perhaps *Orthoceras*, to which the form and obscure annulations give it some resemblance. However, unusually acute powers of discrimination are not required to see that it is a very different organism.

CYLINDROCŒLIA COVINGTONENSIS, n. sp.

To this species I refer six examples, two of them doubtfully, all derived from the middle beds of the Cincinnati group at Covington, Ky. The skeleton in all of them has been changed to crystalline calcite without, however, destroying the canals. Three of them are sub-cylindrical fragments of which the largest affords the following measurements: length 45 mm.; diameter of lower extremity 25 mm.; diameter of upper end 32 mm.; diameter of cloaca at lower end 6 mm.; diameter of same at upper end 22 mm.; thickness of sponge wall at lower extremity from 9 to 10 mm.; thickness of same at upper end from 3 to 6 mm.; canals mostly 1.5 mm. in diameter, but varying from 0.5 to 2.5 mm., with an average of eight in 10 mm. square.

In all but the two doubtful specimens, the canals penetrate the sponge wall in a remarkably irregular manner, all directions being pursued by them. When the dermal layer is preserved the surface appears smooth with here and there a canal aperture.

Two of the cylindrical fragments are smaller, taper less rapidly, and have a narrower cloaca than the third specimen from which the above measurements were taken and which is considered the type. These specimens approach the Minnesota species next described. Another I believe to be the basal portion of the sponge. This is of conical shape, about 50 mm. in length, tapering from a diameter of 24 mm. to a point. The upper end, which I have ground and polished, exhibits numerous irregular canals but no evidence of the cloaca. The two doubtful specimens are also of conical shape, but both have a deep cup and are smaller. It is possible that these may represent a different species but, provisionally, I prefer to regard them as young examples of *C. covingtonensis*.

The canals are larger, more irregular, and less numerous than in *C. endoceroidea.*

CYLINDROCŒLIA MINNESOTENSIS, n. sp,

This species differs from the preceding ones in being almost perfectly cylindrical (*i. e.* allowing for a slight amount of compression apparent in all the specimens) the average taper in a length of 40 mm. being rarely more than 1 mm. Most of the fragments vary in diameter between 10 and 15 mm., but it is sometimes a mm. more or less. Basal extremity not satisfactorily shown in any of the specimens; apparently truncate. The cloaca must have been narrow since it, like the internal portion of the canal system, has in every case been entirely obliterated by the crystallization of the calcite of which the specimens are composed. The surface is smooth and may, according as the dermal layer remained or had been removed at the time of fossilization, exhibit very few or comparatively abundant canal apertures—more irregularly distributed, however, and not nearly so numerous as in the other species. The canals are rounded and vary in diameter from less than 1 to 2.5 mm.

Formation and locality: Trenton shales. Specimens of this species, though not common, have been noticed at Minneapolis, St. Paul and Fountain in Minnesota.

CYLINDROCŒLIA MINOR, n. sp.

Of this species I have two small specimens. They were found in the upper siliceous beds of the Trenton group at a long cut for the Cin. South. R. R., just south of the Harrodsburg Junction. On one of them the lower end is truncate, about 7 mm. in diameter, and shows at the centre a round opening. The specimen is 18 mm. long and 12.5 mm. in diameter at its upper end. The other is 22 mm. long, between 10 and 11 mm. in diameter above and tapered downward apparently to a point the lower extremity being imperfect. The surface of both examples is smooth and exhibits a moderate number of irregularly distributed, small, subequal, canal mouths. averaging 0.6 to 0.7 mm. in diameter. In both specimens the canals seem to have extended from the outer surface to the center of the sponge. If a cloaca was present in the species it must have been either very narrow or unusually shallow.

RECENT OBSERVATIONS ON THE GLACIATION OF BRITISH COLUMBIA AND ADJACENT REGIONS.[1]

BY GEO. M. DAWSON, D. SC., F. G. S.
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Previous observations in British Columbia[2] have shown that at one stage in the Glacial period—that of maximum glaciation—a great confluent ice-mass has occupied the region which may be named the Interior Plateau, between the Coast Mountains and Gold and Rocky Mountain Ranges. From the 55th to the 49th parallel this great glacier has left traces of its general southward or south-eastward movement, which are distinct from those of subsequent local glaciers. The southern extensions or terminations of this confluent glacier, in Washington and Idaho Territories, have quite recently been examined by Mr. Bailley Willis and Prof. T. C. Chamberlin, of the U. S. Geological survey.[3] There is, further, evidence to show that this inland-ice flowed also, by transverse valleys and gaps, across the Coast Range, and that the fiords of the coast were thus deeply filled with glacier-ice which, supplemented by that originating on the Coast Range itself, buried the entire great valley which separates Vancouver Island from the mainland and discharged seaward round both ends of the island. Further north, the glacier extending from the mainland coast touched the northern shores of the Queen Charlotte Islands. The observed facts on which these general statements are based have been fully detailed in the publications already referred to, and it is not the object of this note to review former work in the region further than to enumerate the main features developed by it, and to add to these a summary of observations made during the summer of 1887 in the extreme north of British Columbia, and in the Yukon basin beyond the 60th parallel, which forms ths northern boundary of that province.

The littoral of the south-eastern part or "coast-strip" of Alaska presents features identical with those of the previously examined coast of British Columbia, at least as far north as lat. 59°, beyond which I have not seen it. The coast archipelago has evidently been involved in the border of a con-

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[1] From the *Geological Magazine*, London, August, 1888.
[2] Quart. Journ. Geol. Soc. vol. xxxi. p. 89. Ibid, vol. xxxiv, Canadian Naturalist, p. 272, vol. viii.
[3] Bulletin U. S. Geol. Survey, No. 40, 1887.

fluent glacier which spread from the mainland and was subject to minor variations in direction of flow dependent on surface irregularities, in the manner described in my report on the northern part of Vancouver Island.[4] No conclusive evidence was here found, however, either in the valley of the Stikine river or in the pass leading inland from the head of Lynn Canal, to show that the ice moved seaward across the Coast Range, though analogy with the coast to the south favors the belief that it may have done so. The front of the glacier must have passed the outer border of the Archipelago, as at Sitka, well-marked glaciation is found pointing toward the open Pacific[5] (average direction about S. 81° W. astr.). It is, however, in the interior region, between the Coast Range and the Rocky Mountains proper and extending northward to latitude 63°, explored and examined by us in 1887, that the most interesting facts have come to light respecting the direction of movement of the Cordilleran glacier. Here, in the valleys of the Pelly and Lewes branches of the Yukon, traces were found of the movement of heavy glacier-ice in a northerly direction. Rock-surfaces thus glaciated were observed down the Pelly to the point at which it crosses the 136th meridian and on the Lewes as far north as lat. 61° 40′, the main direction in the first-named valley being north-west, in the second north-north-west. The points referred to are not, however, spoken of as limiting ones, for rock exposures suitable for the preservation of glaciation are rather infrequent on the lower portions of both rivers and more extended examination may result in carrying evidence of the same kind much further toward the less elevated plains of the lower Yukon. Neither the Pelly valley nor that of the Lewes is hemmed in by high mountainous country except toward the sources, and while local variations in direction of the kind previously referred to are met with, the glaciation is not susceptible of explanation by merely local agents, but rather implies the passage of a confluent or more or less connected glacier over the region.

In the Lewes valley, both the sides and summits of rocky hills 300 feet above the water were found to be heavily glaciat-

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[4] Annual Report Geol. Surv. Canada, 1885, p. 100 B.

[5] Mr. G. F. Wright has already given similar general statements with regard to this part of the Coast of Alaska, American Naturalist, March, 1887.

ed, the direction on the summit being that of the main (north-north-west) orographic valleys, while that at lower levels in the same vicinity followed more nearly the immediate valley of the river, which here turns locally to the east of north.

Glaciation was also noted in several places in the more mountainous country to the south of the Yukon basin, in the Dease and Liard valleys, but the direction of movement of the ice could not be determined satisfactorily, and the influence of local action is there less certainly eliminated.

Of the glacial deposits with which the greater part of the area of the inland region is mantled, it is not intended here to give any details, though it may be mentioned that true Boulder-clay is frequently seen in the river-sections, and that this generally passes upward into, and is covered by, important silty beds, analogous to the silts of the Nechacco basin, further south in British Columbia, and to those of the Peace River Country to the east of the Rocky Mountains. It may be stated also that the country is generally terraced to a height of 4,000 feet or more, while, on an isolated mountain-top near the height of land between the Liard and Pelly rivers (Pacific-Arctic watershed) rolled gravel of varied origin was found at a height of 4,300 feet, a height exceeding that of the actual watershed by over 1,000 feet.

Reverting to the statements made as to the direction of the general glaciation, the examination of this northern region may now be considered to have established that the main gathering-ground or névé of the great Cordilleran glacier of the west coast, was included between the 55th and 59th parallels of latitude in a region which, so far as explored, has proved to be of an exceptionally mountainous character. It would further appear that this great glacier extended, between the Coast Range and the Rocky Mountains, south-eastward nearly to latitude 48°, and north-westward to lat. 63°, or beyond, while sending also smaller streams to the Pacific Coast.

In connection with the northerly direction of ice-flow here mentioned, it is interesting to recall the observations which I have collected in a recently published report of the Geological Survey, relating to the northern portion of the continent east of the Mackenzie River.[6] It is there stated that for the

[6] Notes to accompany a Map of the Northern Portion of the Dominion of Canada, East of the Rocky Mountains, p.57 R. Annual Report, 1886.

Arctic coast of the Continent, and the Islands of the Archipelago off it, there is a considerable volume of evidence to show that the main direction of the movement of erratics was *northward.* The most striking facts are those derived from Prof. S. Haughton's Appendix to M'Clintock's Voyage, where the occurrence is described of boulders and pebbles from North Somerset, at localities of 100 and 135 miles north-eastward and north-westward from their supposed points of origin. Prof. Haughton also states that the east side of King William's Land is strewn with boulders of gneiss like that of Montreal Island, to the southward, and points out the general northward ice-movement thus indicated, referring the carriage of the boulders to floating ice of the Glacial Period.

The copper said to be picked up in large masses by the Eskimo, near Princess-Royal Island, in Prince-of-Wales Strait, as well as on Prince-of-Wales Island,[7] has likewise, in all probability been derived from the copper-bearing-rocks of the Coppermine River region to the south, as this metal can scarcely be supposed to occur in place in the region of horizontal limestone where it is found.

Dr. A. Armstrong, Surgeon and Naturalist to the "Investigator," notes the occurrence of granitic and other crystalline rocks not only on the south shore of Baring Land, but also on the hills at some distance from the shore. These, from what is now known of the region, must be supposed to have come from the continental land to the southward.

Dr. Bessels, again, remarks on the abundance of boulders on the shore of Smith's Sound in lat. 81° 30′, which are manifestly derived from known localities on the Greenland coast much further southward, and adds: "Drawing a conclusion from such observations, it becomes evident that the main line of the drift, indicating the direction of its motion, runs from south to north."[8]

It may further be mentioned that Dr. R. Bell, of the Canadian Geological Survey, has found evidence of a northward or north-eastward movement of glacier-ice in the northern part of Hudson Bay, with distinct indications of eastward glaciation in Hudson Strait.[9] For the Northern part of the Great

[7] De Rance, in Nature, vol. xi. p. 492.

[8] Nature, vol. ix.

[9] Annual Report, Geol. Surv, Canada, 1885, p. 14 D. D.; and Report of Progress, 1882-84, p. 36 D. D.

Mackenzie Valley we are as yet without any very definite information, but Sir J. Richardson notes that Laurentian boulders are scattered westward over the nearly horizontal limestones of the district.

Taken in conjunction with the facts for the more southern portion of the Continent, already pretty well known, the observations here outlined would appear to indicate a general movement of ice outward, in all directions, from the great Laurentian axis or plateau which extends from Labrador round the southern extremity of Hudson Bay to the Arctic Sea; while a second, smaller, though still very important region of dispersion—the Cordilleran glacier-mass—occupied the Rocky Mountain region on the west, with the northern and southern limits before approximately stated.

I have refrained from entering into any detail at this time in respect to the glaciation of the northern part of the Cordillera belt, as it is probable that within the year we shall be more fully informed on the subject, as the result of observations to be expected from Mr. R. G. M'Connell of this Survey. Mr. M'Connell is now on the Mackenzie River, which, as well as the Porcupine branch of the Yukon, within the Arctic circle, it is intended that he shall examine during the summer.

CONGLOMERATES IN NEW ENGLAND GNEISSES.

[A letter addressed to Alexander Winchell.]

By Professor CHARLES H. HITCHCOCK.

Your paper upon *Conglomerates enclosed in Gneissic Terranes*, in the March number of the *American Geologist*, brings out very important facts in reference to the origin of gneiss, particularly that in the older Archæan. My observations and studies have inclined me to doubt the presence of water-worn pebbles in the Laurentian or in granite, and I have been waiting to hear from those who have discovered them. The observations of such a veteran in geological service as yourself should certainly be conclusive.

You have made several references to localities in the east with which I am familiar, and I desire to say that I am intimately acquainted with them all and find nothing in favor of your proposition in them. To begin with, none of them are in the true Laurentian, so that, granting the presence of pebbles, they do not prove a sedimentary origin of the older gneisses. The first case you allude to at Newport, R. I., where my father noticed pebbles which had been distorted by pressure belongs to the Carboniferous. The conglomerates on both flanks of the Green mountains described by my father are really at the base of the fundamental quartzite of the Taconic system. Or if they are older, they are a part of the Green Mountain gneiss which is supposed to overlie the true Laurentian. Being on or near the line of junction of the schist and quartzite I have always regarded them as belonging to the later or derived series. The next illustration is cited from Mt. Ascutney in eastern Vermont. The statement about the derivation of the porphyry and granite from a conglomerate is certainly in favor of the origin of granite from the melting of pebbles. This case was brought to my father's notice in 1859 by myself. He accepted my explanation of the appearances and wrote the account of them in the report. After twenty years of experience in studying crystalline rocks I returned to Ascutney and could not accept the earlier view. We had been led astray partly by the unusual position of the apparent beds, which have a direction almost at right angles to the prevalent strike of the neighborhood, consequently, if they are stratified they belong to three different horizons. The view of my father presumed the three rocks to be part of the same bed, altered by thermal influences in proportion to their intensity. The whole mountain is full of fragments of rocks evidently torn from inferior ledges when the syenite came up from below. I have found this syenite to be a truly eruptive mass, coming up through a vent and spread out over Silurian upturned strata. It is a cone 2,000 feet high, having stratified rocks underneath which have been altered by contact with a molten igneous mass forced over them. It must be true, however, that some of the fragments have been forced into the syenite, but there is no appearance of rounding through aqueous attrition in any of the fragments. The illustration from Granby is of the same nature.

It would be possible to add from my New Hampshire report illustrations where the melting up of fragments has been more complete, but there is no evidence of a deposition from water. Take the case of Mt. Pequawket (or Kiarsarge) near North Conway, the cone of granite 2,500 feet high has at its base two masses of slate, each a half mile or more in length, but completely imbedded in granite. Adjacent to them is a breccia whose paste is hardly discernible, but gradually becoming evident at the distance of several rods from the unbroken slate. The fragments gradually diminish in number though they are visible to the very top of the mountain. Upon Mt. Moat, across the valley, the slate fragments also abound. These examples belong to the class of ejections described by Dr. Hawes upon Mt. Willard, (Amer. Jour. Sci. Jan. 1881.) where it is claimed evidences of igneous eruption are to be discerned in the formation of microscopic crystals of tourmaline, the increased amount of silica and other contact phenomena. The slate described is the same with that observed upon Mts. Pequawket and Moat.

The specimen described by Prof. O. P. Hubbard from Warner [not Warren] in 1859 is now in the Dartmouth College museum. The so-called boulder seems to be of concretionary origin. Its mass is essentially the same with that of the enveloping granite, but is separated from it by a thin coating of biotite which covers the oval interior just as the skin covers an apple. Had the inclusion ever been subjected to attrition the biotite would have disappeared. Being in the neighborhood of the curious mica nodules of Vermont its concretionary origin is still more apparent. The last case cited is that of pebbles in mica schist in E. Hanover described by Dr. Hawes. These are paleozoic, and if they have any bearing upon the Laurentian conglomerates lead to an entirely different conclusion from that which you have advocated.

In your note in connection with the Errata of the "separates," you refer to the conglomerate in the Black Hills, as described by W. O. Crosby and F. R. Carpenter. Both these gentlemen present facts showing the probable absence of the Laurentian from the Black Hills; and the particular conglomate cited is correlated with the fossiliferous Taconic of western New England, also with the conglomerate of Bellingham, Mass., which may also be Cambrian, certainly post Laurentian. The point which I desire to emphasize is, that while your view of the Laurentian inclusions may be correct, *there is no support to your position to be derived from any of the cases cited from the East and the Black Hills.*

In my writings upon the granite of New England I have cited many instances of fragments of schists and other pre-existing rocks included in it, many of them showing signs of alteration. There is nothing about any of these fragments to suggest attrition. Furthermore, all our true eruptive granites are post-Laurentian, if not of paleozoic age. This is certainly true of the majority of examples, and those the ones most typical. At all events, granting the rounding of fragments, the work of remodelling was effected in paleozoic times, and hence is not Laurentian.

Furthermore, as to the cases you cite from Minnesota, the pebbles are of rocks recognizable as Laurentian. Hence one of two conclusions should follow. Either the pebbles came from a pre-Laurentian terrane, or the conglomerate being made of Laurentian materials is post-Laurentian. Both conclusions are opposed to the sentiment of your paper. If there is any metamorphism of a conglomerate in the Saganaga pebbles, I should judge from your description, it is the Ogishke conglomerate that has been affected, which is only 15 miles distant and "stocked with similar pebbles."

CONGLOMERATES ENCLOSED IN GNEISSIC TERRANES.

[Supplement.]

BY ALEXANDER WINCHELL.

My article on the subject above named has elicited many comments, some of which render it desirable to supplement the article with explanations and new evidences. One esteemed correspondent whose familiarity with New England geology is everywhere recognized, reminds us that the terranes from which boulders and conglomerates have been cited in Vermont, Massachusetts and Rhode Island, are post-Laurentian.[1] This was well understood in making the citations. They were not made for the purpose of proving directly the fragmental origin of Laurentian gneisses. Some of them were intended to remind geologists that certain terranes generally recognized as real crystalline gneisses—however distinguishable from Laurentian gneisses in position or petrography—inclose features incompatible with an eruptive origin. If, however, an obviously fragmental origin of any gneisses

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[1] See the communication from Professor C. H. Hitchcock in the present number of the GEOLOGIST.

must be admitted, the reader may rationally infer that perhaps even Laurentian gneisses are also fragmental in origin. The evidence is that they *may* be fragmental. When therefore, in addition to this presumption, I cite similar conglomerates from the recognized Laurentian of Canada and Minnesota, we have the same evidence for a fragmental origin of Laurentian terranes as in New England, for post-Laurentian terranes.

If the gneisses of the Black Hills[2] are also post-Laurentian the fact of the association of pebbles and conglomerates has the same significance as the facts cited from New England—neither more nor less.

As to the case of included fragments which evidently are not water-worn, mention is made of them only to prove the contemporaneousness of the gneiss mentioned with processes of sedimentary rock-making. If such contemporaneity existed in New England gneisses, it may presumably have existed with Laurentian gneisses; and when I cite hundreds of similar fragments in Laurentian gneisses, the evidence rises from analogy to demonstration. Gneiss-making and sediment-forming could not be coincident in time and place, if gneiss originated from igneous fusion and sediments accumulated from watery immersion. But no one doubts that sediments so originated; gneisses associated with them, therefore, must have had an aqueous history.

As to New England granites of such character or collocation with schists as to show, as at Mount Pequawket, that they have been in a state of fusion, there is neither reason to doubt the evidence nor to be misled by it. If granites generally have resulted from metamorphism of sediments, it is extremely probable that, exceptionally, the metamorphism reached the stage of fusion, accompanied as it almost necessarily would be, by eruption and vein-filling. Many granite veins, nevertheless, may have originated from heated solutions, and others from in-squeezed plastic material in which the planes of sedimentation had not become completely obliterated.

I have cited the occurrence of pebbles in non-gneissic terranes, as in Rhode Island, regardless of their age, because the

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[2]The allusion to the Black Hills was made only in the slip of "Errata" attached to the "Extras" of my article.

pebbles were reported as furnishing evidence of softening and distortion; and the inference would be that if metamorphic agencies had effected such changes in times as late as the Coal-Measures, it was probable that in earlier times, they had, in many situations, more completely softened once-consolidated sediments, and even reduced them to such state of molecular intermobility that crystallizing rearrangements of the molecules would have taken place.

Professor Hitchcock affirms: "There is no support to your position to be derived from any of the cases cited from the East and the Black Hills." My "position" was simply that conglomerates sometimes occur in gneissic terranes. I think when professor Hitchcock attempts to show that the gneissic terranes of New England which enclose conglomerates are not Laurentian, he yields a clear implication in his own words, to serve as support to my "position." If he conceives my position to have been that Laurentian gneisses are all sedimentary in origin, I admit that the cases cited from New England and the Black Hills do not complete the proof of it, but the inference lies so close to the facts cited that it is a mere matter of form to enunciate it.

I desire also, to notice briefly a comment communicated by the honored Director of the Canadian Survey.[3] He says, "I entirely concur in your remarks. The facts you mention, however, have been so long and so well known to us in Canada as to be considered scarcely worth discussing; and I am a little surprised that among the authorities you cite you have not referred to Logan and the "Geology of Canada." * * * That the whole complex of the Archæan or pre-Cambrian rocks is a great series of mixed igneous, clastic and pyro-clastic rocks greatly altered, physically and mineralogically, by various metamorphic agencies there can be no doubt."

To this I beg to subjoin an expression of surprise that the obvious use of facts "so well known" has been so quietly overlooked, especially in Canada, where at least one of the officials of the survey is insisting that the gneisses are eruptive, and not of sedimentary origin. If those facts are so old and familiar as to have passed the stage of appropriate com-

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[3]This comes in a personal communication, but I assume no objection can be made to public reference to it, since it concerns a geological question of general interest.

ment, beyond the Canadian border, I feel sure that the case is different in cis-Canadian territory. It may be well, however, to ascertain from the documents precisely what has been "so well and so long known." In his description of the Laurentian system,[4] Sir William Logan says: "Notwithstanding the general crystalline condition of the Laurentian rocks, beds of an unmistakably conglomeratic character are occasionally met with among them. * * * On the twenty-fourth lot of the tenth range of Bastard (in the valley of the Ottawa) a bed of *conglomerate* is interstratified between two of the beds of limestone." The following is an abstract of the more detailed succession given changed here to descending order.

Limestone, coarse-grained, white..........................	6 ft.	
Limestone, fine-grained, arenaceous........................		4 in.
Sandstone, fine-grained, calcareous........................		2 in.
Conglomerate, coarse, of which the matrix is a fine-grained, quartzose sandstone. Contains among others, pebbles of sandstone. These are flat, and lie on their flat sides in the general plane of the stratification..............	1 ft.	6 in.
Quartzite, somewhat fine and calcareous..................		2 in.
Quartzite, coarse, granular................................		4 in.
Limestone, white, crystalline, coarse-grained................	5 ft.	

Again, he speaks of a locality north of the village of Madoc, at which, in a higher geological position, a somewhat micaceous schist occurs, which holds "numerous fragments of rock different in character from the matrix, all being without calcareous matter, and some of them resembling syenite or greenstone. North from this ridge another succeeds, consisting of micaceous schists, beyond which for 300 yards, ridges of a decided *conglomerate*, with distinctly rounded pebbles, enveloped in a matrix of micaceous schist, alternate with ridges of schist containing few or no pebbles. * * *

Still further north, another band of *conglomerate* occurs, associated with fine-grained, soft, micaceous, feldspathic schist.

The matrix of the conglomerate weathers white, and appears to be a dolomite. The pebbles, of which the largest may be six inches in diameter, are chiefly quartz, but there are also, pebbles or masses of feldspar, and a few of calc-spar. The quartz pebbles are for the most part, distinctly rounded."

It will be noticed that while these occurrences are embraced, in a wide sense, in the Laurentian system, we learn of no pebbles or conglomerates embraced directly in Laurentian gneiss. They are contained in beds whose aqueous origin

[4] Geology of Canada, 1863, pp. 22-49

would generally be admitted. It is surprising, as may be remarked in passing, that the nature of the associated beds has not been claimed as evidence of a general aqueous history of the whole Laurentian. But as long as the gneisses were free from pebbles and conglomerates the evidence of their aqueous origin was rather presumptive than direct. On the contrary, the cases which it was the main purpose of my paper to describe, presented pebbles *in the midst of gneissic masses*, and a *conglomerate imbedded completely in a gneiss* so massive as to have been commonly denominated a syenite. The matrix itself is a characteristic gneiss. I am not aware that such occurrences are "well known."

The conglomerates cited by Logan have lithologic associations quite analogous with those of the so-called Huronian conglomerates. The associations are directly with sedimentary rocks, more remotely with crystalline rocks. It was not my purpose to refer to conglomerates so situated—any further than to quote the passage from Credner in which the aggregate mass of conglomerates in the Archæan is mentioned.

In the general discussion of conglomeritic occurrences in terranes more or less crystalline, references should be made to the observations of professor W. O. Crosby.[4]

The nucleus of the Black Hills has been again and again reported granitic. But Crosby states that granites occur only as lenticular masses conformable with the stratification of the schistose rocks. This, in fact, was previously reported by N. H. Winchell and by Newton. In the eastern or newer series of Archæan rocks, occurs an important quartzite which, in places, "passes into coarse grits and conglomerate," the pebbles of which have suffered extensive deformation. Professor Crosby regards the conglomerate and associated schists as "strikingly similar to the metamorphic sediments occurring at Bellingham, Massachusetts."[5] "It is perfectly plain," he says, "that the metamorphic series consisted originally of interstratified beds of ordinary mechanical sediments—slate, sandstone and conglomerate; and the metamorphic agents have not only accomplished the chemical change implied in the fact that these rocks are now in the main, distinctly hydro-

[4] *Geology of the Black Hills of Dakota.* From the Proceedings of the Boston Society of Natural History, Vol. XXIII, pp. 488-517.

[5] Proc. Boston Soc. Nat. Hist., XX, 373-8.

micaceous, but also a very marked mechanical change, which is most apparent in the deformation of the pebbles of the conglomerate." "The fragmental nature of the conglomerate and the deformation of the pebbles are, in both regions, indisputable facts."

Even the great lenticular masses of the granite are not recognized by Crosby as eruptive. Though they sometimes branch and enclose masses of schist, the concomitant conditions are such as to furnish "a complete refutation of the view that these masses are eruptive." "True eruptive granite is probably entirely wanting in the Black Hills."

The geological conditions appear to be similar to those along the international boundary in Minnesota and Canada; and professor Crosby's conclusions appear to be entirely accordant with the facts.

Quite recently an important memoir has been issued by Dean F. R. Carpenter.[6] The conditions as found in Minnesota are accurately described in the account of the Black Hills, quoted from the report of N. H. Winchell: "The mica schists become more and more granitic by interstratification, yet the schist maintains its distinctive character, and prevails up to the very base of the granite; and appears in thin, contorted laminæ in the granite itself."[7] To these and similar views he assents. In the further details he is quite in accord with professor Crosby, and reaches the same conclusion in reference to the probable metamorphic history of the crystalline terranes.

Now that attention is particularly directed to the existence of water-worn pebbles and fully formed conglomerates in gneissic terranes, both of post-Laurentian and of Laurentian age, it is quite probable that many additional occurrences will be pointed out, and that the evidences of an early sedimentary history for most of the granitoid and gneissoid rocks will rapidly accumulate.

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[6] *Preliminary Report of the Dakota School of Mines upon Geology, Mineral Resources and Mills of the Black Hills of Dakota.* Rapid City, 1888. This was reviewed in the March number of the GEOLOGIST.

[7] Ludlow's *Report of a Reconnaissance of the Black Hills of Dakota*, 1874, p. 42.

EDITORIAL COMMENT.

THE BUILDING OF THE BRITISH ISLES.—*A. J. Jukes-Browne.*

This little work is an attempt to restore the extinct geography of the British Isles from the best attainable evidence. The author who a few years ago brought out a smaller volume on the same subject but with a less comprehensive scope gives in the present work a much more elaborate account of the various stages of geological evolution which have resulted in the existing geographical outlines. That the book must be of very great interest to the student of geology either in England or in America "goes without saying" (to quote a French idiom) and it is scarcely necessary to add that there is abundant evidence to show that the author has spent great pains and much time on its production. He sketches the various geologic eras in succession and shows what part of the country was formed during each of them, so far as it is at present possible to do so. He also shows how the building of one age was often destroyed by the next or by some other that followed; how Britain has been over and over again a part of a large continental mass, whether that mass could properly be called Europe or not; how it has been repeatedly submerged and re-elevated and how it has been the seat of volcanic action at various epochs, and has been cut into by the waves and the tides; how its materials have been deposited and eroded and again deposited and again eroded, until after the lapse of ages the existing geography was evolved, making it a group of islands, many of them very small and sundered from their continental neighbor by a "streak of silver sea."

Mr. Jukes' book is one of a kind which will multiply as our geological knowledge becomes definite. Such works are the natural outcome of clearer ideas of the past history of the Earth. Similar treatises may be looked for concerning every region and country as its geologists gradually succeed in restoring its former outlines. The day may come when we shall possess atlases of the past geography of our globe stretching back through all the eras of geologic time.

This is one of the vast labors before the geologist. We may fairly call it the sum of all his toil. Not till this is done will the Earth's past be understood or the Earth's history written. It is perhaps beyond hope to look for full details this work. The historian comes at times in his researches to the edge of a gap where the connection is lost, the records are missing, the chain is broken. Fire, or some one of the numerous accidents to which his materials are exposed, has destroyed them and left a chasm that can never be altogether filled. A few scattered extracts from the lost volumes, a few detached references to unrecorded events, a few isolated and disconnected letters and papers are all that he can obtain and from these he must to the best of his ability reconstruct so much of his missing fabric as will make the story which he is putting together intelligible.

And the geologist is in a similar condition in essaying to reconstruct the past geography of the globe. His materials like those of the historian are hidden in places that are difficult of access. They are being slowly brought to light by a multitude of isolated and independent workers from the stony records of the Earth. But in spite of all their labor for so many years past the gaps are still far more extensive than the chapters and many a link must be established before any connected story can be compiled out of the disjointed materials.

Few parts of the world have been more thoroughly examined than the British Isles. The labors of the Geological Survey aided, backed and sometimes corrected by those of a host of equally able and zealous working geologists without official recognition have put on record a mass of facts the mastery and use of which require endless patience and persevering industry. The outcome of these is shown in the work before us —the latest and perhaps the most pretentious (using the word in no uncomplimentary sense) that has yet appeared. Previous and excellent attempts were made by professors Geikie and Hull and by the author, but none of these ventured so far in the direction of mapping the past continents and island, oceans and lakes as Mr. Jukes-Browne has done in the work before us.

Yet he is fully conscious of the difficulty of his task and claims a due consideration from his reader for the errors and imperfections that are inevitable to a somewhat daring attempt especially in the earlier and more obscure chapters. He says:

"The imperfection of our knowledge is one great difficulty and the imperfection of the geological record is another. The latter will never be entirely overcome. * * * I must therefore ask the reader to remember that some of the restorations attempted in the following chapters, especially those of the earlier periods of geologic history, are built on slight foundations and may be modified by the results of new discoveries."

We do not propose to follow in full detail our author through the whole field over which he has traveled. Few American readers are sufficiently familiar with European geology to be interested in them and those to whom the topic is attractive will want to accompany him personally without the intervention of a guide. We shall therefore give only a brief summary of his views sufficient to indicate the scope of the book.

In the present state of our ignorance regarding the Archæan era Mr. Jukes-Browne has done well in giving the merest outline sketch. His representation abounds in shadowy forms and vague description as the maps of the old geographers who supplied their want of knowledge with suppositions such as, "*Hic habitare dicuntur leones*," "*Hic sunt Lunæ montes*," etc., etc. No attempt is made to give an map of Archæan Britain but we are simply told that a few spots in the north of Scotland, the western islands, the northwest of Ireland and certain districts in England consist of Archæan rocks. He evidently inclines to the belief that many of them are of igneous origin.

In the next or Cambrian era the author agrees with Mr. Callaway that there then existed a mass of land in the North Atlantic of which a part of Norway, the Hebrides, Donegal and the highlands of Connemara are the worn and inconspicuous remains. From this passed continent were derived the sediment that built the Cambrian rocks of Europe, then for the most part a sea area to the southeast.

In the Ordovician or Lower Silurian era which followed we are for the first time presented with a map. It represents a mass of land stretching in from the west and reaching the site of Edinburgh with two small islands, one in central England and the other between England and Ireland. All the rest of the area is occupied by sea.

The Silurian (Upper Silurian) which follows shows us the island in central England still persisting but changed in form, being divided into two while the other between England and Ireland is larger but in the same region. The northwest of Scotland and of Ireland is part of a great continental mass whose farther limits are unrepresented and all the British area and the adjoining continent are lying under the waters of the early Silurian sea.

The transition to the Lower Devonian geography is almost kaleidoscopic. Every thing is changed. Sea occupies the south of Ireland and the south of England while the area to the north is dry. But the Scottish district shows five lakes, two of them rivaling in size those of North America. Lake Caledonia covers the sites of Edinburgh and Glasgow and stretches to the northeast into the sea and to the southwest as far as Ireland and resembles lake Michigan in form and size. Lake Orcadie lies on the site of the Orkneys and the northeast of Scotland stretching far over the sea towards Norway. This restoration is in accordance with the view that while the limestones of Devon and Belgium are undoubtedly of marine origin the Old Red Sandstone was most likely laid down in the bottoms of lakes. Evidence of this is afforded by its fossils which are for the most part plant-remains and ganoid fish.

It is not improbable that when the Devonian geography of North America is restored similar conditions will be found to have prevailed on this side of the Atlantic. The Red Sandstone of the Catskill group gives evidence of a similar origin and was probably deposited in a great lake covering part of New York and Pennsylvania.

In the Lower Carboniferous era the map represents a large island in central England as in some preceding ages. This island lies in an arm of the sea covering nearly all of the British Isles except the northern part of Scotland which is shown as a portion of a great northern continent whose farther limits are unknown. Northwestern France also is part of another or perhaps of the same continental mass.

The Carboniferous era in Britain seems as in this country to have been for the most part a time of repose. The land consisted of vast and swampy flats on which grew the vegetation of the Coal-Measures and some explanation of the existence of the identical species on both sides of the Atlantic may be found in the following statement: "At this period a large continent occupied the whole area of the North Atlantic and extended from Finland on the east to the Rocky mountains on the west."

But in Europe as in America the calm of the Carboniferous was succeeded by a storm in the following age which Mr. Browne calls the Dyassic. Then were elevated several of the great mountain ranges which still form prominent features in the geography of both continents. The Alleghenies in the west and the Pennines in the east form, one of them the backbone of the eastern states and the other the backbone of England. Never since that epoch have these mountain masses ceased to be conspicuous in the geography of the two countries. The Dyassic map of the British Isles shows us a large lake occupying central England and extending northwest into Scotland and Ireland while an arm of the European sea stretches from the east into Yorkshire. All the rest of the area in question is dry land. The proportion is greater than at any previous epoch.

But we must hasten. The Triassic era (Keuper) shows an increase of the size of the Dyassic lake which now extends from the south of England to the north of Scotland. The lower Jurassic sea is larger still and reaches into France while the later Jurassic shows us an almost complete drying of the area, the sea remaining only over a small space in the south of the country. A slight increase of sea marks the lower Cretaceous. Here too we see an inroad on the long existing continental area in the northwest. The Atlantic continent at last shows signs of passing away. A patch of blue sea appears off the northwestern coast of Ireland which in the later or upper Cretaceous has expanded into a considerable area while the eastern half of England is beneath the water of a European ocean.

No change is discernible in the lower Eocene except the further enlargement of these two bodies of water but in the Oligocene a new water area appears in the north and the well known ridge, which in the present day is so conspicuous a feature in the submarine geography of the Atlantic, was elevated above the surface. Norway, the North sea and the British islands with the intervening seas were then dry and a long isthmus reached past the Faroe islands to Iceland.

But at the end of the Pliocene age subsidence had broken through this ridge and only the Faroe area was above water constituting a large island half way between Scotland and Iceland. The sea had penetrated between the British Isles and Norway so that the North sea had come into existence, but England was still a part of continental Europe though nearly of its present form and outline.

An era of upheaval followed in pleistocene time when the coast coincided with the contour-line of 80 fathoms. Extensive alterations of the geography followed even this comparatively slight change of level. This was the time when the Rhine flowed off the line of the present coast along the bed of the North sea, received the Thames, the Trent, the Forth and other rivers of England and Scotland as tributaries and itself reached the ocean between the Shetland isles and Norway. Near-by was the mouth of another great river which never had a name but which drained the present Denmark and the eastern Baltic. The Seine then followed down the English Channel and with another great river coming from the Irish Channel entered the Atlantic one hundred miles off the Land's End. The Atlantic was then well developed and extended over nearly its present area. Yet if we disregard the contour-lines there is on the map little to suggest the British Isles of the present day.

But with a change to the 40 fathom-line in later pleistocene times the outlines become familiar. England is nearly separated from France and the only connection of Ireland with the larger isle is by a roundabout passage through the west of Scotland. This was after the glacial era when the islands were receiving their population from the neighboring continent and owing to the short length of this condition and to the circuitous direction of the path the number has always been less than on the larger land mass. Indeed the paucity of reptiles in the Green Isle which is usually attributed to the kind intervention of St. Patrick is with more reason by geologists ascribed to the destruction of the natural bridge before they had had time to pass over it.

We make no apology for presenting to our reader this summary of the "Building of the British Isles." It is the only part of the world whose geological atlas has yet been attempted, perhaps the only part for which any similar attempt is yet possible with reasonable prospect of success. We cannot now stop to point out the bearings of the facts and inferences brought forward by the author on several geological problems of general interest and importance, such as the migration of animals and plants and the permanency of the ocean-basins but at some future time we may return to these topics and consider them as their importance deserves.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Brachiospongidæ: A memoir on a group of Silurian sponges; with six plates. By CHAS. EMERSON BEECHER. (From the memoirs of the Peabody Museum, of Yale University, vol. II, part 1, New Haven). Into this valuable paper are gathered and grouped systematically all important information concerning the rare class of fossils which, while first discovered by Dr. G. Troost, in 1838, and partially elaborated by Von Zittel and Dr. G. J. Hinde, and classified by Dr. F. E. Schulze, have now been first referred to their stratigraphic place. Troost described and figured the fossil without giving it any name, stating that it was obtained in Davidson county, Tenn. After some changes of ownership, and with some doubt thrown on its identity with the original specimen, it was placed in the hands of Prof. O. C. Marsh who described and named it *Brachiospongia vœmerana,* in 1867. Another species was named by him *B. lyoni.*

In 1858 Dr. D. D. Owen had referred them to *Scyphia* Oken, and in 1862 Prof. R. Owen inadvertently altered this to *Syphonia.* To Prof. Marsh therefore is due the credit of separating it from other genera and the erection of the new genus *Brachiospongia.* This genus has since been recognized by Le Conte, Miller (S. A.), Zittel, Rœmer and Hinde.

Recent careful examinations in Kentucky have led to the discovery of the exact stratigraphic position of this curious and rare fossil. Having been found only as isolated fossils in loose fragments of limestone they could only be referred in general to about the middle of the Silurian. Mr. E. C. Went, of Frankfort, Ky., has, however, found it in place in a "fine cherty, nodular limestone, above the horizon of *Orthis borealis,* which has been considered as the upper member of the Trenton." This horizon has been traced over a considerable extent of territory. But a single specimen (of *B. digitata*) has been found from any other horizon, viz., the middle Hudson, at a somewhat higher horizon.

On the ophiolite of Thurman, Warren County, N. Y., with remarks on the Eozoon canadense. By GEO. P. MERRILL. (From the *Am. Jour. Sci. Mar.,* 1889). In this paper Mr. Merrill agrees with most, if not all, lithologists who have examined microscopically the rock containing the form that has the name of *Eozoon canadense,* and refers it, though with due caution owing to the lack of material and of sufficient field-examination, to a metasomatic alteration of pyroxenic granules to serpentinous matter. "Irregular canals of serpentinous matter cut through these aggregates, following cleavage and fracture lines." He suggests that the "mineral pyroxene of the white or colorless variety, occuring often in the lower layers and filling some of the canals" of the Eozoon, as described by Dr. Dawson, is but the residual mineral that has escaped alteration.

A deadly gas-spring in the Yellowstone National Park. Mr. Walter H. Weed describes in *Science*, Feb. 15, 1889, a remarkable place to which the appropriate name of *Death gulch* is given. It was discovered by Mr. Weed in the summer of 1888, while making geological examination of the region. It is in the extreme N. E. portion of the reservation. It is on Cache creek, two miles above its confluence with Lamar river. A ravine here is so charged with gaseous emanations that bears, elk, squirrels and other animals, as well as butterflies and insects are asphyxiated before they can escape. It is a V-shaped trench, not over seventy-five feet deep, cut in a mountain slope, and not a hollow, or cave. The gas which constantly escapes results from the prevalence of volcanic agents in the region. "Death gulch is without a peer as a natural bear-trap, and may well be added to the list of wonders of the Yellowstone Park."

Geological Survey of Arkansas: Second Annual Report of the State Geologist; in 4 volumes, Vol I. Dr. Branner is conducting a work in the state of Arkansas for which American men of science should feel grateful, and the first volume of his report shows that he has done his work in a fearless, honest straight-forward manner, under the impression that the object of a state geological survey, is to make a geological survey of the state, and not to provide political dependents with office or to boom speculative enterprises. As a result of rigid adherence to this line of policy after two years of labor upon the small appropriation of $10,000 a year, in a region most difficult to investigate and against hygienic and prejudical obstacles not ordinarily encountered, he presents for publication four volumes of results which throw the first intelligible light we have yet had upon that region. Since Dr. Branner's constituency was impregnated with the idea that geology is merely the study of metallic minerals, and since the state was flooded with fraudulent mineralogists and assayists who were finding gold and riches in marvelous plenitude, the first step of the geologist was to have the mineral resources thoroughly investigated, the result of which is embraced in Vol. 1, which lies before us.

This report, written by Prof. Theo. B. Comstock, although mostly negative in its opinions of value, sets forth thoroughly and exhaustively the exact geologic and economic conditions of the region studied, and will save prospectors far more than its cost, and relieve true geologic investigation of the future of the "mineral" incubus. From a scientific standpoint, while presenting some defects, it is an excellent contribution, and contains much new and interesting geologic data, especially concerning the heretofore little known mountain region of southwest Arkansas. The chemical and petrographic work, by Dr. R. N. Brackett is also up to the standard of to-day.

Having relieved Arkansas and the survey of the "mineral" incubus Dr. Branner proceeds to bring the attention of the people from the extraordinary features of geology to the ordinary; and the second, third and fourth volumes now in press will contain exhaustive reports upon certain well defined geologic areas, and their economic capabilities. These reports will include several accurate topographic and geologic sheets. Vol. II, about ready, will consist of a report upon the neozoic geology of southwestern Arkansas, by R. T. Hill, in which the Cretaceous, Tertiary and Quaternary areas are mapped and discussed and attention called to the rich marls, chalk and gypsum beds of the region. The exhaustive study of the Cretaceous—especially the upper formation, in this volume, will be of interest. The third volume, will be devoted to the coal regions. Mr. Arthur Winslow, late of the Pennsylvania survey, has done this work, and in a most excellent manner. The fourth volume will be made up of several papers upon geology by Dr. Branner, Prof. R. Ellsworth Call and others; and upon botany and zoology, by various writers. It is gratifying to know that the Legislature of the State have appreciated Dr. Branner's work and is preparing to endorse it by increased appropriations for the coming two years.

Texas Geological and Mineralogical Survey: First report of progress. E. T. Dumble, State Geologist, 1888. Austin, State Printing Office, 1889. 8vo., 78 pp.

This little volume is creditably printed and contains along with much rubbish some things which are good. The peculiar political conditions of the State of Texas, notwithstanding its illiberality to scientific institutions, have always been productive of an army of scientific experts (self imagined) to fill its scientific offices, and Mr. Dumble has secured his share of these for assistants, judging from the number of new names in the work and the recklessness with which they handle that most dangerous tool known as mere assertion. For instance, it is refreshing to learn that rainfall can without doubt be increased in the arid regions of Texas, and that the hitherto supposed worthless Tertiary woody lignites may prove of great value. The number of new terranes, Jurassic, Tertiary, Cretaceous, etc., discovered by professor Jermy, is bewildering. The lengthy report upon that most interesting *terra incognita* of American geology, the mountainous trans-Pecos region, about which we know almost nothing, would be of interest, but one necessarily feels disappointed when he finds it void of original observations, and filled with such interesting statements as the following: "I reached old Camp Rice a few minutes before the outbreak of a storm, followed by a severe thunderstorm with rain and hail, but was compelled to take shelter in an empty adobe home with a leaky roof that kept us moving round the room all night to keep dry." This and similar statements deserve a place in geologic annals along side that of a former state geologist who records that a certain plant is "a good remedy for rheumatism; the virtue to be extracted by placing in pure whiskey or brandy after which it is to be drank. Mr. G—— says he has seen it tried repeatedly and never knew it fail making a cure." [First annual report of the Geological and Agricultural survey of Texas by S. B. Buckley, p. 122.] The report upon the Carboniferous area is also unworthy of the price paid for it.

Two papers in the volume however deserve a better place of publication. The first of these is an excellent statement of the upper Cretaceous coal field of the lower Rio Grande by Mr. J. Owen, a practical and successful miner who has made considerable study of structural geology. The other is upon the iron ores of eastern Texas by R. A. F. Penrose Jr., and throws much light upon their extent and origin.

An idea of the report as a whole may be gleaned from the plan of operations of the survey, as published on page 4, where it reads that: "The work will be particularly directed first to a search for ores, minerals, oils, coals, clays, and other materials possessing a commercial value. * * * The collection of fossils and *study of geologic strata* * * * will be made subordinate and subsidiary to the economic features of the survey."

The work gives no credit whatever to the investigations of previous geologists in Texas, although their results are frequently restated; nor does it acknowledge the extensive services of those who have at its request, given it gratis much time and labor. As a whole however, the work is a decided advance over any previous attempt, and its defects may be excused on the grounds of haste, and the inexperience of the state geologist. That its object is more to secure an appropriation than to disseminate geologic information is apparent throughout. By a state geologist, unless he be independent of the problematic ways of state Legislatures, this object must always be kept in mind, but it should not be allowed to dominate the scope and direction of the work. These two ideas, the study of the actual geology, and the prevalent partiality for the "mineral incubus," have sometimes come into collision, to the detriment of both. No survey can run solely on one of these ideas, but like the militia in time of peace, the "incubus" has its place if kept subordinate to law. In Arkansas the incubus had run wild without law, until subordinated by Prof. Branner. In Texas it is in a fair way to take the law into its own hands.

Les modifications et les transformations des granulites du Morbihan; par Charles Barrois. (From the annals of the *Société géologique du Nord*; Lille, vol. xv.) After giving in detail his observations in the field and illustrating the stratigraphy by several sections and the distribution of the massive rocks by geological maps of the areas considered, M. Barrois concludes the study with the following general results:

The preceding observations show that the great masses of granulyte, having an area of several hundred square kilometers, present modifications, according as they are studied at the center or on their borders, modifications at once of composition and structure. The small, granulitic masses do not exhibit such modifications; it fails to be seen only in some apophyses of the more important deep-seated masses:

The modification of granulyte at contacts is not due, in the Morbihan, to molecular changes between the eruptive magma and the enclosing rock, but simply to the cooling, which acts upon the orientation of the elements of granite, upon their manner of grouping and the order of their crystallization.

Two principal cases result from our study; according as the contact observed is parallel or perpendicular to the direction of the enclosing rocks: in the cases of parallel contact the prevailing modification is the passage from a granular granulyte to a porphyroidal granulyte, the leading elements being arranged in fluidal lines; in the cases of perpendicular contact there can be seen generally the development of aplytes, fine, granular, massive rocks of which the crystalline elements present regular geometric outlines.

The consideration of these two cases shows that the endomorphous changes of granulyte depend on the surroundings, such as a chemically inactive agent, acting differently in the presence of heat and pressure. We should note that this conclusion should be applied simply to the granulytes of Morbihan; it would be incorrect and even entirely false to generalize from it: we shall show this in describing the granitites of the region.

Notwithstanding the difference, quite considerable at first sight, between the porphyroidal granulytes and the aplytes, it is easy to recognize in them homologous formations, equally characterized by their idiomorphic structure.

The structure of these contact rocks, compared to that of massive granular rocks from the center of the masses studied, shows that the crystallization of the elements of granite is carried on progressively, and that, beginning in the vicinity of the walls, (*salbandes*), in a mass still in movement, it advances toward the interior of the mass across a magma in repose, without showing any more trace of flowage.

The schistose granulytes of the Morbihan, rocks having a gneissic structure, fine or coarse, are confined, like the preceding, to the periphery of the granulitic masses, and are nothing but the preceding rock themselves, aplitic, granular or porphyroidal, mechanically metamorphosed. The micaceous lamellæ, torn and stretched, the feldspar crystals broken and blunted, attest powerful mechanical forces experienced by the rock. These minerals were afterward recemented by sheets and fibers of sericitic white mica, sometimes of black mica, and by films of secondary granular quartz formed from the broken debris of the original constituents.

Finally the gradual passage from the schistose granulytes to the granular granulytes, when they are followed from south to north, brings out, as elsewhere, the general fact, recognized by us, of the localization of the schistose granulytes on the southern flanks of all the masses of granular granulyte in the Morbihan, and allows the reference of the lamination which has marked their formation to a powerful lateral pressure acting from the south toward the north.

RECENT PUBLICATIONS.

1. *State and Government reports.*

Eighth annual report of the state mineralogist of California, for the year ending Oct. 1, 1888. William Irelan, Jr., 8vo, 948, pp. California state Mining Bureau.

First report of the *State Forestry Commission of Michigan*, 1887 and 1888. 8vo. 90 pp. with plates and text illustrations. W. J. Beal and Chas. W. Garfield, Agrl. College, Lansing.

Bulletin from the Laboratories of Natural History of the State University of Iowa. Vol. 1, No. 1, 96 pp. 8vo; contains, Some geological problems in Muscatine county, Iowa, by Prof. S. Calvin (published in the Feb. GEOLOGIST); Notes on the synonymy, characters and distribution of *Spirifera parryana* Hall, by the same; and Description of a new species of Spirifer from the Hamilton group, near Iowa City, also by Prof. Calvin. It also contains botanical and zoological papers by McBride, Hitchcock, Shimek and Wickham.

Bull. No. 46, U. S. Geol. Sur. Nature and origin of deposits of phosphate of lime. R. A. F. Penrose. 143 pp. maps and text illustrations.

Sixteenth annual report of the Director of the mint. J. P. Kimball. 1888.

Sixteenth annual report of the Geological and Natural History Survey of Minnesota, for the year 1887. N. H. Winchell, state geologist.

2. *Proceedings of scientific societies.*

The Journal of the *Cincinnati Society of Natural History*, vol. xi, No. 4, contains an acccount of a human skull (the Riverside skull) found in connection with remains of an elephantine tusk two or three miles below the city in the terrace gravel of the river. By *Dr. A. J. Howe.*

The proceedings of the *Acad. Nat. Sci., Phil.* Part iii, 1888, contains among other papers, Megalonyx Jeffersonii, by JOSEPH LEIDY; Additional observations on the structure and classification of mesozoic mammalia, by H. F. OSBORN; Discovery of the ventral structure of Taxocrinus and Haplocrinus, and consequent modifications in the classification of the crinoidea, and Crotalocrinus, its structure and zoological affinities, by WACHSMUTH and SPRINGER. (Reviewed in the GEOLOGIST, Mar. 1889.) Theories of the formation of coral islands, by CHARLES MORRIS.

3. *Papers in Scientific journals.*

Am. Jour. Sci., Feb. No. Points in the geological history of the islands Maui and Oahu. Two plates. J. D. DANA. Occurrence of Monazite as an accessory element in rocks. ORVILLE A. DERBY. Geology of Fernando de Noronha. Part i. JOHN C. BRANNER; with a map. Restoration of *Brontops robustus* from the Miocene of America. O. C. MARSH. One plate. *March No.* Geology of Fernando de Noronha, Part ii, Petrography; GEORGE H. WILLIAMS. Ophiolite of Thurman, Warren Co., N. Y., with remarks on Eozoon canadense. GEO. P. MERRILL. Origin of the deep troughs of the oceanic depression; are any of volcanic origin? JAMES D. DANA, with a bathymetric map. Description of a problematic organism from the Devonian at the Falls of the Ohio. F. H. KNOWLTON. Some curiously developed pyrite crystals from French creek, Delaware Co., Pa. S. L. PENFIELD. Crystallized Bertrandite from Stoneham, Me. and Mount Antero, Colorado. S. L. PENFIELD. Mineralogical notes. J. S. DILLER.

Am. Naturalist, Jan. No. Among the ancient glaciers of North Wales. F. JOHNSON EVANS.

4. *Excerpts and individual publications.*

On the classification of the Cambrian rocks in Acadia, No. 2. By G. F. Matthew, M. A., F. R. S. C. *Can. Record of Sci. Jan. 1889.*

Climatology of New Jersey, by John C. Smock. From vol. i of the *Final report of the State Geologist of New Jersey.*

On the serpentine of Montville, New Jersey. Geo. P. Merrill. One plate. *From the Proceedings of the U. S. Nat. Museum.* 1888.

Preliminary list of the foraminifera from the Post Pliocene sand at Santa Barbara, Cal. Anthony Woodward. From the *Journal of the N. Y. Microscopical Society.* Jan. 1889.

A geological and topographical map of the New Boston and Morea coal lands, in Schuylkill Co. Pa., scale 400 feet to an inch. By Benj. Smith Lyman.

The probable cause of the displacement of beach-lines. An attempt to compute geological epochs. By A. Blytt. From *Christiana Videnskabs-Selskabs Forhandlinger.* 1889, No. 1.

The oil-field of Colorado. By J. S. Newberry. From the *School of Mines Quarterly.* Jan. 1889.

The construction of topographic maps by reconnoissance methods. Arthur Winslow. *Ark. Soc. of Engineers, Architects and Surveyors.*

Evidence that lake Cheyenne continued till the ice-age. Prof. J. E. Todd (Abstract. from *Proc. A. A. A. S.* vol. xxxvii.)

The terraces of the Missouri. Prof. J. E. Todd. (Abstract, from the same).

On some dates of the report on the geology of Vermont. Jules Marcou. *Proc. Boston Soc. Nat. Hist.* vol. xxiii. 1888.

Canadian geological classification for the Province of Quebec. Jules Marcou. *Proc. Bos. Soc. Nat. Hist.* vol. xxiv.

5. *Foreign publications.*

Trans. Geol. Society, Glasgow, vol. viii, part 2, contains papers by Robt. Craig on Post-pliocene beds of the Irvine valley and organisms beneath the boulder-clay; by John Young on Erect stems of fossil trees in the lower Carboniferous, on Quartz as a rock-forming mineral, and on Carboniferous Anatinidæ; by Dugald Bell on the Glacial phenomena of Scotland; by R. Kidston, Thomas Scott, J. S. McLennan, James Bennie, G. G. Henderson, and John R. S. Hunter on the fossils and some other geology of the Carboniferous of Scotland; A notice of the late professor de Koninck by James Thompson; by Robt. Dunlop on a fossiliferous peat in a boulder-clay; on Glaciation and raised beaches by James Anderson, and by Sir Wm. Thompson on Polar ice-caps and their influence in changing sea-levels, with illustrations.

On the Eozoic and Paleozoic rocks of the Atlantic coast of Canada, in comparison with those of western Europe and of the interior of America. Sir J. William Dawson. *Quart. Jour. Geol. Soc.* Nov. 1888.

Annales de la *Société géologique de Belgique.* Tome xv, liv. 3.

The mineral wealth of Queensland. By Robt. L. Jack, Government Geologist. 71 pp. 8vo, with a map showing the position of the mineral fields. Published by the *Queensland Centennial Commission, International Exhibition,* Melbourne, 1888.

CORRESPONDENCE.

Observations on Three Kinderhook Fossils. Among the fossils described as Kinderhook species, none are prettier or more instructive than Dr. White's coral, Zaphrentis calceola. More correctly, this is White and Whitfield's species. The authors of this species obtained the type specimens at Burlington, Ia., from the base of the Burlington limestone and the underlying Kinderhook beds. Afterward Prof. Broadhead found this fossil in the Chouteau limestone at Sedalia, Mo., and sent specimens of it to the National Museum, where they were examined by Dr. White and one of them figured in Hayden's 12th annual report of the survey of the territories.

We have found this beautiful little polyp ranging through three quite distinct formations and undergoing in its ascent some noticeable changes. The first examples we collected were from the lower Burlington limestone at Louisiana, Mo., about ten feet from the base of this division. The specimens from the soft white cherts are small and flattened while those from the limestone are somewhat more robust and less compressed.

About eight years after our first acquaintance with this cyathophylloid we discovered a very much weathered outcrop of about three feet of the very base of the lower Burlington group; and, among other peculiar fossils, we picked up two grotesque looking examples of Zaphrentis calceola, somewhat larger than the limestone specimens above, strongly wrinkled, very much flattened and the point (base) in one, directed backward, contrary to the outline of the typical specimens.

Four miles east of Curryville, Mo., in an outcrop of the upper Chouteau limestone associated with Michelinia placenta, is a very small, wrinkled and flattened variety of this interesting little Zaphrentis. In the same formation at other localities in the western part of this county and at one outcrop in Audrain county, we have also noticed this coral.

Occurring as natural casts in cherts of the upper Burlington beds, two miles north of Curryville, we have found excellent examples of Zaphrentis calceola associated with Granatocrinus norwoodi and Batocrinus pyriformis.

The examples of this variety are very much larger and less compressed than any of the lower forms, but easily recognizable from their peculiar rugose appearance.

From the shales beneath the "Lithographic limestone" at Louisiana, among other cyathophylloids collected, is one very much flattened example but with the basal point twisted to the side; and, though it is somewhat wrinkled, yet it bears but a faint resemblance to the Burlington form.

There is little doubt in our mind that Zaphrentis calceola has descended in a direct line from the Corniferous species, Z. ungula and that it struggled upward through the Kinderhook, lower Burlington and "was gathered to its fathers" in the upper Burlington.

A companion to Zaphrentis calceola in the lower Burlington at Louisiana, is Porcellia nodosa, a gasteropod described by Hall and recognized by Meek and Worthen as a Kinderhook species.

The only (?) specimen of this species in the Illinois State Museum (found at Kinderhook, Pike Co., Illinois) was misplaced, some years ago, as we were informed by Prof. Worthen. If this was the type specimen, the species now exists without a type.

We have found but two examples of this fossil and both are natural casts in white chert, and both found some ten or fifteen feet from the base of the lower Burlington limestone.

The third and last form under consideration is Batocrinus pistiliformis M. and W., described from a fragment and referred to the Kinderhook group.

As a natural cast in the upper Burlington chert, we have found examples of this fossil not uncommon at Louisiana and even as abundant as B. pyriformis at Curryville.

As casts the collector is perplexed to place this form, the calyx being that of B. pyriformis while the dome is that of B. christyi. A cast in the mold settles the question and the fossil becomes B. pistiliformis with the arm openings directed outward instead of upward as in B. pyriformis.

In an outcrop of upper Burlington limestone on Spencer creek, we found one body and a number of fragments of this crinoid, associated with Granatocrinus norwoodi var. cornutus, G. sayi and Batocrinus æquibrachiatus, well known upper Burlington forms.

Curryville, Mo., March 1, 1889. R. R. Rowley.

Foliation and sedimentation. The tone of portions of Prof. A. Winchell's rejoinder published in the March number of the "Geologist" is such that I would much rather drop the discussion of the points of difference between us than continue it. The dramatic role which I seem to play in his imagination of appearing and disappearing in some lurid scene which he does not more fully describe, affords him, I trust, some amusement in the lonely moments of his occasional jaunts through the lakes of northern Minnesota. That it should form part of an argumentative discussion, however, on an important and utterly impersonal scientific question is something for which I was not prepared, and indicates a state of irritability on the professor's part which I am loath once more to excite. But there are some misunderstandings and misrepresentations of my views and arguments which I feel constrained, even at the risk of appearing on the "scene" more suddenly than may be good for his nerves, to endeavor in a few words to clear up.

1. Prof. W. says: "My former and only contention, it will be noted, was for the original sedimentary condition of the great granite and gneissic masses." This was not the issue between us. I laid down, and, I think, substantiated, the following proposition: "It is highly improbable that the foliation of the gneiss has anything to do with an original sedimentation. * * * "This conclusion does not necessarily imply that the gneiss and schist may not have been originally sedimentary and conformable." This is the proposition Prof. W. combatted, for to use his own words he proceeded "to summarize briefly the facts which have led him to believe the foliation of the gneisses sustains a relation of dependence on an antecedent sedimentary structure."

It is just as well in discussions of this sort to have a clear understanding of the question at issue. I certainly never advanced an argument to combat "the original sedimentary condition of the great granite and gneissic masses." I have never discussed the question *pro* or *con*. I have adduced evidence in abundance to show that they have passed through a magmatic and irruptive (not *eruptive*) stage. I have shown that these gneisses and granites were in this magmatic condition at a time when the overlying schists of the upper Archæan were in a hard and brittle state; that in this condition they penetrated the schists and now hold inclosed in them angular and lenticular fragments of those schists in great profusion, and therefore as rocks they are of later age than the schists and truly irruptive.

2. Prof. W. misrepresents me when he quotes my statement, "We know nothing of the kind" and makes it appear that I deny that rocks may be reduced to a state of plasticity or semi-fluidity at sufficiently high temperature. I beg to refer to the paragraph (10) of my "Reply" in proof of the misrepresentation.

3. Prof. W. says: "In the end Dr. L. makes it appear that he has come almost to my position." Prof. W. has evidently misunderstood my position from the first, and fails to understand that without entering into the question of the former sedimentary condition of the gneiss, the evidence adduced proves it to have been in a fused or magmatic condition, and to have been irrupted through the upper and confused

portions of the Archæan. I have not receded in any way from the position which I took and which is defined, so far as this discussion is concerned, in the proposition I have quoted; and if Prof. W. finds we tend toward agreement I am very glad of it.

4. Prof. W. again misrepresents me when he asserts that I say "it is very important for geologists to arrest its action before the softened state of the original sediments is reached." I simply stated that "The sooner the well defined line which exists in nature between rock metamorphism and fusion is recognized by geologists, and the former understood to stop where the latter begins, the better for the progress of investigation in Archæan geology."

5. I find myself for the most part quite in accord with those British investigators whom Prof. W. so gratuitously advised me to consult, particularly with those who regard the granites and gneisses as the result of *fusion* of overlying rocks. I do not, however, agree with them in regarding the gneisses as an intermediate state. It seems to me from what I have seen that the granite is the first stage, gneiss the second; that the gneiss of our Laurentian areas is a differentiated granite, the differentiation being due to motion in the cooling and crystallizing magma. It is to be borne in mind of course that there are many feldspathic mica schists in the upper Archæan commonly called gneisses, which are truly metamorphic, but for which, owing to the poverty of our nomenclature, we have no good name. Nor can I of course agree with some of them in regarding "fusion" and "metamorphism" as synonymous terms.

6. With regard to "conglomerates in gneissic terranes" referred to by Prof. W. in the last paragraph of his rejoinder I would only say, that pebble and boulder conglomerates are no novelty in the upper, schistose or metamorphic division of the Archæan; and the numerous inclusions in the granites and granitoid gneiss such as the "Basswood granite" and the "Saganaga granite" with both of which I am somewhat familiar, are, in my opinion, certainly *not* conglomerates in any accepted sense of the word. It seems to me to be introducing confusion of the most lamentable sort into the science to call such appearances conglomerates. I have studied the phenomenon for some years over a wide extent of Archæan country and find the inclusions most abundant near the shattered edges of belts of upper Archæan rocks, where there is the most conclusive evidence that they are simply detached fragments from the brittle, unfused rocks in contact with the granite magma. Evidence of this will be advanced in a forthcoming report on the geology of the Rainy Lake region. Frequently these inclusions are much altered by the conditions to which they have been subjected and are rounded. For the most part, however, they are more or less angular or lenticular in shape. Some few of these inclusions appear not to be foreign to the granite or gneiss, but to be more basic earlier secretions of the magma from which the granite crystallized. I hasten to give expression to these views that Prof. W. may perhaps

examine more carefully into these matters before further confounding the conglomerates of the upper Archæan metamorphic schists with the granite breccias of the Laurentian or lower Archæan. Having done so I may be permitted to make my bow and, wrapping myself in "glory" and "immortality," as the professor hath it, disappear from the "scene."

ANDREW C. LAWSON.

PERSONAL AND SCIENTIFIC NEWS.

MR. U. P. JAMES, THE WELL-KNOWN PALEONTOLOGIST of Cincinnati, died at his residence near Loveland, Ohio, on Monday morning, Feb. 25, in his 78th year. In a future number the GEOLOGIST will give a more extended notice of his life and scientific work.

BURNING-GAS WAS ENCOUNTERED at San Antonio, Texas, in sinking a well, at the depth of 373 feet. Water and gas burst up together with great force, through an eight-inch pipe, rising ten feet. The gas burns steadily. The strata passed through were gravel and clay. J. L. TAIT.

THE GEOLOGICAL SURVEY of Arkansas has now completed two years of work and Prof. Branner has submitted a voluminous report of four volumes, only one of which has yet come from the press.

The General Assembly of the State now in session appointed a committee to examine into the work done and advise as to its continuance. This committee has made an investigation and in their report state that six typical areas of the state have been carefully examined and mapped. These include a part of the coal region—the formation in which gold was supposed to exist—a preliminary examination of the silver deposits and partial studies of the lead, zinc, antimony, manganese and iron ores, In the making of maps the State was assisted by the United States Survey.

The Committee say that "the report on the gold mines of the state is of very great negative value, for much of the area examined contains no mineral of any commercial importance and this information saves the expense of seeking what does not exist." "Of positive value, however, are the discovery of fertilizing marls, chalk and gypsum and calling attention to our undeveloped manganese fields and to our silver ores; and the analyses made of our mineral waters."

Among the resources of the State enumerated at some length by the Committee's report is an area of 2,080 square miles examined for coal, 1,027 square miles of which are found to have workable beds of coal. The State of Arkansas owns about 5,100 acres of this land estimated to contain

15,300,000 tons of marketable coal, and this refers only to lands owned by the state, being but 1-126th part of the total area thus far found to contain coal of commercial value.

Four-fifths of the state remain to be examined and mapped. The Committee recommend that the geological work be continued by Prof. Branner, that work on botany and zoology be carried on, and that he be allowed four assistants with salaries not to exceed $2,000 each and that an appropriation of $10,000 be made to meet the contingent expenses of the survey for the next two years.

At a recent meeting of the San Francisco Microscopical Society, Prof. Hanks submitted a newly discovered specimen of diatomaceous earth which attracted much attention and was considered of great scientific value. The scrapings of the earth examined were unwashed and the powers used were not sufficient to determine whether the specimen was a "Santa Monica" or not.

Dr. M. E. Wadsworth of the Michigan Mining School, has been appointed State Geologist of Michigan for two years from May 1st. He is now holding the position by appointment to fill out the vacancy caused by the death of Mr. Charles E. Wright. It is reported that the Board has decided to publish another volume of the report of the survey, covering the works of Rominger, Wright and Wadsworth.—*Mining and Scientific Review.*

Mr. B. W. Thomas read a paper recently before the Chicago Academy of Sciences announcing the discovery of three new forms of the spore-cases of Protosalvinia, a marine plant of the Devonian. These and other forms named at first *Sporangites* by Dr. J. W. Dawson in 1871, are found in great abundance in the drift materials excavated in the construction of the subterranean aqueduct that supplies Chicago with the water of lake Michigan. In one case a large nest of them was pumped out along with a deposit of quicksand and thrown into the lake. They floated off in the form of a thick black scum and on examination their nature was ascertained. Mr. Thomas suggests that in the light of the researches of Prof. Orton in Ohio as to the origin of natural gas from these spores in the Devonian, these drift-contained nests which in this instance supplied tons which were pumped into the lake, may be the source of the small quantities of natural gas that from time to time have been observed by those who have made excavations in the drift in the vicinity of Chicago.

The average of cassiterite in the tin ores of the Black Hills is estimated by Prof. Carpenter at two per cent, on a basis of treating all rock carrying ten pounds as recommended by Prof. W. P. Blake.

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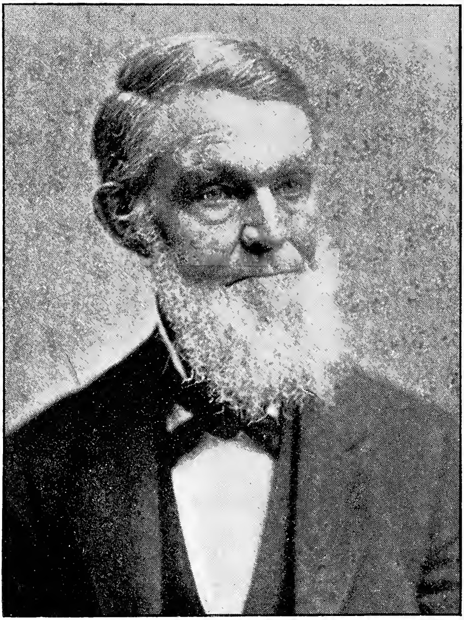


Very truly

U. P. James.

THE

AMERICAN GEOLOGIST

VOL. III. MAY, 1889. No. 5

URIAH PIERSON JAMES.

Mr. U. P. James, palæontologist and geologist of Cincinnati, died at his residence near Loveland, Ohio, on the 25th of February, in the 78th year of his age.

He was born in the town of Goshen, Orange Co., N. Y., on December 30th, 1811. His father, Thomas James, was a carpenter, who followed his trade until his death in 1824, the result of an accident. His mother, Rhoda Pierson James, was a direct descendant of Thomas Pierson, a brother of Rev. Abraham Pierson, the first president of Yale College. He had two brothers and three sisters, all of whom he survived, so that he was in reality the last of his immediate family.

In 1831, long before any railroad had crossed the Alleghanies, he and his brother Joseph traveled by stage and canal, west to Cincinnati, arriving in August and witnessing the great flood of February, 1832. Having learned the trades of printer and stereotyper, he began to work at these soon after his arrival in Cincinnati, and followed them successfully for a number of years. In a short time he began publishing books, and his first venture, the "Eolian Songster," was printed in 1832, the copyright being dated June 15. This book was followed at intervals by others, until the complete list would number hundreds. In 1847 he entered into partnership with his brother Joseph as publishers, printers, stereotypers and type-founders, the firm name being J. A. & U. P. James. The business increased rapidly, book publishing became a prominent part of it, and the firm became widely known throughout the Mississippi valley as the "Harpers of the West." Many of the books published by the firm and later by Mr. James himself have had a very wide circulation. The "James's River Guide," and the "Western Pilot," were standard works among river men on the Ohio and Mississippi rivers. These books contained charts of the river channels, and accounts of the cities and towns along their banks, and they were considered so accurate that in several instances they were used to settle disputed points in the courts.

He published an edition of "Vestiges of Creation" soon after that celebrated book first appeared. He was a patron of many of the early authors of the west, and was the means of bringing many of them before a very wide circle of readers. For many years he edited and published the "Farmer's and Mechanic's Almanac," long considered a standard among the farmers, who looked upon its predictions of the weather, with the greatest respect and confidence. The flood of patent medicine almanacs and calendars finally made this unprofitable and its publication was discontinued in 1869.

As a business man his reputation was of the highest. He never failed to meet an obligation; he always preferred to pay cash rather than ask for credit; he never entered into a lawsuit if it were possible to avoid it, and he would rather have been defrauded a hundred times than defraud any man once.

Turning to his scientific life we find that soon after going to Cincinnati his attention was attracted to the wonderful profusion of fossils on the hills around the city. He has frequently stated that in his walks he often picked up pocketsful of the fragments of coral that lay upon the ground, and at first wondered if they were twigs of trees turned to stone. His early love for geology never left him, and up to within a few months of his death he was adding to his collection of fossils.

He was thus among the very first of all the fossil collectors of Cincinnati and was also almost the last of that early generation of students and collectors. He was a companion of John Locke, John G. Anthony, George Graham, Robert Buchanan, Dr. John A. Warder, Edw'd. P. Cranch, S. T. Carley, Joseph Clark and many others, all but two of these having preceded him to the grave. He was an active member, at one time president, and for a long time treasurer of the old Western Academy of Natural Sciences, the predecessor of the present Cincinnati Society of Natural History, and one of the very earliest scientific societies established in the Mississippi valley.

In those early days conchology was very prominent among the sciences, and the unrivaled facilities of the neighborhood enabled the early collectors of Cincinnati to gather collections which their successors have not been able to rival. Before the growth of the city many streams swarmed with mollusks which are now entirely deserted by them. Certain species were abundant which are now extinct in the neighborhood. Mr. James was not slow to avail himself of this opportunity, and he amassed a collection of the Unios and univalve shells of the Ohio, the two Miamis and the White rivers, which is probably the largest and best local collection now in the neighborhood of Cincinnati. One result of this early study of conchology, was a catalogue of the shells of Cincinnati, compiled by a committee appointed by the Western Academy of Natural Sciences, and published by Mr. James. He was also the publisher of the catalogue of plants of Cincinnati, compiled by Joseph Clarke and Robert Buchanan.

There were no facilities in the days of the '40's as there are now, for the study of palæontology. The difficulties under which the collectors labored were enormous. There were no books upon the subject until the "Palæontology of New York" appeared, and this only partly covered the ground of the Cincinnati horizon. Still the collectors, Mr. James among them, persevered. They read papers now and then before the Academy, or sent drawings or specimens to the east for identification or description. One of these was drawn by Mr. James and sent to Prof. Dana, who figured and described it under the name of *Palæaster Jamesi*, by which it is still known.

The visit of Lyell to Cincinnati in 1845 gave renewed impulse to the study. Mr. James was among those who received this eminent authority, and piloted him over the familiar hunting ground, even making diagrams of some of the more interesting sections seen in the neighborhood. Agassiz visited Cincinnati and saw Mr. James's collection, pronouncing it among the finest he had ever seen.

The first catalogue of fossils of the vicinity of Cincinnati was compiled and published by Mr. James in 1871. In this were embodied the results of his studies for thirty years, and in it a number of names were proposed for new species, many of which were subsequently adopted by Meek, Hall and Whitfield. A supplement to this was published in 1873, and a second edition with many additions and corrections in 1875. In this there were also included descriptions of a number of new species from the vicinity of Cincinnati. A few years later, 1879, a supplement was published, which contained the names of new species described by various authors up to that time. He contributed various articles to the Cincinnati Quarterly Journal of Science, and in 1878 issued the first number of a small periodical which he called "The Paleontologist." This contained descriptions of many new species from the Cincinnati and Clinton groups, and was continued for seven numbers, the last one containing two etched plates. This periodical was distributed to his correspondents and to many libraries and societies, and was also sold. Later on he contributed various papers to the Journal of the Cincinnati Society of Natural History, some of which were illustrated. A full list of his writings is appended to this notice.

He was the first collector and student of the fossil corals found so abundantly in the rocks of the Cincinnati group; and it was he who first called the attention of Prof. Nicholson to them. All the workers among the fossils in the vicinity had been afraid to attempt the study of these organisms, and it was only after he had begun his work that others took it up. He furnished many specimens to the paleontologists of the geological survey of Ohio for description and illustration, and his cabinet contains many of these type specimens. It also contains many new or peculiar forms, which we hope may yet be brought before the public. His labors in this field are commemorated by having many species called by his name. It was in the reports of this survey that many names proposed by him in his catalogue of 1871 were adopted and rightly credited to him.

One of the results of his intimate knowledge of the corals of Cincinnati was the publication of a monograph of the Monticuliporoids of the vicinity. In this he was assisted by his son, Prof. Joseph F. James. This paper was published in three successive numbers of the Journal of the Cincinnati Society of Natural History (October 1887, January and April 1888). The sheets were afterward collected and issued in a separate pamphlet. This monograph contains descriptions of sixty-four species, with a number of varieties, and remarks upon each one and upon synonymy. Only one new variety was described, as both authors considered that too many species and genera had already been made.

Mr. James was essentially a self-educated and a self-made man. His early schooling was such as could be had at a country school, attended at intervals and for a few years only. He was neither a rapid nor a prolific writer, but his descriptions bear the marks of care and pains-taking and are generally acknowledged to be full and accurate. He was a life member of the Cincinnati Society of Natural History, and at one time a member of the American Association for the Advancement of Science. His membership in the latter was during the early days of that association.

Of the man it may be said that he was simple-hearted and kind to all with whom he came in contact, ever ready to oblige, and ever reluctant to ask the granting of a favor. His domestic life was a happy one. He married, in 1847, Miss Olivia Harriet Wood, a daughter of an English lady of Cincinnati. His widow, two sons and three daughters survive him, a third son having died in infancy. All who knew him, knew him to be an honest man, and "To be honest, as this world goes, is to be one man picked out of ten thousand."

One of his sons carries on the father's book business in Cincinnati, while the younger one hopes to carry on his geological work.

Mr. James was buried in Spring Grove Cemetery, and a granite boulder, brought by the glaciers from the Canadian highlands and lodged on a hill-side of his place at Loveland, will mark his last resting place.

J. F. J.

List of the Writings of U. P. James.

1871—Catalogue of the Lower Silurian Fossils, Cincinnati Group, found at Cincinnati and vicinity—within a range of forty or fifty miles—pp. 14. 32 new species proposed.

1873—Additions to Catalogue of Lower Silurian Fossils, Cincinnati Group, pp. 4. Many alterations and corrections. One new species proposed.

1874—Descriptions of new species of Brachiopoda, from the Lower Silurian rocks—Cincinnati group.—Cincinnati Quarterly Journal of Science, vol. 1, pp. 19-22. 4 new species described.

1874—Description of one new species of *Leptæna* and two species of *Cyclonema* from the Lower Silurian rocks.—Cincinnati Group.—Cin. Quar. Jour. of Sci., vol. 1, pp. 151, 153. 3 new species described.

1874—Remarks upon Nullipores.—Cin. Quart. Jour. of Sci., vol. 1, pp. 153, 154.

1874—Description of new species of fossils from the Lower Silurian Formation, Cincinnati Group.—Cin. Quar. Jour. of Sci., vol. 1, pp. 239-242. Five new species described.

1874—Description of new species of Brachiopods from the Lower Silurian Formation, Cincinnati Group. Cin. Quar. Jour. of Sci., vol. 1, pp. 333-335. Two new species described.

1875—Catalogue of Lower Silurian Fossils of the Cincinnati Group. Found at Cincinnati and vicinity, within a circuit of 40 or 50 miles. New edition, much enlarged. With descriptions of some new species of Corals and Polyzoa. pp. 8. Eight new species desscribed.

1878—The Paleontologist. No. 1., July 2nd, 1878, pp. 8. Contains "Descriptions of newly discovered species of fossils from the Lower Silurian Formation. Cincinnati Group;" with 20 new species. Also, two species from the upper Silurian rocks.

1878—The Paleontologist, No. 2, Sept. 14, 1878, pp. 9-16. Contains "Descriptions of newly discovered species of fossils and remarks on others, from the Lower and Upper Silurian rocks of Ohio," with ten new species. Also, "Remarks on Constellaria antheloidea, Hall;" "A Strange Fossil;" "Remarks on Helopora dendrina, James;" "A Classified List of Lower Silurian Fossils, Cincinnati Group. By John Mickleborough and A. G. Wetherby," A review, and a notice to Correspondents.

1879—The Paleontologist, No. 3, January 15, 1879, pp. 17-24. Contains "Description of new species of fossils and remarks on some others, from the Lower and Upper Silurian Rocks of Ohio," with two new genera and eighteen new species. "Bibliography;" "Book Notice" (Andrew's Elementary Geology.)

1879—The Paleontologist, No. 4. July 10, 1879, pp. 25-32. Contains, "Descriptions of newly discovered fossils" with three species. "Geological Nomenclature (*The Cincinnati Group*—The "Hudson River Group"); "Supplement to Catalogue of Lower Silurian Fossils of the Cincinnati Group" with remarks.

1881—The Paleontologist, No. 5, June 10, 1881, pp. 33-44. Contains "Contributions to Paleontology: Fossils of the Lower Silurian Formation; Ohio, Indiana and Kentucky," with descriptions of 16 new species, and remarks on others.

1882—The Paleontologist, No. 6, Sept. 12, 1882, pp. 45-56. Contains "Descriptfons of ten new species of Monticulipora, from the Cincinnati Group, Ohio;" "Corrections," "Index."

1883—The Paleontologist, No. 7, April 16, 1883; pp. 57-60, with two plates. Contains "Descriptions of new species of Fossils from the Cincinnati Group, Ohio and Kentucky," with three new species, and remarks on another, "Tracks of a Crustacean (?)"

1883—Descriptions of Fossils from the Cincinnati Group—Journal of the Cincinnati Society of Natural History, vol. 6, pp. 235, 236. Two new species described, with one plate.

1884—Description of three species of Fossils,—Jour. Cin. Soc. Nat. Hist., vol. 7, pp. 20-24. With illustrations of species described.

1884—On Conodonts and Fossil Annelid Jaws,—Jour. Cin. Soc. Nat. Hist., vol. 7, pp. 143-150. Four new species described; one plate.

1884—Descriptions of four new species of Fossils from the Cincinnati Group,—Jour. Cin. Soc. Nat. Hist., vol. 7, pp. 137-140. With a plate.

1885—Glyptocrinus Baeri, Meek,—Jour. Cin. Soc. Nat. Hist., vol. 8, p. 71. Note on fine specimen.

1887—Genus Agelacrinus, Vanuxem (mis-printed *Agelacinus*),—Jour. Cin. Soc. Nat. Hist., vol. 10, p. 25. One species described and figured.

1887-1888---On the Monticuliporoid Corals of the Cincinnati Group, with a critical revision of the species, by U. P. James and Joseph F. James,---Jour. of the Cin. Soc. Nat. Hist., part I, vol. 10, pp. 118-141; part II, same Journal (1888) vol. 10, pp. 158-184, with one plate; part III, same Journal (1888) vol. 2, pp. 15-44; one plate. Descriptions of 64 species and six varieties; one new one.

A PORTION OF THE GEOLOGIC STORY OF THE COLORADO RIVER OF TEXAS.

By Robert T. Hill.

Often have I scanned the topographic maps of this little known south-western region, pondered over the peculiar bends and meanderings of its rivers and endeavored to create hypotheses for their vagaries. The past year has afforded opportunities to study most of these from the Mississippi to the Rio Grande. All were interesting in their relation to topography and formation, but the Colorado of Texas presented the most interesting features, rivaling in some respects those of its world-famed name-sake, the Colorado of the West.

The Colorado begins in the dry arroyas which border the eastern scarp of that great plateau, the Staked Plains of Texas. These cañons, cut nearly a thousand feet perpendicularly in the soft Quaternary, Cretaceous, Triassic (?) and Permian strata, which record in their precipitousness both the aridity and the gradual elevation of the region. Flowing eastward through the Red beds, Permian and Triassic, across the strike of the formations, the middle third of the river is reached between the 97th and 98th meridian. Here the Colorado cuts through the area of paleozoic rocks which has been the land barrier between the Atlantic ocean and the inland sea during numerous oscillations which have marked the neozoic history of interior North America. The story of the sediments upon each side of this axis—east and west—although a harmonious history, records events of entirely different characteristics. This paper deals only with the eastern or Atlantic slope leaving for a future time the interior basin. While this section does not record the sediments of the Permian, Triassic, Jurassic and enclosed Laramie of the interior United States, it furnishes equally interesting data for a study of other formations.

Topographically, the area is very diversified by erosion, but primarily consisted of a great eastwardly sloping plain separated into two steppes by a gentle monoclinal scarp, and extending north-east across the state to the ancient mountain axis that runs east and west across southern Indian Territory and southwestern Arkansas. The uniformity of these open plains has been broken by a few igneous disturbances and degraded by the extensive erosion of the drainage systems, which cross their strike at right angles and cut valleys from 300 to 750 feet in depth. Of all these streams the Colorado river has cut the deepest channel and in it can be read the whole sequence of geologic events.

Within this short distance the river has worn through the crust of Cretaceous sediments that formed the floor of the plains and now traverses nearly every terrane from the late Quaternary to the earliest Cambrian. Perhaps no where else in the world can be seen a more comprehensive geologic section, a better illustration of sedimentary and igneous rocks, and their relation to topographic form and economic conditions or other geologic features dependent upon structure than in that portion of the Colorado which traverses the counties of Burnet and Travis, as illustrated upon the accompanying sketch map. Here the erosion of the river basin has exposed nearly 10,000 feet of structure that would otherwise not be exposed, and every bend and curve seems to reveal some interesting topographic or geologic fact. Since these are so intimately dependent upon structure it is necessary that a brief enumeration of the formations of the section should first be made. This section is illustrated upon the accompanying figures.

THE SECTION.

Along this portion of the Colorado as shown in figures the following formations are revealed:

	THICKNESS.
1. QUATERNARY.	
1. Older Terrace deposits of Colorado river at Austin, superficial.	
1 a. Upland gravel as seen at McDade, superficial.	
2. TERTIARY.	
Eo-Lignitic ("Laramie") or basal Eocene, Bastrop county probably	1,000
3. UPPER CRETACEOUS.	
a. Upper arenaceous beds, eastern edge Travis county	300
b. Middle (Exogyra ponderosa) marls, east half of Travis county	1,000
c. Austin or Niobrara chalk, city of Austin	600
d. Eagle Ford or Benton shales, city of Austin	300
The Lower Cross-Timber or Dakota sands are missing here; present in North Texas	200
4. LOWER CRETACEOUS.	
a. Vola limestone, or Shoal Creek horizon, Austin	50
b. Exogyra arietina clays, west of Austin	100
c. Washita limestone (metamorphosed chalk) west of Austin	160
d. Medial or Hippurites limestone (metamorphosed chalk) West of Austin	900
e. Basal or Fredrickburg limestone, (metamorphosed chalk) Burnet	300
f. Trinity, basal littoral beds, Burnet	300
5. CARBONIFEROUS.	
a. Bituminous shales and sandstones, Marble Falls and Smithwick	300
b. Encrinital, or Marble Falls limestone	500
6. SILURIAN	
Barren white limestone beds, Lower Marble Falls.	
7. CAMBRIAN.	
a. Upper { Indeterminate limestone flags	1,150
a. Upper { Potsdam sandstones; western Burnet county	625
b. Lower.—The Llano group of Walcott, Sand mountain	2,000
Total	9,520

It is impossible to give the details of each of these formations. The general character of the paleozoic section has been defined by Walcott,* except the Carboniferous. The writer has previously defined the Cretaceous with the exception of the horizon here mentioned as the Vola limestone, which is new. The basal Tertiary or Eo-lignitic beds have been studied by the writer and others during the past year from the Rio Grande to the Alabama. The Quaternary beds will be more fully defined later.

UNCONFORMITIES AND DISTURBANCE.

This section presents an extensive perspective of the stratigraphic history of the region from earliest Cambrian to the present. As previously shown by Walcott, the Llano beds are

* Notes on the Paleozoic rocks of Central Texas. Am. Jour., Sci. Dec, 1884.

almost vertical, while the Potsdam sandstones and limestones are deposited almost horizontally upon their upturned edges, showing remarkable disturbance and erosion in middle Cambrian time. Mr. Walcott, probably, saw the Potsdam in its regions of least disturbance, for, as shown in our section, between Sand Mountain, Llano county, and Marble Falls, Burnet county, there was a remarkable crumpling and flexing of those strata in common with the Silurian and Carboniferous, which accompanied the great igneous intrusions at the close of paleozoic times.

The Silurian history is more obscure; careful study may yet reveal more details of the 1,000 feet of limestone.

THE DEVONIAN.

The absence of the Devonian is probable. Dr. B. F. Shumard intimated the presence of its strata. I made a section at Marble Falls to conclusively settle the question and, as final authority, sent the faunas to Prof. H. S. Williams for determination. In my opinion the alleged Devonian is identically the Carboniferous limestone of North Texas, which has here been intensely metamorphosed by igneous contact.

The Marble Falls of the Colorado are among its most interesting and scenic features. Here the river has cut a broad valley through the Carboniferous shales; it is dammed back by the dip of the underlying limestone formations over whose imbricated edges through an extensive cañon the water tumbles for a mile or more. In this cañon the metamorphism and disturbance of the limestone beds by the adjacent granitic area are clearly shown. This section of Marble Falls shows that the Devonian sediments were probably not laid down in this southwestern region, but if so, they were not later than the Corniferous and were eroded by later Carboniferous events.

The Carboniferous rocks throw much light upon the region by showing (a) a complete difference of sedimental sequence from those of the Appalachians, and (b) the probable absence of the Sub-carboniferous of the Tennessee and Missouri sections, or at least their characteristic facies and fossils. The presence of Spirophyton, as recorded by Lesquereux in supposed lower Carboniferous rocks of Arkansas, and of Chonetes and other forms, indicates a lower Carboniferous position for these limestones, however, while there is a complete unconformity between them and the overlying shales, sandstones and conglomerates of the Coal Measures.

DISTURBANCES CLOSING THE PALEOZOIC.

Perhaps the two most remarkable features of this section are the great igneous disturbances at the close of the paleozic and Cretaceous respectively. The one at the close of the Carboniferous is most beautifully recorded in the southwest corner of Burnet county.

A few miles east of Marble Falls the uppermost paleozoic strata, the Carboniferous shales begin to show much disturbance in the shape of faults, joints and excessive dip. The underlying limestones also show this by extensive metamorphism as well as by folding until finally a peculiar topographic feature known as Shinbone ridge is reached two miles northwest of the village. This is caused by the lowest or encrinital limestone strata of the Carboniferous having been thrust up almost vertically by the great granite mass which is exposed here, and extends nearly ten miles due west to Sand mountain, where its western edge is seen to similarly protrude from the almost vertical Llano beds, as described by Walcott. This great granite outcrop, from which the material was secured for the State Capitol, occupies a circular area ten miles in diameter, and is of late Carboniferous or post Carboniferous age.[1]

This outcrop shows in an unequaled manner the contacts of granite and stratified rocks—the beds of the whole paleozoic section showing this in turn—and will prove an admirable field for future study. Near the village of Lacy, Burnet county, the contact between the granite and the Potsdam sandstones can be followed for miles in a north-east and south-west direction, forming waving undulations in the face of the steep scarp that marks the western border of the granite field. The "Backbone," another conspicuous topographic feature, is an anticline which forms the north-east border of the circular area; it is composed of hardest metamorphosed limestone of the Carboniferous, and is underlaid by granite. This granite core has been uncovered by the erosion of theColor-

[1] The writer believes that Mr. Walcott was justifiable from his observations to the westward in concluding that all the granite of Burnet county was Cambrian, but the evidence here described, which I think he did not see, shows it to be of later age.

ado basin and forms the resistance causing the great bend of the river in the south-west corner of Burnet county, the river flowing around its western and southern borders. The Cretaceous sediments once covered all this paleozoic area. At many points, as in the town of Burnet, where the stratified rocks have not been removed, the presence of the granite is apparent from the undulatory folds accompanied by intense metamorphism and crystallization of the limestone. It is from these contacts that the rare mineral crystals of the region are collected.

THE EARLY MESOZOIC HIATUS.

The extent of this post paleozoic disturbance seen in the excavation of the Colorado river is obscured in most parts of Texas, as will be shown later, by the sediments of the great subsidence in early Cretaceous times, but there is no doubt that it was connected with the extensive orographic movement (as illustrated by somewhat different phenomena) of the Ouachita system of Arkansas and Indian Territory. It is also apparent from evidence which cannot be quoted here, that this disturbance outlined the axis which at intervals separated during Permian, Triassic and Jurassic times the interior basins of the west from the Atlantic shore line.

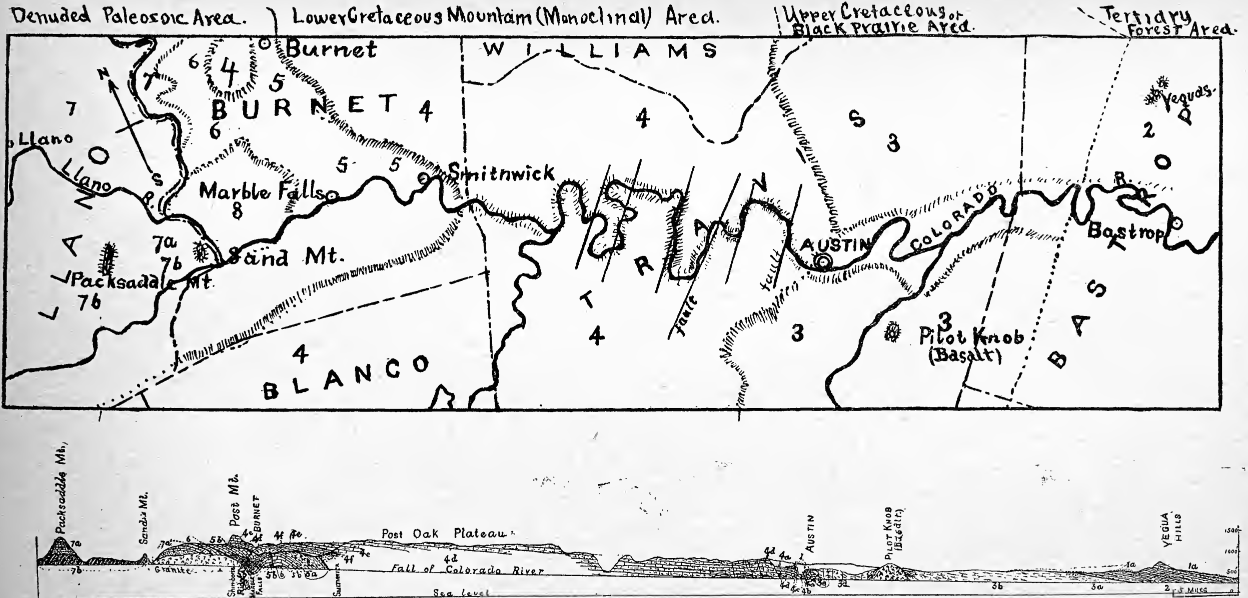
The record shows, as far as such evidence is reliable, that the eastern slope of this disturbed area remained above water during early mesozoic time until the beginning of the great lower Cretaceous subsidence. Whether it was a part of the post-paleozoic continent whose southern border is so sharply defined through south-western Arkansas and southern Indian Territory which has not been submerged since, is another question. There is evidence that this Texas paleozoic area,if not an island entirely cut off from the Arkansas-Indian Territory system, was a very long and narrow peninsula.

THE CRETACEOUS HISTORY.[1]

The section shows between 3,000 and 4,000 feet of Cretaceous sediments, including the oldest and the latest known horizons in this country.

These sediments belong to two entirely distinct formations of about equal thickness, separated by complete sedimentary and faunal unconformity. In fact the differentation is so

[1]See Am. Jour. of Science, April 1889, pp. 282-297.



Geologic Section and Profile of Central Texas revealed by the Colorado River.

1, Quaternary Terraces of Colorado below its emergence from the plateau and cañon area (4); 1a Quaternary littoral deposits; 2, Marine Tertiary; 3, Upper Cretaceous of undulating Black Prairie area; 4, Lower Cretaceous of "Hard Lime Rock," "Mountain" or plateau area; 5, Carboniferous shales and limestones; 6, Silurian; 7a Potsdam; 7b, Llano; 8, Granite. Basalt at Pilot Knob.

clear that it is safe to predict that after the knowledge of this region recovers from the misinterpretation and speculation of theorists, it will be the hight of impropriety to speak of the American Cretaceous as a single formation.

The two formations, the upper or Meek and Hayden's section, and the lower (the author's Comanche series) respectively, were separated by a land epoch probably as long as either of them. Each records every phase of a profound marine subsidence; each records the transition from littoral sands to shales and deeper chalk, making long periods.

The lower Cretaceous rests directly upon the metamorphosed limestones of the Carboniferous at Burnet. Their stratigraphic characteristics are well exposed in the slope and cañons of the Colorado valley from Burnet to Austin. From the summit of Post mountain at Burnet its scarp can be traced northwest and southeast for 60 miles, while the river upon leaving the Carboniferous east of Smithwick enters this formation and follows it for 50 miles to Austin through vertical cañons often cutting to a depth of 750 feet.

In ascending sequence the basal, littoral, Trinity beds of this formation are soon followed by deeper limestones which were once pure chalks; and these in turn are succeeded by the Exogyra arietina clays and these by a uniform lime stratum, heretofore unmentioned, 100 feet thick, with an undescribed fauna to which I have given the name Vola limestone from the characteristic and beautiful fossil resembling the *Vola quinquecostata* Lamarck, or *Janira fleuriansiana* d' Orb.

The base of this formation—the Trinity beds—has a fauna predominately Wealden, and the top, some 1,200 feet above, contains fossils distinctly Turonian or middle Cretaceous. That this lower Cretaceous marine epoch was closed by elevation is shown by a series of vertical faulting near its eastern edge (which must not be confused with disturbances of a later date) and by the unequally eroded surface of the deep sea limestone upon which the littoral beds of the unconformable and entirely different basal beds of the upper Cretaceous formation are deposited. This unconformity has been traced across Texas north-east and south-west for 600 miles. The lower Cretaceous sediments represent a profound subsidence until lately not considered as a factor in American Cretaceous history. This subsidence deposited its deep sea sediments over all Texas including the post paleozoic axis and the Jurassic and Triassic basins of the west. It was one of the grandest but heretofore least appreciated events of American geologic history.

The close of this epoch was marked by the elevation of the great monoclinal plain extending in an extensive level plain over the central portion of the state. At its eastern edge, however, its eastwardly dipping strata suddenly bend beneath the upper Cretaceous. This plain is transected by the rivers but the divides are always mesas, and the isolated hills always of the butte type of structure. Where the Colorado flows parallel with the strike the western scarp of the formation consists of benches resembling the Quaternary lake terraces of Utah, but really the result of unequal resistance of the layers. Where the river transects the formation deep cañons and mountains mark its course. These mountains, as beautifully seen to the west from Austin, are the result of faulting and erosion, and often assume large proportions. They form the eastern border of the monocline and extend south-westward to the Rio Grande. Some of the cañons are in fault lines. Their walls are usually of a rich cream-colored chalky limestone resembling the Caen stone of France. Just west of the city of Austin they are of metamorphosed chalk, in which can be seen at intervals bands of flint nodules. It is from this interesting horizon that the beautiful calcite fossils recently described by Dr. Rœmer, were found, and not in the Austin chalk, as he in his far-away home supposed them to be.[1] The soil and cultural aspects of the region are entirely different from those of the upper Cretaceous, agriculture being possible only in alluvial valleys, and uplands poorly adapted for drouth.

THE UPPER CRETACEOUS FORMATION.

At the city of Austin the Colorado emerges from the rugged cañons and mountains and enters a beautiful undulating re-

[1] See *Paleontologische Abhandlungen*, Herausgegeben von W. Dames und E. Kayser. Vierter Band. Heft 4. Berlin 1888. pp. 281-296. Dr. Ferd. Rœmer describes and figures in his usual excellent manner an interesting fauna of beautiful calcite fossils from this lower Cretaceous formation but includes with it several forms from entirely different horizons, and assigns the whole to the Austin chalk, which is 500 feet above it and separated by a half dozen distinct horizons. Such has been the nature of most paleontologic deductions by non-residents when based upon collections of others.

gion with wide valleys, comparable to the chalk downs of England.

Here the parting between the upper and the lower Cretaceous formations is clearly shown and may be traced north or south across the state. Although the Dakota or lower Cross Timber sands are not represented here the succeeding finely laminated basal shales of the Benton or Niobrara epoch are found resting unconformably directly upon the Vola limestone above described. The center of the city is built upon the Niobrara chalk (Austin limestone of Shumard). Succeeding the latter and forming the eastern half of the county is 1,000 feet of Ponderosa marls or laminate calcareous clays from which the great body of residual soils known as the black lands are derived. These phases, basal clays, chalk and marls are widely distributed and uniform, and if we add to them the Hilgard section above the basal Tombigbee sands, they will represent what has until my previous announcement[1] been considered all of the American Cretaceous or the Meek and Hayden section.

The uppermost or arenaceous beds as represented in New Jersey, Alabama and Arkansas were mostly eroded during the post-Cretaceous land epoch and the early Tertiary subsidence. The total thickness of the upper Cretaceous formation in the Arkansas Texas region—sands, chalk marls, chalk clays and basal sand—I estimate to be from 1,500 to 2,000 feet.

Like the lower Cretaceous epoch the upper was closed by an upward movement and a succeeding continental epoch but of slighter elevation and shorter duration than the mid-Cretaceous land. This is attested by the unconformity between Cretaceous and Tertiary, as my studies in Arkansas and Texas during the past year showed. The movement preceding this uplift was slow and long continued as proved by the great thickness of more shallow marls and sands succeeding the chalk.

THE TERTIARY.

Near the eastern edge of Travis county the Cretaceous is succeeded by the basal Tertiary formation or Lignitic beds of Hilgard. These sediments are composed of debris of the

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[1] Am. Journal Science, April, 1887. Am. Naturalist, Feb., 1887.

upper Cretaceous sands and marls. With the exception of the beginning of the great Atlantic timber belt there is no sharply defined topographic line of demarcation between them. After the first hundred feet there are great beds of lignite derived from the post-Cretaceous continent. They continue northward to Alabama and south to the Rio Grande.

THE QUATERNARY.

Reaching half way across the Lignitic and uppermost Cretaceous areas, are great beds of gravel composed of quartzites entirely foreign to Texas and smilar to those of the Hatchatigbee gravel of Alabama and the drift of south-western Arkansas and connected with them by probable continuity. This is probably an accompanying phenomenon of the great glacial depressions at the north.

ANCIENT RIVER TERRACES.

From an altitude of 150 feet above the Colorado at Austin to within 50 feet of its present level there is a series of ancient terraces composed of quartz and flint, accompanied in the younger terraces by red clays which have been removed by lixiviation in the older benches. This gravel quartz and flint is the remnant of the granite and chalk of the Burnet and lower Cretaceous region, the feldspar and chalk having long since decomposed. In the terraces we have the record of three important events, to-wit: The change of level of the land in late Quaternary time; the amount of degradation the Burnet granite has undergone, which can be also shown by studies of the granite area proper, and finally an idea of the immense amount of the chalk removed as recorded by the flints. These terraces do not extend westward of the scarp at Austin, but are well marked to the east.

DISTURBANCES IN THE CRETACEOUS FORMATIONS.

Throughout the two Cretaceous formations and possibly the Tertiary there are numerous disturbances which throw much light upon the history of the region. These disturbances belong to two classes, the first of which occurred during or at the close of the early Cretaceous and the other at the close or later than the later Cretaceous.

The first class of the disturbances is shown in the excessive dip, faulting, and folding of the strata in a manner different from anything found in the later Cretaceous. The structure is that of a great monoclinal fold faulted at the axis of the great curvature. The faulting occurs in and immediately west of Austin, Mt. Bonnell being in the line of upthrust, and the numerous north and south turns of the river (see figure) being in the line of the faults. This fault line extends south-west to the Rio Grande and explains several peculiar phenomena. Among these is a remarkable line of springs whose outburst causes the beautiful streams at San Marcos, New Braunfels, San Antonio and other places. The volume of the Colorado at Austin is augmented greatly from these sources. The springs are natural artesian wells whose outlets to the surface are furnished by the fault lines. The occurence of gold in these deep marine Caen-like limestones is also explained by the faults; the gold in aqueous solution has been infiltered from below but, owing to the porosity of the country rock, is disseminated in "blanket leads" instead of concentrated as it would be if the containing walls were impervious.

There is also evidence of extinct warm water springs. Some of the disturbances in the lower Cretaceous are of the same age as those in the upper, but many of them are much older as seen in the differential elevation.

The upper Cretaceous shows a disturbance of so decided a nature that its interpretation is not difficult—This is a great basaltic outburst seven miles south-east of Austin. This igneous area, as seen from the windows of the Texas university is a double dome resembling the two humps of a camel; on closer examination it is found to consist of a circular body of black columnar basalt about one mile in diameter, protruding through the chalk, the contacting edges of which are converted into crystalline marble. Although this is the chief outcrop of this igneous rock in Travis county (a score or more have been reported along a line westward to the Rio Grande and eastward in Bastrop county in the vicinity of Yegua Knobs) the rocks in many places show its near approach to the surface and, I am inclined to believe, the whole region is underlaid by a system of laccolites like those in the Henry mountains of Utah described by Gilbert.

From the serious displacement of the Tertiary strata at Yegua Knobs and elsewhere it is probable that the igneous protrusions are of early Tertiary age.

It is impossible here to dwell upon the numerous economic features of the region. In the Potsdam there are superb beds of iron ore which, according to Prof. Everhart[2] of the university of Texas are equal in quality to the best Swedish. In the Cretaceous there are inexhaustible beds of the best Caen limestone, chalk and flints. In localities the conditions for hydraulic and Portland cements are exactly similar to those of the best European localities and unequaled in America. The black soils of the upper Cretaceous support one half the present population of Texas and produce two thirds the wealth. When proper country roads are built across it from the abundant road-making materials of the basaltic cones and lower Cretaceous limestones, it will be trebled in value.

Such is a brief summary of the phenomena exposed by the erosion of the Colorado valley within forty miles of Austin. When it is added that there is no evidence that man has ever explored the deep cañons, that the paleontology is almost untouched, that hardly any details of all these grand features have been recorded, one can but feel that the student of geology has here an inexhaustible field before him and the University of Texas a laboratory whose resources are not limited by the generous hand of Nature.

In future papers I shall describe the upper and lower thirds of the Colorado, and endeavor to show the surface geology and evolution of the present topographic feature of Texas.

University of Texas, March, 1889.

CARBONIFEROUS GLACIATION IN THE SOUTHERN AND EASTERN HEMISPHERES,—WITH SOME NOTES ON THE GLOSSOPTERIS-FLORA.

BY C. D. WHITE.

I.

An apology is perhaps required for bringing before American geologists a subject the scene of which is laid, for the most part, in the opposite quarter of the globe; and I should hardly venture to discuss such a question here, were it not for the certain and more or less direct effects on the climate and life changes of America which must necessarily have attended a period of glacial cold in paleozoic time extending over a considerable part of the earth's surface. Should it once be proved that a glacial climate prevailed in extensive

[2] See Bulletin 4, University of Texas.

areas of India, Africa and Australia at some time during the Carboniferous epoch, a key to many of the stratigraphical and biological problems in other parts of the world will have been obtained.

The object of the present paper is threefold: first, to set briefly before American geologists a summary of the prevailing opinions respecting the so-called palæozoic glacial epoch of the southern and eastern hemispheres, with outlines of its evidence, extent and probable age as based on paleontological or stratigraphical relations; secondly, to bring together and correlate some recently published data, while suggesting some conclusions, which may be drawn therefrom, as to the development of the mesozoic plant life of the western hemisphere; and, finally, to further interest our geologists and paleontologists in observing the later evidence and results in this hemisphere of such an important climatic change in the south and east.

The general geological features, so far as they are known, of all the countries with which we are concerned have been so often repeated in the large number of recent contributions to the subject in hand, that I shall confine myself chiefly to the glacial indications themselves, assuming that my readers are either already more or less familiar with the grand geological divisions of those parts, or will be able to refresh their memories from the enumerations and accompanying charts.

In 1856, the brothers W. T. and H. F. Blanford, while making the first exploration of the coal region in the district of Cuttack, India, found an extensive formation which they named the Talchir group, and whose composition was such as to cause them to regard it as glacial; and in their report[1] Mr. W. T. Blanford suggested that certain phenomena, there observed, must be due to the movement of ground ice, and he ventured to predict that further investigation would reveal satisfactory evidence of ice-action.

In 1861, Dr. Thomas Oldham, while examining some lithological specimens from the formations at Wollongong, in New South Wales, sent him by Mr. W. B. Clarke, was surprised at

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[1] W. T. Blanford, H. F. Blanford and Wm. Theobald. Geological structure and relations of the Talchir coal field in the District of Cuttack. Mem. Geol. Surv., India, vol. I, 1859, pp. 33-88. See p. 40.

the remarkable identity between one of the Australian formations and the Talchir boulder bed[1] of India.

In 1869,[2] Dr. Sutherland described certain beds ("Ecca") in Natal, South Africa, whose characters were such that he considered them due to glaciation, and suggested a contemporaneity with the Permian breccias of England whose glacial origin had lately been proposed by Sir A. Ramsay.

It is remarkable indeed that in three widely separated continents observers, working independently, and in two cases, at least, without the knowledge of each other, should within so short a time make known to the world the discovery of glacial formations in those continents, and still more remarkable that, as we shall see later, all these great formations should prove to belong to one great system of paleozoic, and probably contemporaneous age. Without waiting to follow the history of the theory through the period of its struggle for existence,[3] I will attempt to present, as briefly as possible, a summary of those peculiar features and characteristics of formation which have caused certain extensive terranes, bordering on the Indian ocean, to be satisfactorily accounted for only by considering them due to glacial action. For the sake of convenience I shall at the same time introduce some of the paleontological data which will afterwards be of use in discussing the geological epoch in which the glaciation occurred.

INDIA.

Although the first evidence of ancient glaciation in India was discovered in 1856, well-founded proofs were not obtained until 1872,[4] when Thomas Oldham and Mr. F. Fed-

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[1] Thomas Oldham. Additional remarks on the geological relations and probable geological age of the several systems of rocks in central India and Bengal. Mem. Geol. Surv. India, III, 1863, pp. 197-213. Jour. As Soc., Bengal, May, 1861.

[2] Sutherland. Notes on an ancient Boulder Clay of Natal. Quart. Journ. Geol. Soc. London, XXVI, 1870, pp. 514-516.

[3] Though the evidence of glaciation is in some way treated in nearly all the volumes published by the Geological Survey of India, the list appended includes approximately all the literature that discusses the question of the glaciation itself; and from it the history of the matter may easily be reviewed.

[4] Oldham's note in W. T. Blanford: Description of the geology of Nagpur and its neighborhood. Mem. Geol. Surv. India, IX, art 2, pp. 1-36. See pp. 10, 28-31

F. Fedden. On the Evidence of "Ground-ice" in tropical India, during the Talchir period. Rec. Geol. Surv. India, VII, 1875, pp. 16-18.

den succeeded in removing numerous scratched and grooved blocks from the Talchir terrane in the valley of the Godaveri, and found the underlying hard Vindhyan limestone scored with innumerable deep parallel scratches and furrows. It must be remembered that the Talchir terrane is the basal member of the great sequence of fresh water or lacustrine formations forming the great plateau of central India, and extending into Bengal on the east and reaching over into the Trans-Indus region on the west. It is a typical system, based on biological and stratigraphical relations and sequence. The lower Gondwanas consist of the Talchir, Karharbari, Damuda and Panchet; the upper division of the system includes the Rajmahal, Kota-Maleri, Cutch and Jabalpur, respectively, passing upwards. The boulder beds characterize and constitute a large part of the Talchir terrane which blends upwards into the Karharbari. They underlie the coal-bearing strata in deposits of varying depth, often from 500 to 800 feet in thickness, and consist of clays, fine silts, boulders, sandy shales, conglomerates, and soft sandstones. The Talchirs are remarkable everywhere, and are to be at once distinguished by the presence of semi-angular and somewhat rounded pebbles, boulders and rock masses of quartzite, Vindhyan rocks, granite, gneiss and other metamorphic rocks. The boulders, which consist of rocks usually foreign to the localities in which they are found, are generally but slightly rounded, and are smoothed, furrowed, and striated in parallel straight lines. Frequently the fine silty matrix contains boulders, facetted and perfectly polished as by a lapidary, the surface scored, often in two or more directions, in sets of parallel striations precisely similar to the scoring, furrowing and polishing which rocks carried down by glaciers are so well known to exhibit.[1] These boulders are not at angles of repose incident to current action, but often lie at all angles, and, further, they lie imbedded in silt too fine to admit of any explanation other than that they must have been dropped there in quiet water from floating ice above. In the neighborhood of Madras Mr. R. B. Foote found at numerous places, quartzite boulders of 800 to 1,000 cubic

[1] Descriptions are given in nearly all the papers referred to and illustrations of the boulders may be found in those by Grisebach, Oldham, Warth, Wynne, Waagen and W. T. Blanford.

feet in a matrix of friable clay.[1] In many regions where the older rocks, on which the Talchirs rest generally unconformably are newly exposed, they are found to be worn with striations and grooves; and in the great Indian Desert which stretches from the Arvali Range to the Indus river, Mr. R. D. Oldham has found, about Pokran (N.lat. 26° 55'.), a country of porphyry and syenite completely covered with scratches and striations. The same was observed by W. T. Blanford in 1875.[2] On the surface of this lies a tenacious mass of glacial origin, consisting of gravels of porphyry and syenite, which Oldham considers to be till or "moraine profonde." In the near neighborhood and in unmistakable connection with these deposits are the Talchir boulder beds themselves, in which he found one mass measuring 10 by 7½ by 3 feet, of a rock similar to none nearer than the Arvali mountains, 150 miles away to the southward, from which he believes it to have been transported. Of the further extension of the Talchirs I shall treat when considering their probable age. It may be noted here that they contain few fossils, and these in the upper stage.

AFRICA.

Concerning the geological details of South Africa much less is known than of any other region with which we have to do. A vast sandstone region occupies the entire center, and is fringed by older formations, old slates, crystalline and Devonian rocks. This so-called "Karoo" formation extends over the north part of Cape Colony, the Orange Free State, Transvaal, and the deserts lying westward, and presents a series of sandstones and shales, interrupted in places by eruptive rock, which reaches a maximum thickness, as shown by T. R. Jones, of nearly 10,000 feet. The Karoo formation rests, for the most part, or in some regions, at least, conformably, on the Table Mountain sandstone, containing remains of Lepidodenron and Calamites, and generally regarded as Devonian, though considered recently by Cohen[3] as be-

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[1] R. B. Foote. Notes on the geology of the neighborhood of Madras. Rec. Geol. Surv. India, III, 1870, pp. 11-17.

[2] W. T. Blanford. Additional evidence of the occurrence of glacial conditions in the palæozoic era, etc., Quart. Jour. Geol. Soc. London, XLII, 1886, pp. 249-260.

[3] E. Cohen. Geognostisch-petrographische S kizzen aus Süd-Afrika. N. Jahrb. f. Min., Beil. Bd. v. Heft. 1, 1887, pp. 195-247. p. VIII, 2 IX.

longing to the Carboniferous system; and this rests unconformably on the Silurian slates, and partly conformably on richly fossiliferous Devonian beds.

The series of these freshwater formations in South Africa is as follows: The Ecca beds, at the base, consist of three members of which the lowest, the Ecca shales, which appear only in a few places, are strongly contorted. All the other horizons are nearly absolutely horizontal.

Between the upper and the lower Ecca beds lies the Ecca conglomerate, or "Dwyka conglomerate" of T. R. Jones, which contains the glacial indications first discovered by Sutherland and afterwards described by Dunn[1] and others. These conglomerates, regarded at first as volcanic, consist of a blue clayey material in which fragments of granite, gneiss, greenstone and clay slate are imbedded. These vary in size from grains of sand to boulders six feet in diameter and weighing 6 to 10 tons. "They are often smoothed as if ground down in a clayey sediment, but they are not rounded like blocks which have been exposed to surface action." The fracture of the clayey matrix is not conchoidal. A tendency to obscure, wavy bedding has been observed, and traces of ripple marks show distinctly. As a rule the contacts of the Ecca boulder-beds and the Table Mountain sandstone are unconformable, the contact surfaces being marked generally with scratchings and deep grooves "as if some heavy semi-plastic substance with included hard angular fragments had moved across it." These features have been noted in many localities. The upper Ecca shales and sandstones show a gradual transition from the boulder beds and conglomerates. Coal seams occur here in places, with fossil wood, saurian, and plant remains; but of the last named only the genus *Glossopteris* has been described. Ascending from the Ecca beds, the Karoo beds (proper) are met, beginning with the Kimberly conglomerate, and including the Koonap, Beaufort and Stormberg beds, and resting unconformably on the Ecca beds. In his paper on the Geology of South Africa,[2] T. R. Jones pronounces the Kimberly beds

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[1] E. J. Dunn. Report on the Camdeboo and Nieuweldt coal, Cape of Good Hope. Cape Town, 1878, 24 pp., 4to. Reviewed by T. R. Jones, Geol. Mag., [2] vi, 1879, No 12.

[2] Rept. Brit. Assoc. Adv. Sci., Montreal meeting, 1884.

to be glacial; but the reasons therefor are not given in full, and so far as I know, the opinion has never been corroborated by any other author.

Undescribed plants have been obtained from the Koonap terrane. The Beaufort terrane is not well known. Vertebrate remains, described by Owen and pronounced by him to be Carboniferous, and plants consisting of four species of *Glossopteris* and one of *Phyllotheca* have been found. The plants are most nearly allied to those of the Damuda series of India, and many of them are also found in Australia. The Stormberg beds, consisting of thick, light sandstones, with shales and coal seams, contain vertebrate remains and plants, among which Dunn,[1] has identified *Sphenopteris elongata, Pecopteris odontopteroides*, *Cyclopteris cuneata*, and *Tæniopteris Daintreei*, all of which occur in the uppermost plant beds, which we shall later review in eastern Australia. Near the coast and above the Karoo system lies the Uitenhage group, consisting of marine beds alternating with plant beds. The plants belong to what is generally accepted as the mesozoic flora. The fauna has been studied by Neumayr,[2] who in a recent work has assigned the whole group to the Neocomian. Though glaciation was thought impossible when proposed as a hypothesis to account for the Ecca boulder-beds by Sutherland in 1869, it was pretty well established by Dunn in 1872, by the discovery of striated, grooved, and otherwise glaciated stones in the strata near the Orange river. The distribution was worked out, so far as geological knowledge extends in that part of the continent, and published by him in the Cape Colony Government report for 1886.

Before leaving Africa it may be well, perhaps, to summarize the results obtained so far in a table compiled from Jones, Wyley, Dunn and others.

Karoo System.		Uitenhage–Neocomian fauna.	=Rajmahal.
	Karoo Beds.	Stormberg, 1,800 ft., vertebrates,	=Panchet & Rajmahal.
		Beaufort, 1,700 ft., plants	=Damuda.
		Koonap, 1.500 ft., " not described.	
		Kimberly. (glacial?)	
		—Uncomformity—	

[1] E. J. Dunn, Notes on the occurrence of Glaciated Pebbles and Boulders in the so-called mesozoic conglomerate of Victoria. Trans. and Proc. Roy. Soc. Victoria, xxiv, 1888, pp. 44-46.

[2] E. Holu band M. Neumayr. N. Jahrb. f. Min., 1884, vol. i, p. 279 et seq.

Karoo Sys.	*Ecca* Beds.	Upper Ecca shale, 1,200 ft.-2,700 ft.
		Ecca conglomerate, 500 ft.-800 ft. (Dwyka). (glacial).
		Lower Ecca shale, 0 ft.-800 ft..
Table Mountain and older formations.		

AUSTRALIA.

New South Wales.—We now pass to the remaining one of the three continents lying about the Indian ocean. So far as known, we have here to do with three provinces, viz. New South Wales, Victoria, and Queensland; and we shall consider them in the order named. From the time of the first description of the boulder beds of New South Wales by Dr. Thomas Oldham in 1861,[0] to the present, the knowledge of these interesting formations has steadily increased, and in no region are palæontogical or stratigraphical data more abundant. Dr. Oldham, in describing the carboniferous marine beds at Wollongong, remarks: "And still further, many of the lower beds of the Australian group, there so abundantly rich in fossils, are very similar to many of the beds in the Talchir series. There is the same mixture of pebbles and large rolled masses in a matrix of fine silt; and much of this silt is of exactly the same peculiar bluish-green tint so characteristic of these beds in this country, and which when once seen can never be mistaken." Similar beds were observed in the upper marine coal measures (of W. B. Clarke) in the neighborhood of Branxton, by Mr. C. S. Wilkinson who reported finding a very coarse conglomerate containing large sub-angular boulders of rock foreign to the district, which he considered as erratic, though no ice-scratches were found. However, when in 1885, Mr. R. D. Oldham,[1] Deputy Superintendent of the geological survey of India, made a visit to Australia for the purpose of comparing its strata with those of India, he made the important discovery of the presence of boulders and pebbles unmistakably striated and polished by ice, not far from where the erratics were noticed by Wilkinson. "Blocks of slate, quartzite, and crystalline rocks, for the most part sub-angular, are, " he says,[2] "scattered through a matrix of fine sand or shale and these latter beds contain delicate Fen-

[0] Memoirs Geol. Surv. India, Vol. III, p. 209.

[1] R. D. Oldham. Memorandum on the correlation of the Indian and Australian coal-bearing beds. Rec. Geol. Surv. India, XIX, 1886, pp. 39-47.

[2] Loc. cit., p. 44.

estellæ and bivalve shells with the valves still united, showing that they had lived, died, and been tranquilly preserved where they are now found, and proving, as conclusively as the matrix in which they are preserved, that they could never have been exposed to any currents of sufficient force and rapidity to transport the blocks now found lying side by side with them. These included fragments of rock are of all sizes from a few inches to several feet in diameter." It is stated on the authority of Wilkinson that some of these boulders might be measured in yards. Mr. Oldham describes similar deposits as far north as Wollongong, in the Blue mountains on the west, and extending northward into Queensland. A minute description of a section of the Stony Creek terranes (Lower Coal Measures), together with a chart recently given by Mr. T. W. Edgeworth David before the Geological Society of London,[1] fully corroborates the evidence and the conclusions of Mr. Oldham. In roughly sketching the series of formations in New South Wales, much time will be saved by introducing paleontological data with the stratigraphical, trusting that the reader will carry them in mind until we reach the consideration of the age of the various terranes especially that containing the glacial indications.[2]

The Muree beds of New South Wales rest generally on older rocks of granite, etc., and in places in uncertain relations on the Silurian and the fossiliferous Devonian. In the interior they rest, conformably as stated by several writers, on a great deposit of yellow sandstone, from which only Lepidodendron and a species of Cyclostigma have so far been obtained, and which are supposed to be Devonian. Near Stroud Arowa and Port Stephens an older flora, regarded by Feistmantel as Sub-Carboniferous, occurs, containing, among others, *Calamites radiatus* Brongt., *Lepidodendron veltheimianum.*, *L. Volkmannianum*, and representing the genera *Cyclostigma*, and *Archæopteris*. It is not definitely known whether these plants came from the lower part (glacial) or the Muree beds, or below them. The chief point, however, is

[1] Evidence of glacial action in the Carboniferous and Hawksbury series, New South Wales. vol. XLIII, No. 170, 1887, pp. 190-195.

[2] The important bearing of Australian geology in the establishment of the age of the Gondwana system is my apology for introducing a more detailed description of its terranes.

to record the presence of a Sub-Carboniferous flora in a terrane which is described by W. B. Clarke[1] as the lower part of the Muree beds, and as passing down into the Lepidodendron beds. The Muree beds include three terranes; the Lower Marine beds, the Stony Creek beds, containing the older coal seams, and the Upper Marine beds. As described above, these marine beds are considered glacial in their origin. It is important to note that nearly all of these terranes are fossiliferous, and occasionally marine plants and animals are found in the same beds. According to Dr. Ottokar Feistmantel's list,[2] the flora includes one species of *Phyllotheca*, four of *Glossopteris*, one of *Nœggerathiopsis*, and one of *Annularia*, and presents on the whole a mesozoic aspect, though the marine strata, both above and below, contain a fauna that is unquestionably Carboniferous, including such genera as Spirifer, Conularia, Orthoceras, Fenestella, etc. These were fully described by De Koninck,[3] and of the 176 species identified, 74 are found in the Carboniferous limestone of Europe. There is hardly an exception to the opinion that the boulder beds of the Muree terrane were deposited at some time in the Carboniferous period, and it is generally believed that it was during the latter part of the Carboniferous, proper.

The Newcastle terranes, nearly 1,000 feet in thickness, and consisting of sandstones, shales and coal-seams, overlie the Muree terranes. The only animal remains from the Newcastle were those of *Urosthenes australis* described by Dana,[4] who considered the coals as of paleozoic age. Twenty-three species of plants have been found, many of which are identical with those of the Damudas of India. It was this circumstance, as well as the similarity of the beds, together with their underlying terranes, which first led to a comparison of the Australian formation with the Indian, and helped to confirm the paleozoic age of the lower members of the latter.

Above the Newcastle is a formation of coarse-grained sand-

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[1] W. B. Clarke. Remarks on the sedimentary formations of New South Wales, etc. 4th Ed., Sydney, 1878, 8vo.

[2] Trans. Roy. Soc., N. S. W., 1860.
Palæozoische und mesozoische flora des ostlichen Australiens.
Palæontographica, Suppl. III, Lief. 3, Cassel, 1878-'79, 195 pp.,30pl.

[3] Recherches sur les fossiles paléozoiques de la Nouvelle Galles du Sud. Bruxelles, 1876-77. 8vo.

[4] U. S. Exploring Expedition, Geology, 1849, p. 495.

stones and conglomerates, said by Clarke to be from 800 to 1,000 feet thick, and known as the Hawksbury beds. Here, again, we have evidence of glacial action, though not so extensive, nor indicative of the violent changes of the period in which the Muree terranes were formed. These were first published by Wilkinson,[1] in 1879, who described "angular boulders of shale of all sizes up to twenty feet in diameter, embedded in the sandstone in a most confused manner, some of them standing on end as regards their stratification and others inclined at all angles." These nearly always occurred above shales, and were mixed with rounded pebbles of quartz. He says, "they are sometimes slightly curved as though they had been bent whilst in a semi-plastic condition, and the shale beds occasionally terminate abruptly as though broken off." It was the fact of the occurrence of boulder beds in the Hawksbury terrane that first made Feistmantel correlate these with the Talchirs of India, a conclusion which he has long since abandoned.[2]T he evidence of glaciation in the Hawksbury formation has since been supported by the testimony of Haast, and more recently by David.[3]

The Hawksbury terrane was somewhat denuded, according to Clarke, before the Wianamatta terrane, next overlying, was deposited. The latter consists of soft shales and fine sandstones. The Hawksburys have furnished two fishes and four plants, one of which, *Thinnfeldia odontopteroides* Feist., is also found in the Panchets of India. One of the fishes is a Permian species, the other mesozoic; and on the whole the plants present what is commonly considered as a Jurassic phase, though Feistmantel now regards them as Triassic. A still higher series of beds has been found at several points, and this has taken its name from the Clarence river where it was described by Wilkinson. Two species of plants, *Tæniopteris Daintreei* McCoy, and *Alethopteris australis* McCoy, have been identified by Feistmantel as coming from this series.

The following scheme will serve to illustrate the order of the beds and the general evidence of the organic remains, considered according to the European standard:

Clarence river	Jurassic Fauna	—Jurassic	Flora.
Wianamatta, 700 ft.—Permian–Trias	"	— "	"

[1]Trans Roy. Soc. N. S. W., XIII, 1880, p. 106; and *ibid.*, 1884, p. 105.
[2]Records Geol. Surv. India, XIII, 1880, pp. 251, 252.
Palæontologia Indica, Ser. XII, III pt. 3, 1881, p. 131.
[3]Quart. Jour. Geol. Soc., London, XLIII, 1887, pp. 190-195.

Hawksbury, 800 ft.–1,000 ft. (glacial)	Permian fish	Jurassic Flora.
Newcastle,	Carboniferous fauna,	" "
Muree. — Upper Marine (glacial,)		
Muree. — Old Coal Seams (Stony Creek of Blanford)	Carb. fauna.,	Trias. and Carb. Flora.
Muree. — Lower Marine (glacial)	" "	Lower Carb. " = Mountain Limestone of Eng.

After observing the great variance between paleozoological and paleobotanical evidence, which extends from the first occurrence of glaciation upwards, it is interesting to note the recurrence of harmony in the mesozoic beds of the Clarence river series.

Victoria.—Glacial evidence was first reported in Victoria, as observed in the Baccus Marsh formation, by Sir R. Daintree in 1866.[1] This discovery, which was corroborated in the following year by Dr. A. R. C. Selwyn,[2] at that time director of the geological survey of Victoria, and verified by him at Baccus Marsh, Darley creek, Wild Duck creek, and many other localities, has since received well nigh indisputable confirmation from Mr. E. J. Dunn,[3] the same to whom we owe much of our knowledge of the geology of South Africa. At the base of the observed terranes of Victoria is a sandstone which is well exposed at Iguana creek, and which has yielded, according to McCoy, one species from each of the genera, *Sphenopteris*, *Aneimites*, *Archæopteris*, and *Cordaites*. Over this terrane lies the Avon River sandstone, with *Lepidodendron australe* McCoy. These two terranes are generally regarded as Devonian, though Feistmantel considers the latter as Carboniferous. Above this lies the Baccus Marsh sandstone alluded to above. This terrane contains deposits over 100 feet in thickness of conglomerates and boulders, often striated and facetted, and was the earliest of the terranes, which we are considering, to be generally accepted as glacial. From the Baccus Marsh terrane have come only three species of plants, belonging to the genus *Gangamopteris*, whose affinities are not yet understood. Above the Baccus Marsh terrane, and complet-

[1] Report on the geology of the District of Ballan, Melbourne, folio.

[2] Notes on the physical geography, geology, etc. of Victoria. Melbourne, 1866-1867. (See p. 16.)

[3] Notes on the occurrence of glaciated pebbles and boulders, etc. Trans. & Proc. R. Soc. Victoria, XXIV, 1888, pp. 44-46.

ing the series of Victorian mesozoic strata, are found the Bellarine beds. These are of great thickness and contain unimportant coal seams. Six species of plants of mesozoic age have been described by McCoy, and on these, the only paleontological evidence furnished, Feistmantel has based his conclusions, in correlating them with the Clarence River series of New South Wales, as upper Trias or lowest Jurassic.

QUEENSLAND.

The discovery of traces of glacial action northward into Queensland, first made known by R. L. Jack in 1879,[1] has since been corroborated by several other geologists. The evidences of glacial phenomena were found in the older of the Queensland coals, and chiefly as exposed in the Bowen River coal-field. Here, again, we have Carboniferous types of marine fossils along with remains of *Glossopteris*, *Schizopteris*, and *Pecopteris*. A younger flora is found in the upper coals which Feistmantel correlates with the Clarence river series.

GENERAL.

From the foregoing roughly-outlined data, which I have sought to condense as much as possible, it appears that an area extending from 40° south lat. to 35° north, and from 20° east of Greenwich to 155° east, and including more than one fourth of the earth's surface, is characterized by great table lands of enormous thickness, resting, usually nearly horizontally, on folded Devonian and older rocks, or in places conformably on rocks of lower Carboniferous age, and that these immense terranes, which present the strongest resemblance to one another both paleontologically and lithologically are in turn characterized in their basal members by abundant evidence of glacial action. Indeed, notwithstanding the reluctance of the scientific world to accept the startling theory of a glacial epoch in later paleozoic or earliest mesozoic time, the idea has gained steadily in credence since 1872, until at last it is supported, not only officially but individually, by nearly every geologist who has specially examined the evidence or studied in the field in India, Australia, or Africa. As the knowledge of the geology of these great fields has increased, the evidence has not only grown so strong as to force

[1] Report on the Bowen River coal-field, Brisbane, 1879, folio, 44 pp., map.

the consideration of the possibility of glaciation, but it has become so characteristic in its nature and so important in its extent as to make it impossible to satisfactorily account for its origin according to any other known law of action. Not only is such an explanation supported by the conclusions of the many competent observers in the field, but it is quite generally accepted by European geologists, among whom may be quoted such conservative authors as Prestwich,[1] or Neumayr,[2] who, in his "Erdgeschichte," after reviewing the causes for such a deduction, adds, "there can no longer be any doubt that during the latter half of the Carboniferous period strata were deposited in southern Australia, Farther India and the Cape region of South Africa, whose material shows all the characteristic features of transportation by means of glaciers."

PERIOD OF GLACIATION.

To give a satisfactory representation of the paleontological evidence of the different classes of contained organic remains as to the age of the terranes with which we are concerned would be impossible within the limits of the present paper; and, indeed, the work has already been so thoroughly and accessibly done by W. T. Blanford, Feistmantel, Waagen, Lydekker and others, that I shall content myself with giving but little more than a synopsis of the general results obtained by the workers in the different domains of paleontology, at the same time putting those, who may wish to carry the matter more into detail, in the way of finding the desired information by means of the references and appended list of papers.

The paleontological anomalies which are everywhere characteristic of the great formations with which we have to deal are the best known as well as the most remarkable that have yet been met with in the progress of geological discovery. Perhaps no better or more striking presentation of the contradictory evidence of organic remains has ever been offered than that of W. T. Blanford in his address on "Homotaxis as illustrated in India," delivered before the geological section of the British Association at its Montreal meeting in 1884.

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[1] Joseph Prestwitch. Geology, Chemical, Physical and Stratigraphical. Oxford, 1886, 2 vols.

[2] Melchior Neumayr. Erdgeschichte. Leipzig, 1887, 2 vols. (See vol. II, pp. 181-198, with figures.)

While many new data, of such a nature as to decide certain points as to age, have since been obtained and worked out by the same author, Waagen, Feistmantel, Oldham, Dunn, and others, the paleontological facts remain none the less notable or significant.

Each of these great terranes of India, Africa, and Australia, contains coal seams with floras which are mostly identical among themselves, embracing many peculiar and more or less problematic types, and which, when they are brought before the tribunal for comparison with the fossil floras of Europe, find their nearest European allies in the mesozoic, and for the most part in the Jurassic. Likewise they all contain in their lower members faunas which are distinctly characteristic of the Carboniferous period, and are largely identical with those of that age in Europe and America. In Australia and Africa the glacial formations rest, in part at least, on lower Carboniferous terranes, and in the latter continent we have marine fossiliferous formations intercalated with plant beds. Typically Carboniferous species of *Orthoceras*, *Spirifer*, *Conularia* and *Fenestella*, are found both above and below the Stony Creek beds which contain four species of *Glossopteris*, and one each of *Nœggerathiopsis*, *Annularia*, and *Phyllotheca*. These, with the exception of the Annularia, are all found again in the Newcastle beds above, while their genera are included in the flora of the Damuda series of India. Though in Australia and Africa the proofs of paleozoic age are most apparent and conclusive, the correlation of the glacial horizons could not be secured beyond all controversy while the age of the glacial formations of India was supposed to belong to the early mesozoic.

The history of the correlation of the terranes of the Gondwana system of India is noted for an incessant struggle between the most of the supporters of the paleobotanical evidence on the one hand and the students of the animal remains on the other. As representing the adherents among paleobotanists to the mesozoic side of the question I shall mention only Dr. Ottokar Feistmantel, who spent eight years in India, and whose masterly work on the Gondwana flora comprises, besides numerous minor publications, four large volumes of the " Palæontologia Indica." While holding with unflinching tenacity to the European paleobotanical standard, he has been forced step by step to yield to the overwhelming pressure of other evidence, as well as in part to the evidence furnished by a better knowledge of the plants themselves, until in 1883, he assigned the Talchirs to the uppermost paleozoic, though this admission, it should be stated, was largely due to the fact of their presumable contemporaneity with the Australian glaciation. In order apparently to maintain his earlier conclusions as to the greater part of the terranes of the Gondwana system, he proposes, in the fourth and last volume of his "Fossil Flora,"[1] to divide the system into three parts, instead of two by cutting off the greater part of the "Lower Gondwanas" to form a "middle" division. So unwarranted seems such a division that the late director of the Indian survey deemed it expedient to criticise it officially; and in a notice which was published with the last part of the same volume, Dr. Medlicott says (p. 5): "Having let down his lower Gondwana division into the paleozoic era, the chief effort of Dr. Feistmantel's present contention clearly is to extend that division so as to force up the Damuda (as defined by him); and forced it accordingly is. His main divisional boundary, which on page XXIII is said to be sufficiently marked, is placed where no one has yet been able to draw a boundary in the field, within the Barakar measures, one of the most homogeneous of the hitherto accepted stages of the Damuda Group." However, Dr. Feistmantel still adheres to his late divisions of the system, though in his two contributions[1] to the general subject, published since then, his correlations of the various horizons are, in the main, much more harmonious with those of the other paleontologists and geologists of India.

Primarily, for the sake of giving what may fairly represent the most recent conclusions on the paleobotanical side of the matter, as reached while considering also the animal remains, and, secondarily, to present compactly and graphically some of

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[1] Memoirs Geol. Surv. India, Palæontologia Indica. Series XII, vol. IV, Calcutta, 1886, (See preface with last part).

[1] Ueber die Pflanzen-und Kohlenführenden Schichten in Indien (beziehungsw. Asien), Afrika und Australien und darin vorkommende glaciale Erscheinungen. Sitz. K. böhm. Gesell. Wiss., math.-nat. Cl., 1887, (Prag., 1888), pp. 1-102. Nachtrag, ibid. pp., 570-576.

Geologische und palæontologische Verhältnisse der Kohlen-und Pflanzenführenden Schichten im östlichen Australien. Ibid., pp. 717-734.

the palæontological data, especially the low origin of the mesozoic flora, I give the correlation chart published in his last paper,[1] with which, however, I have combined the column for Africa, along with other materials taken from the two preceding papers, in the same volume, with palæontological data compiled from all. The range of the genera, *Glossopteris*, *Gangamopteris*, *Vertebraria*, and *Phyllotheca*, is both interesting and important.

The contemporaneity of the Talchirs, Eccas and Baccus Marsh terranes with the marine formations of New South Wales was first demonstrated by R. D. Oldham [2] during his explorations and researches in the latter province in 1886. Still another link in the evidence as to the age of the glacial formations of India has during the last two years been discovered and confirmed in the "Olive group" of the Salt Range of the Punjab. This was the discovery at Nilawan, and many other localities in the eastern portion of the Salt Range, of incontestable evidence of glacial action in a boulder bed which, though underlying strata of Cretaceous age, and formerly supposed to belong to that period, has lately been proved to belong to the horizon of the speckled sandstone (upper Coal Measures) of the western portion of the range. This knowledge originated in the discovery by Dr. H. Warth, in 1886,[3] of fossiliferous concretions in a gravelly layer overlying the boulder beds of the Olive group. These concretions contained eleven species of invertebrate remains, among which were the genera Conularia (3 species), Aviculopecten, Nucula, and Spirifer. Of these eleven species four are found in the Australian Coal Measures and several in the Productus limestone of the western Salt Range. The spirited discussions called forth by this announcement presented a vigorous and brief struggle, the reports of which are still fresh in the leading geological journals of Europe. Subsequent researches in the field, by various members of the Survey, have shown that the concretions are not only in place, and lithologically identical with the surrounding matrix, but also that, while they

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[1] Ibid. p. 732.

[2] Memorandum on the correlation of the Indian and Australian coal-bearing beds. Records Geol. Surv. India, XIX, 1886, pp. 39-47.

[3] W. Waagen. Notes on some palæozoic fossils recently collected by Dr. H. Warth in the Olive group of the Salt Range. Ibid., pp. 22-38, **pl. i.**

	SOUTH AFRICA.		INDIA.	AUSTRALIA. (N.S.W.)
Neocomian.	Uitenhage. Jurassic pl. Neocomian Invert. ——?	Upper Gondwanas.	Cutch. Plant Beds. Lower Oolite pl. Marine Beds. Tithonian. Upper Jurassic fauna.	? Marine beds, Queensland.
Tithon.				
? Rhetic-Jura.	Stormberg. Rhetic pl. Permian Vert.		Jabalpur. Low Oolitic pl. Kota-Maleri. Intermediate pl. Lias fish, Triassic reptiles. Rajmahal. Rhetic pl.	Bellarine beds. Clarence River. Jurassic fauna. Coals of South Queensland. Jurassic pl.
(?) Trias.	Beaufort. Triassic pl.	Lower Gondwanas.	Panchet. Rhetic pl. Lower Trias. Vert.	Wianamatta. Jurassic pl. Permian fauna. / Unconformity.
Permian.	Koonap. Undescribed pl. [Kimberly Glacial ?]		Damuda. Mid. or Upp. Jurassic pl. Permian Vert.	Hawksbury. Jurassic pl. Permian Vert. (Glacial ?)
Carboniferous.	Unconformity. / Upper Ecca Shale. Only Glossopteris described Ecca (Dwyka) Conglomerate. (Glacial). Lower Ecca Shale.		Karharbari. Lower Trias. pl. / Talchir—Speckled Sandstone. (Glacial). Upper Carbonif. invert. Carboniferous Vert.	Newcastle. Jurassic Pl. Carbonif. invert. Carb.-Perm Vert. / Upper marine. (Glacial) Old Coal (Stony Creek). Low. Carb. and Mesozoic pl. Lower marine. (Glacial.)
Lower Carbonif.	Lepidodendron. Sandstone.	Unconformable on Vindhyan rocks—of doubtful age, but generally regarded as Silurian.		Lepidodendron. Sandstone.
Devonian.	Marine.			Marine.

were abundant, none with fossils indicative of higher formations, as Jurassic, Cretaceous, etc., were found, as would very probably have been the case, had fossils or concretions been transported. It was while investigating these that the pebbles and boulders showing facets, grooves, striæ, etc., were found which proved the glacial origin of the boulder beds, and which have been so frequently described and illustrated in the works above referred to.[1] Later and special study in the field has resulted in ascertaining a wide distribution for the boulders, their stratigraphical as well as palæontological identity with the speckled sandstone of the western part of the range, and the discovery of glacial indications at the base of the Speckled sandstone itself. In his last annual report,[2] William King, the new director of the survey of India, after reviewing briefly the case, and summarizing the later results, announces that the horizon of the Olive group boulder-bed is co-ordinate with and will hereafter be known as the "Speckled sandstone." For the sake of brevity I have omitted particulars and geological descriptions. The Speckled sandstone lies above the Neobolus beds (Lower Carboniferous) and below the Fusulina beds and the Productus limestone (Permian) of Waagen.

Correlation:—Meanwhile the data for the correlation of the various horizons of the great Africo-Indo-Australian terrane, to which Feistmantel has proposed to apply the term "Gondwana system," have been summed up and reported upon in several important contributions by Feistmantel,[3] Waagen,[4] W. T. Blanford,[5] and Oldham.[6] The tabulated results of the first named of these have already been given. Those of the others, which agree so remarkably as to be substantially identical, will be presented in a table to which are added the general indications of the different kinds of paleontological evi-

[1] The boulders, which consist chiefly of red porphyry, a rock foreign to the region, are frequently facetted, showing grinding and scratching on each face, and occasionally in two or more directions on the same face showing their fixture at different times at different positions in the ice. At Mount Chel the bed was found to be several feet in thickness and was accompanied by about 25 feet of thick greenish mud through which boulders were scattered.

[2] Records Geol. Surv. India, XXI, Pt. I, 1888, pp. 1-6.

[3] Sitzb. K. böhm. Gesell. Wiss., 1887, (1888) p. 1.

[4] Jahrb. K.-K. Geol. Reichsanst., XXXVII, 1887, (Wien, 1888) p. 143.

[5] Rept. Brit. Assoc. Adv. Scei., Montreal meeting, 1884; Quart. Jour. Geol. Soc. London, XLII, 1886, p. 249.

[6] Records Geol. Surv. India, XIX, 1886, p. 39.

dence contained in the different terranes, that of the vertebrates of India being given on the authority of Lydekker.[1] It should be mentioned that Blanford is inclined to correlate the Newcastle terrane with the Damuda and Koonap terranes, the Hawksbury being considered by him as equivalent in part to the Panchet, while, in common with Medlicott and Lydekker, he seems disposed to put the glacial horizon slightly lower than the position given it by Waagen. None of the authors named, except, perhaps, Feistmantel, adopt T. R. Jones' conclusions as to glaciation in the Kimberly formation in South Africa. Such a horizon, should the evidence prove conclusive, would suggest for itself a correlation with the probable glaciation of the Hawksbury terrane in New South Wales, being regarded as contemporaneous with the change of climate in the northern hemisphere at the close of the Permian.

Possible further Geographical Extension.—While considering the extent of the paleozoic glacial epoch, it remains to add the reports of the advance guard of geological exploration, in two widely distant territories.

The first is that of the results of Oldham and Griesbach, in the Simla-Himalaya, and in Afghanistan and Turkistan. The former, in his work in the Simla-Himalaya,[2] was able to indicate the highly probably identity of the already known Mahandi, Bawar, and Blaini boulder-beds with the Panjal conglomerates, showing that all of them underlie carbonaceous beds containing 46 species of invertebrates, of which 17 are in the Carboniferous of Europe, 12 in the marine Carboniferous of Australia, and 16 in the Productus limestone of the Salt Range. The evidence is therefore *prima facie* in favor of a correlation of these boulder-beds with those of the Salt Range and the Talchirs. Of still more importance are the discoveries made by Mr. Griesbach,[3] during the last three years, in the more northwestern field, in the course of which he has made known the existence, near Herat, and on the border of Turkes-

[1] Ibid., xx, 1887, p. 51.
Each author reviews the palæontological data and from their papers the references to all the orignal palæontological authorities may be obtained. I omit the queries sometimes put after the word "glacial."

[2] Sequence and correlation of the pre-Tertiary sedimentary formations of the Simla-Himalaya. Records Geol. Surv. India, XXI, August, 1888, p. 130, etc.

[3] Afghan Field-notes. Ibid., XVII, 1885, pp. 57, etc.; XIX, 1886, pp. 48, etc.; pp. 235, etc.; xx, 1887, pp. 17, etc.; pp. 93, etc.

Europe.	Africa.	India.	Australia. New South Wales.	Australia. Victoria.	Australia. Queensland.
Jurassic	Uitenhage. Stormberg.	Upp. Gond Glossopteris Jabalphur. Kotomaleri. Rajmahal.	Clarence River Carbonaceous.	Upper Mesozoic Carbonaceous	Upper coal-bearing Carbonaceous
Triassic	Upper Karoo Dicynodont, etc. Paleoniscus Glossopteris Phyllotheca, etc. Kimberly (Glacial conglom)	Middle Gond. Transition Vertebraria Glossopteris, etc. Panchet and Damuda Dicynodon. Pachygonia, etc. Phyllotheca Vertebraria Nœggerattiopsis Glossopteris, etc.	Wianamatta Hawksbury Palsoniscus Labyrinthodont Glacial ? conglom.	Wanting	Wanting
Carboniferous—Permian	Upper Ecca Glossopteris Lower Ecca (Dwyka) (Glacial)	Lower Gondwanas Karharbari Vertebraria Glossopteris! Gangamopteris! Talchir Shales Talchir Conglom. (Glacial)	Newcastle Upper coals Phyllotheca Vertebraria Glossopteris! Gangamopteris, etc. Upper Marine (Glacial) Lower coal Glossopteris! Lower Marine (Glacial)	Baccus Marsh sandstone Gangamopteris! Baccus Marsh conglomerate (Glacial) Gippsland	Lower coal-bearing strata Upper beds mostly fresh water Glossopteris! Marine Terranes Glossopteris! Unfossiliferous
	Carboniferous flora in upper part. Alethopteris Lepidodendron Sigillaria Stigmaria	Vindhyan Series	Sub-carb. Smith's creek Lepidodendron Rhachiopteris Glossopteris	Avon river Lepidodendron	Bobuntungen Lepidodendron
Devon.	Devonian		Goonoo-Goonoo Lepidodendron nothum	Iguana creek	Mt. Wyatt

tan, of extensive boulder beds and conglomerates, lithologically resembling the Talchirs, underlying a great plant-bearing system with *Vertebraria*, a typical lower Gondwana plant, and resting conformably on richly fossiliferous marine terranes of Carboniferous age. The study of the paleontology of these beds may be looked to with great interest as affording a possible means for tracing the correlation and connection of the Gondwana system and the terranes of the Elburz and Armenia, and consequently with Europe and the north through the Herat beds and the plant-bearing beds of Turkestan.

The second report, above referred to, is a short communication by letter from Orville A. Derby in South America to Dr. Waagen.[1] In it Dr. Derby says that a great paleozoic area exists in southern Brazil, which includes a great part of the Parana plain, and concerning which nothing, so to speak, has been published. This is covered to a great extent by a broad band of rock of Carboniferous or Permian age, or both, which contains few fossils. In the province of Parana he saw rounded fragments, ranging in size from a fist to four times the size of a man's head, buried in an extremely fine clay shale. Also in the province of Itú, on the river Jutí, in Itapetininga, and many other localities, in an extraordinarily fine-grained sandy shale, he found isolated rounded blocks, a foot and a half or more in diameter, of granite, gneiss, etc. On the Capavary river, boulders over a meter in diameter were discovered, resting in a matrix of Carboniferous clay shale. Although no striations were observed, Dr. Derby believes that an examination of the terranes by an experienced eye will, no doubt, disclose all the characteristic indications of glaciation. Certainly, in the absence of striations and other more decisively glacial characteristics, the evidence is far too unsatisfactory, when taken by itself, to warrant for a glacial agency any higher consideration than as a possibility, even when taken in connection with the established glaciation in the other continents of the southern hemisphere; and while glaciation in the Africo-Indo-Australian terrane is an accepted fact, and that of Afghanistan and Turkestan a possibility, that of South America can only be regarded as an hypothesis. Never-

[1] Mittheilung eines Brief von Herrn A. Derby, über Spüren einer Carbonen Eiszeit in Südamerika. Neues Jahrb. f. Min., 1888, vol. II, Hft. 2, pp. 172-176.

theless, the lessons of the past have taught geologists not to be too dogmatic in their creeds, nor too zealous in forcing each new and half-discovered increment to knowledge to conform wholly within the bounds of creeds suited to the limitations of what was known before.

Concerning paleozoic glaciation in Europe, much has been said by many authors. Among the leading contributions might be named that of James Geike,[1] in which he attempted to show the proofs of glaciation in the conglomerates at the base of the Carboniferous in Scotland; Ramsay's [2] arguments for glaciation in the Permian breccias of the midland counties of England; Godwin-Austen's for the conglomerates underlying the Coal-Measures of France;[3] Stur's discussion of the rock masses in the Silurian coal-seams;[4] and the studies of the coal-seam boulders in Europe by Mark Stirrup,[5] who has found some of those in the Lancashire coal to be "similar and almost identical in mineralogical composition" to some found by professor Orton in the Coal-Measures of Ohio. Bain has described a Permian moraine in Prince Edward's Island [6] and James Croll professes to find evidence of assured glaciation in nearly all the geological epochs.[7]

It is unadvisable to discuss here the merits of the arguments presented in the boulders, conglomerates, and rock masses, often of immense weight, found in coal seams, or sometimes in silty deposits, of the Carboniferous of the northern hemisphere. Though some of the problems appear inexplicable (see Stur), the evidence lacks some characteristic features of glaciation, and the question must be regarded as far from

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[1] James Geike. The Great Ice Age. London, 1874, 8vo, maps, etc.

[2] A. C. Ramsay. On the occurrence of angular, sub-angular, polished, and striated fragments and boulders in the Permian breccia of Shropshire, Worcestershire, etc., and on the probable existence of glaciers and icebergs in the Permian epoch. Quart. Jour. Geol. Soc. London, xi, 1855, pp. 185-205.

[3] R. Godwin-Austen. On the possible extension of the Coal-Measures beneath the south-eastern part of England. Quart. Journ. Geol. Soc. London. xii, 1856. pp. 38-73.

[4] D. Stur. Ueber die in Flötzen reiner Steinkohle enthaltenen Stein-Rundmassen und Torf-Sphärosiderite. Jahrb. K.-K. geol. Reichsanst., xxxv, Wein, 1885, pp. 613-648, pl. x, xi. (One mass weighed 55 kilogrammes.)

[5] Mark Stirrup. On foreign boulders in coal seams. Rept. Brit. Assoc., Montreal meeting, 1884, pp. 686, 688.

[6] F. Bain. On a Permian moraine in Prince Edward's Island. Canadian Rec. Sci, ii, 1887, pp. 341-343.

[7] James Croll. Climate and Time, etc., London, 1875, 8°, 577 pp.

being proved. Undoubtedly the arguments set forth by Ramsay and Godwin-Austen in favor of a glacial epoch in the Permian of Europe, together with the known change of climate at that time have exercised a powerful influence on the subsequent opinions of Sutherland, Feistmantel, and others, as to the age of the Indo-Capricornian glaciation, causing them at first to place it rather later in geologic time than subsequent knowledge of the circumstances has justified.

Glossopteris-Flora.—From the time that the resemblance of the great lower mesozoic sequences of terranes in Africa, India, and Australia was understood, the theory of an Africo-Indo-Australian continent has prevailed; and the probability of its existence is as generally accepted as the existence of the paleontologic anomalies which it contains. The consensus of opinion, based on both palæontological and stratigraphical grounds, is almost unanimous in the conclusion that all the evidence not only proves unquestionably the former connection of the continents, but that it also indicates the strongest probability of the union having comprised, at one time, one great continent, over a part of which now lies the Indian ocean. This continent, nearly as large, at least, as Europe and Asia together, was covered with an enormous thickness of nearly horizontal and mostly freshwater beds, and populated in the history of its formation with a fauna comparatively widely distributed, and with its own peculiar and isolated flora. It is probable that, as the Europeo-Asiatic continent arose, this ancient continent was gradually overflowed, with occasional subsidences, until finally only fragments remained with newer terranes of later mesozoic or Tertiary age along their margins.

The causes of the glacial cold which visited this continent at that time are still a subject of discussion;[1] but it is well-nigh certain that glaciers existed then within the tropics, and that they descended to the sea-level at points that are now within 27° of the equator.[2] With the increasing severity of the climate the plant life, which is always the most sensitive to climatic effects, took on new forms, capable of resisting the changes, and

[1] The majority of the writers on the subject seem to favor change of latitude, though many support the theory of change in ocean currents. Should the presence of Carboniferous glaciation be proved in South America, then the question will undoubtedly be given to those who support the theory of the earth's changes in perihelion.

[2] See Oldham R. D. in Geol. Mag. [3], III, 1886, p. 303.

the disappearance of the more delicate Lepidodendra, Sigillariæ, Stigmariæ, and other paleozoic genera and species was accompanied by the development of hardier types, such as Glossopteris, Gangamopteris, Vertebraria, etc.,[2] which afterward became distributed over the world and formed the basis, of a great part at least, of the mesozoic flora of the globe. This early flora is known by reason of its principal and characteristic genus, as the *Glossopteris*-flora. The elements and distribution of the fauna of this ancient continent have been worked out in a most thorough manner by Waagen.[3] Thus the prototypes of the European Jurassic and Cretaceous floras found the conditions necessary to their development in the southern hemisphere during the change of climate which accompanied the Carboniferous glacial epoch.

It has always been the argument of the paleobotanists, in support of their view of the later age of the terranes, that the Carboniferous faunas "lasted on" into mesozoic time, citing for illustration the archaic facies of the present fauna and flora of Australia. Against this, however, stands the evidence, that the fauna and flora of the upper mesozoic and Tertiary were similar and related to those of the rest of the world. Moreover, the certain mutations of the organic life due to continental subsidence and elevations during the deposition of the vast terranes of the long section of geological time from the Carboniferous to the close of the Tertiary, make such an explanation highly improbable, if not totally unreasonable. The study of the Tertiary flora of Australia by Ettingshausen,[4] and Johnston,[5] shows that flora to be modern in its aspect, resembling that of the other continents, with relations in all. The characteristic mesozoic genera of ferns, Thinnfeldia, Alethopteris, Pecopteris, Neuropteris, Sphenopteris, Tæniopteris, and Cyclopteris are wanting, and all the cycads, horsetails and conifers, Podozamites, Phyl-

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[2] See Feistmantel chart, supra. p.—

[3] Die Carbone Eiszeit. Jahrb. K.-K. geol. Reichsanst., XXXVII, Wien, 1888, p. 143, etc.

[4] C. Von Ettingshausen. Beiträge zur Tertiärflora der Vorwelt, Die Tertiärflora Australiens. Denkschr. d. k. Akad. Wiss. Wien., math.-nat. Cl., Vol, XLVII, Abth. I, 1886; vol. LIII, Abth. I.

[5] R. M. Johnston. Observations with respect to the nature and classification of the Tertiary rocks of Australia. Pap. & Proc. R. Soc. Tasmania, for 1887. Hobart, 1888, pp. 135-207.

lotheca, Ginkgophyllum, etc., have entirely disappeared at the beginning of the Tertiary. Considering the great terrestrial changes which must have occurred, even in Australia since the paleozoic era, and the contradictory evidence intervening, the fact that the present life of Australia contains many types that have "lasted on" cannot with any degree of rationality be adduced to prove a consequent "lasting on" of the Palæozoic fauna. Hardly less rational would it be to suppose that the Carboniferous flora of Europe extended into mesozoic time, than to presume that the Carboniferous fauna of a continent as large as Europe and Asia together prevailed in lower mesozoic time, because the recent life of Australia presents an archaic aspect.

In what part of the Africo-Indo-Australian continent the Glossopteris flora originated, it is impossible to know; but, so far as the scattered remains of that continent have been explored, the earliest appearance of mesozoic plants was in Australia, and perhaps in the lower Carboniferous of New South Wales. It is probable that during the latter half of the Carboniferous epoch, this flora spread over the whole of the ancient continent, replacing the more delicate palæozoic forms. Meanwhile there occurred changes of the land masses, causing changes of the ocean currents, with consequent climatic effects, and changes in organic life, though to what extent the currents may be regarded as a cause is still a subject for speculation. Paleontology shows pretty clearly that that part now in Australia was separated from the rest of the continent at the close of the palæozoic, and that arms of the sea cut off all connection with Africa in the Jurassic. In the Trias or possibly at the close of the Permian, a connection existed between Europe, Asia and that part now represented in India, through southeastern China, and in Tonkin we have a flora of 22 species, as identified by Zeiller, of which ten are in the Lias and Rhetic of Europe, five in the Damudas of India, one in the Newcastle beds, with two allied species in the same terrane, while five others are common to the Rajmabal terrane The Tonkin flora, considered by Feistmantel and Zeiller as Rhetic contains, then, a mingling of European mesozoic types with plants represented in several stages in the midst of the Gondwana system. Through this region the southern flora probably found its way northward to be distributed, during the Triassic and Jurassic, over the rest of the world.

To show the further development and remarkable distribution of this flora, I will only add two illustrations, which I take from the flora of the western hemisphere. The first case is that of the flora of the Richmond coal-field, whose relationship with the upper Gondwana flora was pointed out[1] in professor Fontaine's able monograph on the Older Mesozoic Flora of Virginia. Indeed Dr. Stur, the eminent phytopaleontologist of Vienna, to whom a collection was sent, has lately announced that by far the greater part of the flora of that field, (which he considers the equivalent of the upper Trias, "Lunzer," of Europe), is identical with the flora of the older mesozoic of Germany, France, and Scandinavia, and forms a branch of the phyllogeny, escaped from the Indian continent through the south of China. The second instance to be noted is the general Glossopteris-flora aspect of the mesozoic of South America, especially that of the Argentine Republic, regarded by Geinitz as Rhetic, though the species were largely new. But a most suggestive, and perhaps significent flora is the strange company which was found by Dr. Rudolph Zuber at Cacheuta, in the province of Mendoza, and which was submitted by him to Prof. Szajnocha for study.[2] The importance of its bearing on the possiblity of paleozoic glaciation in South America is my apology for the details introduced, though it is perhaps still too early to attempt to draw any conclusions, or to go farther than to make the suggestions which present themselves naturally. Of the twelve species found there, *Sphenopteris elongata* Carr, has also been reported from the coals of Queensland; *Pecopteris Schönleiniana* Brgt., from the Newcastle mines of New South Wales and the "Lettenkohl" of Wurzburg; *Thinnfeldia odontopteroides* Morr., from the Queensland coal, Jerusalem basin, Van Diemensland, and the Stormberg in South Africa; *T. lancifolia* Morr., from Jerusalem basin; *Neuropteris* aff. *remota* Presl., from the Keuper of Europe; *Schizoneura hoerensis?* Hising,

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[1]U. S. Geol. Surv., Monogr. vi, 1883.

[2]Ueber die von R. Zuber in Süd-Argentina und Patagonien gesammelten Fossilen, L. Szajnocha. Verhandl. K.-K. geol. Reichsanst., Wien, 1888, No. 6, pp. 146-151.

Ueber fossile Pflanzenreste aus Cacheuta in der Argentinischen Republik. Sitzb. K. Akad. Wiss. Wien., math.-nat. Cl., Vol. xcvii, 1888, Abth. 27 pp. 2pl.

from the Rhetic of Scandinavia, Baden, and Portugal; *Podozamites* aff. *ensis* Nath., from Sweden; *P. schenkii* Heer, from the Jurassic of France and Sweden; *Pterophyllum?* sp. ined.; and a new species of *Cardiopteris*, a genus hitherto represented only in the sub-Carboniferous. The only animal remains were those of *Estheria manjalensis*, a phyllopod described by Jones from Mangali in central India.

Whether the glacial period of the Carboniferous epoch was brought about by ocean currents resulting from the contemporaneous relations of the land masses, or by the high phase of the eccentricity of the earth's orbit in combination with winter in aphelion, or by changes of latitude, I shall not presume to discuss. Each cause has good supporters, with strong arguments. It is sufficient to remark that the establishment of Carboniferous glaciation in South America would relieve the followers of the theory of changes of latitude from putting one pole in the Indian ocean, while giving at the same time, stronger grounds for the astronomical hypothesis. In the meantime the problem involved in the occurrence of glacial cold within the tropics, together with the subsequent northward advance of the lower temperature, seems to find the best solution in a combination of both, the geographical and astronomical causes.

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U. S. Geological Survey, March, 1889.

VARIATION EXHIBITED BY A CARBONIC GASTEROPOD.

By Charles R. Keyes.

It has recently[1] been intimated that among certain species of *Platyceras* there often exists considerable diversity in the form of the shell and in the configuration of its aperatural margin. Both of these variant features have been attributed in great part to certain habits peculiar to the mollusca of this and allied groups. Specifically it is the attachment, during a greater part of life, of these gasteropods to foreign bodies, and especially to the ventral surfaces of paleozoic crinoids. In summarizing[2] the observations elsewhere more fully discussed it was shown that invariably the lip of the calyptræan shell adapted itself exactly to all the inequalities of the surface with which it came in contact, and that not unfrequently the entire form of the gasteropod shell was more or less determined by its accidental station. In a group so closely allied to the modern *Capulus* and having a habitat like many *Platycerata* manifestly possessed, these phenomena might naturally be expected; but the direct evidence as to the extent of variability in a single species, and the actual variant range of the different characters has never been more than merely suggestive. Definite results from comparative studies of this kind have always been attended by more or less difficulty arising from divers sources. When extreme forms are presented there is always a slight suspicion that in reality they may not be specifically related; and when the comparison is extended to specimens from localities widely separated geographically, and perhaps also geologically, the problem of specific identity becomes even more highly complicated. A large series of *Platyceras equilaterum* Hall from the blue

[1] Keyes. Proc. Am. Philosophical Soc., vol. xxv, p. 240, 1888.
[2] Keyes. Am. Jour. Sci,, vol. xxxvi, pp. 269-272. Also, Am. Naturalist, vol. xxii, pp. 924, 925.

clayey shales at Crawfordsville, Indiana, has eliminated many of the inherent difficulties just mentioned. On account of its extensive numerical representation, and also for reason of the occurrence of many examples still adhering, as during life, to the vaults of crinoids, this species is especially well adapted for elucidating certain hitherto obscure points in the important problem of specific variation. *Platyceras equilaterum* as it occurs at Crawfordsville is here graphically represented by the projection of ten specimens (figure 1); eight of which, projected from above, are also shown in figure 2. In both figures the numbers refer to the same individuals respectively; and in all the anterior margins coincide.

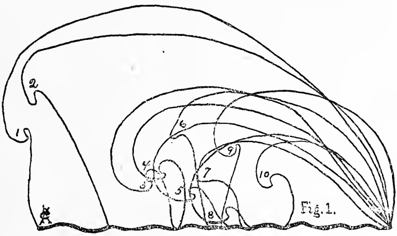


Fig. 1.

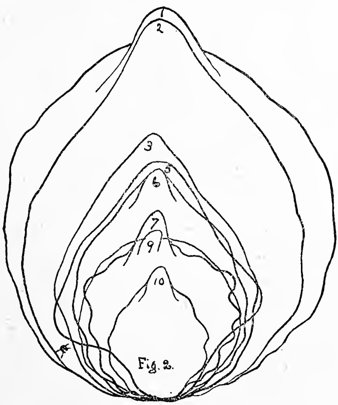


Fig. 2.

The suggestion as here presented, though affecting but a single one of many similar cases in this and other zoological groups is of much significance in its bearing upon the real basis of species. The vast synonymy existing in nearly all departments of paleontology has arisen chiefly from inattention to variation as the result of individual environment; and the invalidity of a large number of now recognized species is clearly evidenced by a comparison of specimens having apparently the same genetic origin, either from identical or from widely separated localities and from different horizons. Elsewhere[1] it has been shown that, in general, shells of *Platyceras* attached to flat vaults of crinoids have a tendency to become very much depressed; while those adhering to convex surfaces are relatively much higher. On the other hand several of the specimens examined illustrate another phase of variation which has not until quite recently been thoroughly understood; a phenomenon which suggests that accidental station is not the only factor in modifying the form of the shell, but that gravitation also exerts a potent influence. In nearly all of the numerous examples noticed in which *Platyceras equilaterum* is intimately associated with crinoids, the echinoderms have been of the type of *Strotocrinus* and *Ollacrinus*, genera in which the vault is comparatively very large, nearly flat, and having the anal opening eccentric in position. In several instances, however, *P. equilaterum* has been found attached to the calyx of *Platycrinus hemisphericus* M. & W. from the same blue shales at Crawfordsville, Indiana, in which occurs *Ollacrinus tuberosus* Lyon and Casseday. The *Platycrinus* presents some marked structural differences to *Ollacrinus*. The vault is very much elevated, nearly hemispherical, with the anal aperture situated laterally between, and slightly above, the bases of two arms. The *Platyceras* usually attached to this crinoid is *P. infundibulum* M. & W. a, more or less elongate conic species. *P. equilaterum* when occupying the same position is pendant, the apex of the shell being directed downward instead of in the opposite direction as when resting on the ventral surface of *Ollacrinus*. The shell thus pendant exhibits a decided tendency to straighten out, or uncoil, consequently becoming longer, and the apex freeing itself entirely from the body whorl. *P. infundibulum* M. & W.

[1] Proc. Am. Philosophical Soc., vol. xxv., p. 240.

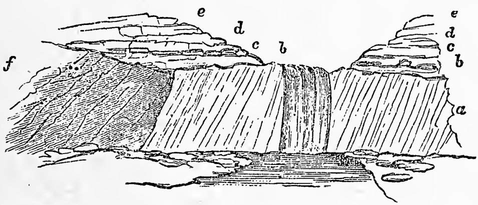
appears when young as a straight, conical shell, but after its attachment to *Platycrinus* assumes a very different aspect. As growth proceeds the posterior side becomes relatively shorter, the apex slightly curved backward, and the entire shell has frequently a tendency toward a strongly arcuate form.

In comparison therefore with a representative example of *Platyceras equilaterum* those shells resting on flat crinoidal vaults are very much depressed, the aperture proportionally broader, and the spire more closely coiled; those shells attached laterally to crinoids have a tendency to become more conical, the aperture relatively smaller, the spire entirely free from body whorl, and the apex extended often to a considerable distance beyond the posterior margin of the aperture.

EDITORIAL COMMENT.

UNCONFORMITY AT THE FALLS OF THE MONTMORENCI.

There seems to be a question of fact at issue respecting the stratigraphic relations of the different rocks at the falls of the Montmorenci, a few miles below Quebec. In the August (1888) No. of the GEOLOGIST, is reprinted an article from the *American Magazine* of Nov. 1847 by Dr. E. Emmons, giving a description of these falls and the geology of the immediate vicinity. The illustration there alluded to was not reproduced. In order to throw some light on this description by Emmons the following illustration of the falls is reproduced from his "Manual of Geology," published in 1860, which corresponds closely with the description referred to.



Unconformity of the Lower Silurian with the Gneiss at Montmorency, Canada East.
e, d, c, b. Lower Silurian. *a.* Gneiss. *f.* Black Slate.

It is very evident, from a careful reading of this paper, that Dr. Emmons, at the time it was written, which must have been some time before its publication (1847 ?), was not yet satisfied of the existence of two separate formations of slates in this area. He speaks of the " Hudson slates " as lying nearly horizontal sometimes, above the Trenton limestone, and being but a thin and unimportant formation; at other places he says they stand nearly on edge and are several thousand feet in thickness, instancing their extent through Rensselaer and Washington counties, in Vermont, and through the entire length of Lower Canada. The " Black Slates," at the falls of Montmorenci, he plainly intimates he considers as belonging above the Trenton, although his figure represents them as lying below it. He supposes their lower position here to be due to a " down-heave," by which the slates were thrown at the same time into an inclined position, and placed unconformably on the underlying "gneiss," their absence above the Trenton at the same place being due to erosion in the lapse of time. In this interpretation he is supported by the later observations of Mr. Selwyn, but not by those of Mr. Marcou who maintains that the slates that lie adjacent to the gneiss (?) in an inclined position really are no part of the Trenton, but belong to the primordial zone. Mr. Lapworth, who has examined some graptolites from these inclined slates, seems inclined to the same view.

There is nothing unreasonable in the supposition that the Trenton overlies unconformably some tilted primordial beds at this place, and if the evidence of other observations on the position of the Trenton be appealed to even within the St. Lawrence valley, it is necessary to admit that the Trenton epoch was one of such subsidence that the rocks of that age were laid down unconformably on strata still older than the primordial. Such a position could not be attained by these beds had they not been brought, by the same overlap, unconformably also over the primordial.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Examination of water for Sanitary and Technical Purposes. By Dr. H. Leffmann and Wm. Beam. 106 pp. 12mo. 1889. Philadelphia. (Blakiston, Son & Co.)

The editors give clear and concise statements of the most approved methods for the analysis of water for the purpose of determining its fitness for domestic, boiler and other industrial purposes.

They omit the well known process for determining the hardness of water by means of a standard soap solution, as it has been found to be unreliable in certain cases, and they give Hener's method instead, which has been found to be of more general application.

The book is not overloaded with processes, but on the contrary contains but a limited number, well chosen, and rearranged in a very comprehensive manner.

Bommelöen og Karmöen med omgivelser geologisk beskrevne, af dr. Hans Reusch, Kristiania, 1888; 442 pp. 8vo, with three colored maps and 205 text illustrations, and accompanied by an English summary of the contents. In this work special interest is attached to the discussion of compression and stretching of the rocks. These phenomena are seen most distinctly in the fossiliferous strata and in the conglomerates. The fossils and pebbles are pressed flat, or sometimes they are stretched in length in one distinct direction. The arrangement of the folia of mica in gneiss in parallel bands is attributed to stretching. This band structure is said to be often independent of the dip of the gneiss. Instances are given of gneiss with a conglomerate bedded in it, both being stretched in the same direction, making it evident that the gneiss is really stretched. Compression of granitic rocks is said to have given rise to gneiss-granite and porphyritic gneiss. The former is a foliated rock having the mica laminæ in parallel position. A very coarse-crystalline pegmatite vein is illustrated showing foliation caused by pressure. The stretching structure in the granitic rocks is seen either combined with foliation or without it. The rocks in the latter case show a certain parallellism in the arrangement of the component minerals on faces running in the stretching direction. Faces running across it have a much more granitoid appearance.

Many instances of conglomeritic structure in granitic masses are mentioned. The following is one of the descriptions of such a structure (p. 411.)

"On the farm Orevik, on the eastern coast of the Bommels is observed a peculiar rock We see a granular crystalline, gray, granitic rock, stained with dark spots where the biotite occurs rather abundantly. In the same mass also occur distinct rounded fragments of fine-grained gray gneiss, feldspar-bearing quartzyte and white quartz. The fragments are often as big as a man's head, sometimes still bigger. The fragments of quartz have very sharp contours; the contours of the feldspar-bearing are not quite so distinct quartzyte. Still more welded in the surrounding rock are the gneiss-fragments, especially a granular-crystalline variety rich in biotite. The larger fragments of the latter appear like dark patches; as to the smaller ones we are in doubt whether we have before us true fragments or only occasional spots rich in black mica in the usual granite. In the northern part the ground mass assumes a parallel structure, and there the doubtful fragments show curved forms clearly due to motion in the mass. The rock described gradually merges, by loss of fragments, into common granite.

The author supposes that the rock was originally puddingstone, in which the fragments have mostly consisted of gneiss and granite; those only have been left that contained most quartz; the rest have changed into a granitic mass."

He regards the Scandinavian mountains as constituting with those in the northern part of the British islands, *a single system*, and to have originated, or to have participated in, a great post-Silurian folding process, the folding axes running S. W. and N. E. "The forces acting during the folding process have changed the form of great rock-masses, as well as of single mineral grains. The changes are not explained merely by assuming the whole to have been made 'molecular plastic;' on the other hand all superinduced structures are not cataclastic, neither is it possible to account for the changes by chemical processes only. If for instance we observe bending of the twin-lamels in plagioclase we must needs regard the mineral as having been plastic to a certain degree. If a plagioclase individual is divided into small parts, we have a cataclastic phenomenon. If the mineral is seen to be filled with epidote microliths, we must suppose chemical processes."

The author adheres to the origination of granite masses *in situ* by metamorphism from sedimentary beds, and also "that in some cases originally sedimentary rocks may be, regionally metamorphosed, and at last protruded as true eruptives."

Shall we teach Geology?. By ALEXANDER WINCHELL. [S. C. Griggs & Co., Chicago, 218 pp. 12mo 1889.]

The author first states what position geology really occupies in the schools and colleges of the country and all countries. He claims that it *should* be taught in both schools and colleges for many reasons, among which are: that it has a high educational value, considerably higher than such studies as geography, history, and literature, that childhood is the period of observation and that geology is pre-eminently an observational study; that it promotes ethical culture from its broad scope and character and constantly recurring evidences of one guiding influence, that it is of value in everyday life and that the course of governments in respect to it proves that they think it very valuable, that it has a very good moral effect in that it produces a strong love for truth and avoidance of error, which, brought into life, prevents misunderstandings. He severely critisizes Chancellor Payne's positions in regard to education, not without cause, and compares geology to the latter's "culture trivium." Coming to the practical side of the question as to how to get geology into the schools he seems to think it is going there, though this is a change, and as such will be opposed for some time. His examples for teachers are very good and, although his position will be considered radical, he answers his topic very decidedly, yes.

RECENT PUBLICATIONS.

1. State and Government Reports.

Seventh Annual Report of the U. S. Geol. Surv. for 1885-6. By J. W. Powell, Director, Washington, 1888, 4to, 656 pp. numerous illustrations. Besides the official and administrative reports this contains the following papers: The Rock Scorings of the great ice invasions. T. C. CHAMBERLIN. Obsidian Cliff, Yellowstone National Park. JOSEPH P. IDDINGS. Report on the Geology of Martha's Vineyard. NATHANIEL S. SHALER. On the classification of the early Cambrian and pre-Cambrian formations. R. D. IRVING. The structure of the Triassic formation of the Connecticut valley. WILLIAM MORRIS DAVIS. Salt-making processes in the United States. THOMAS M. CHATARD. The Geology of the Head of Chesapeake Bay. W. J. MCGEE.

The Geological and Natural History Survey of Minnesota. Vol. II. of the final report. 4to, 695pp, 42 plates and 32 figures. By N. H. WINCHELL, assisted by WARREN UPHAM.

2. Proceedings of scientific societies.

Transactions of the Wisconsin Academy of Sciences; Arts and Letters. VOL. VII, 1883-87, Madison, 1889. Contains articles on the *Raised beaches of lake Michigan*, by Frank Leverett, and a report by S. D. Peet on *The so-called Elephant mound in Grant County, and effigies in the region surroundiug it.*" Mr. Peet concludes "that there are no elephant effigies in the state, and that the so-called elephant mound was designed to represent either the bear, the wild-cat the buffalo, or the moose, every one of which contains the same elements of a heavy body, a large head, and a protruding snout."

Proceedings of the Davenport Academy of Natural Sciences, VOL. V, part 1, 1884-1889. Davenport. Contains, *Defense of our local Geology*, by W. H. Barris; *Volcanoes of the Sandwich Islands*, by C. S. Watkins; *An Ancient mine in Arkansas*, by Wm. A. Chapman; *A description of the Rockford shales of Iowa*, by Clement L. Webster; and *Mound exploration in northwestern Iowa*, by Frederick Starr, with a variety of zoological papers.

3. Papers in scientific journals.

Am. Journ. Sci. April No. The Denver Tertiary formation. W. CROSS. Events in North American Cretaceous history, illustrated in the Arkansas-Texas division of the southwest region of the United States. ROBT. T. HILL. The distribution of Phosphorus in the Ludington Mine, Iron Mountain, Michigan. D. H. BROWNE, with two plates. Palæohatteria *Credner*, and Proganosauria. G. BAUR. New American Dinosauria. O. C. MARSH.

American Antiquarian. May No. The animals known to the effigy-builders. STEPHEN D. PEET. Ancient mining in North America. J. S. NEWBERRY.

4. Excerpts and individual publications.

Events in North American Cretaceous history, illustrated in the Arkansas–Texas division of the southwestern region of the United States. Robt. T. Hill. *Am. Jour. Sci.*, April 1889.

A summary of progress in mineralogy and petrography in 1888. W. S. Bayley; from monthly notes in the *American Naturalist.*

Notes of Microscopical examinations of rocks from the Thunder Bay silver district, By Dr. W. S. Bayley. From *Rep. Geol. Sur. Canada*, 1887.

The Denver Tertiary formation. Whitman Cross. *Am. Jour. Sci.*, April 1889.

Shall we teach Geology? Alexander Winchell, 12mo. 218 pp. S. C. Griggs & Co., Chicago.

Glaciation of Eastern Canada. Robert Chalmers. *Canadian Record of Science.* April 1889.

On nephrite and jadeite. F. W. Clarke, and G. P. Merrill. *Proc. U. S. Nat. Mus.* vol. xi. 1888.

Some definitions in dynamical geology. W. J. McGee. *Geol. Mag.* Nov. 1888.

Paleolithic man in America; his antiquity and environment. W. J. McGee, *Popular Science Monthly.* Nov. 1888.

Notes on the geology of Macon county, Missouri. W. J. McGee. *Trans. St. Louis Acad. Sci.* Aug. 24, 1888.

The classification of geographic forms by genesis. W. J. McGee. *Nat. Geog. Mag.* vol. i.

Some thoughts on eruptive rocks, with special reference to those of Minnesota. N. H. Winchell. *Proc. A. A. A. S.* 1888.

Geology of Baja California, Mexico. By W. Lingren. Map., geological map and plate of sections. *Proc. Cal. Acad. Sci.*, vol. i. part 2, Sept. 1888.

5. *Foreign Publications.*

Mount Morgan gold deposits; second report of Robert L. Jack, Government geologist for Queensland. Folio, 6 pp. with map. Townsville.

Coal Discoveries on the Flinders; report of R. L. Jack, Government geologist. 2pp. folio. Townsville.

The annual report of the department of the interior for the year 1888, Ottawa, contains the *Summary report of the Canadian geological survey* for the year, by director Alfred R. C. Selwyn.

On fulgurites from Monte Viso. By Frank Rutley, F.G.S. From the Quar. Jour. of the Geol. Soc. February, 1889.

Études sur les schistes crystallins; (presentés par leurs auteurs sur l'invitation du Comité d'organization). Congrès géologique international, 4me session, London, 1888. Contains the following papers: Les schistes crystallins, T. Sterry Hunt; Zur classification der krystallinischen schiefer, Albert Heim; Sur la constitution et la structure des massifs de schistes crystallins des Alpes occidentales, Ch. Lory; Bemerkungen zu einigen neueren Arbeiten über kristallinisch-schriefrige Gesteine, J. Lehmann; Sur l'origine des terrains crystallins primitifs, Michael Lévy; The Archæan geology of the region northwest of lake Superior, A. C. Lawson; On the crystalline schists of the United States and their relations, Powell, Irving, Chamberlin, Van Hise, Becker, Dutton; Einige Fragen zur Lösung des Problems der krystallinischen Schiefer, nebst Beiträgen zur deren Beantwortung aus den Paläozoicum, K. A. Lossen.

CORRESPONDENCE.

"Two Systems Confounded in the Huronian," is the title of a letter by professor Alexander Winchell in the American Geologist, vol. III, No 3.—Yes: but then arises the question, by whom? and my reply to this is: by those who would attempt to include the Animikie silver-bearing formation of Thunder bay in the Huronian, with which it has, as I have pointed out since I first examined it in 1883, no similarity or correspondence whatever.

The relations of the Huronian, Archæan, and the Animikie Cambrian are so plain and unmistakable, that it seems to me most extraordinary that any one who has examined them in the field could possibly confound these silver-bearing Animikie rocks with any part of the copper-bearing Huronian as known in Canada.

Prof. Winchell refers, page 213 to " the great Plummer Argillites"—a name by the way I have no recollection of having met with before in Canadian geology—"or slate conglomerates of Logan," and a few lines further he says "I do not regard, therefore, as Huronian the series of rocks succeeding the Plummer argillites (Animikie slates) downwards, though the Canadian geologists may so regard them." I must confess I do not understand what the foregoing paragraph means. Are the Plummer argillites the same as Logan's slate conglomerates, or are they the same as the Animikie slates? and if so what are the rocks succeeding the "*Plummer argillites downwards*," that are not regarded as Huronian?

If not Huronian, what does professor Winchell consider them to be? This we are not told, neither is there any reason given why they are not Huronian. The only reason seems to be personal conviction.

Professor Winchell is certainly not very complimentary to the intelligence of Canadian geologists. But, evidently we are not wise, and are unable to recognize our own children though we have lived with them all our lives, as well as the stranger who has only recently become acquainted with them.

Professor Bonney's conclusions a. b. and c., referred to by Professor Winchell, may be all perfectly correct, but do not therefore in any way affect the validity of the Huronian system, as such. a. is a very natural result of metamorphic action on a mixed series of clastic, pyroclastic and igneous rocks, as varied in composition as they are in origin. *b.* Great thickness has always been recognized, and consequently long time. The alternative *c*, to which professor Bonney is most inclined is certainly correct, but this is a feature common to all the geological systems, and I fail to see why there should be any objection to two or even more groups or series being included in the Huronian system. There are several in the Cambrian and in the Silurian, why not in the Huronian or in the Laurentian.

That a break or local unconformity necessarily limits a system, is also, I think, a somewhat novel doctrine, and if difference in the lithological character of strata or local accidents of unconformity are to be so accepted, then a vast number of new systems will have to be introduced into the existing, recognized geological sequence, and a magnificent field will be opened up for the inventors of new names for old things; but what advantage will thereby accrue to geology or to science is a problem not easy to answer.

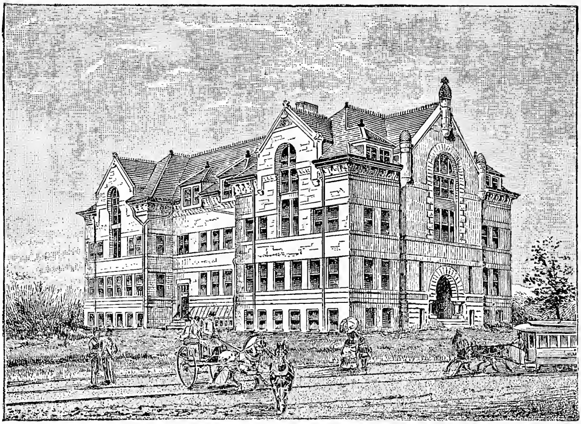
Ottawa, March 18th, 1889. ALFRED R. C. SELWYN,
Director of the Geol. & Nat. History Survey of Canada.

PERSONAL AND SCIENTIFIC NEWS.

VERY STRIKING EXAMPLES OF GLACIER ACTION may be seen at a number of points on the eastern flanks of the higher ranges of the Sierra Nevada mountains.

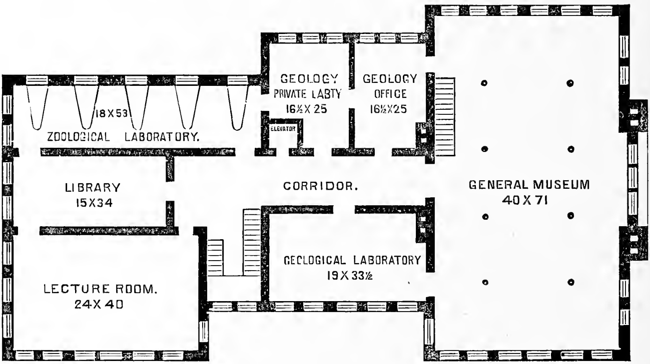
Near the Young America mine on the opposite side of the "Buttes" from Sierra City, and nestling in a valley between lateral spurs of the mountain range, are two small bodies of water that are known respectively as Upper and Lower Sardine lakes. Between the two lakes there is a difference of level of 213 feet. The upper lake has a depth of 175 feet. Its lower margin is formed by hard, diabasic rocks that are cleft and seamed in various directions, but with a general tendency to dip toward the lake. Here are examples of glacier-planing on a grand scale. The striæ come up out of the lake as if the lake bed had been scoured out by the glacier, pass over the rocks forming the eastern rim of the lake basin, conform to all sorts of inequalities of level in the surface, arch over numerous *roches moutonees*, descend in a series of precipitous ledges and pass on into the basin of the lower lake. The sides of the gorge-like valley are scored to a hight of a hundred or a hundred and fifty feet above the bottom.

In the lateral valley next north of that occupied by the Sardine lakes, occur the beautiful, blue transparent sheets of water known as Salmon lakes. Here the same phenomena occur and on a scale even grander than in the preceding case. This valley like the preceding terminates to the west in the high rocky buttes that constitute the crest of the main range, and from which the glacier descended to scoop out the basin of the upper Salmon lake. The same diabasic rocks, as in the case of Upper Sardine lake, and dipping in the same direction, formed a rim over which the glacier plunged to exca-



INDUSTRIAL COLLEGE BUILDING.

(*Nebraska Hall.*)



PLAN OF SECOND FLOOR.

(*Nebraska Hall.*)

vate a small basin now known as "the pond hole." Another ledge of hard rock, another descent and the old glacier traversed the basin of the lower Salmon.

A lateral spur of considerable hight separates the Salmon lakes from Gold lake. Gold lake is a larger sheet of water than any of the others mentioned. Like the others, however, it occupies the bed of a glacier, the former presence of which is attested by magnificent examples of glacier-planing on the crystalline rock masses about its outlet.

A GENEROUS GIFT OF $150,000 was made recently to the University of Minnesota by ex-governor and regent John S. Pillsbury, of Minneapolis. It was conditioned only on the pledge by the Legislature that the university should not be weakened by the division of the funds that now constitute its endowment, but that the so-called agricultural land grant (under the law of congress of 1861) should remain inseparably connected with the university proper. This pledge the Legislature gave. The gift will be used, as intended, to complete and furnish the new Science Hall. At the university of California the Lick astronomical observatory was the result of a large private donation. At Madison, Wisconsin, the Washburn observatory was largely the gift of the citizen whose name it bears, and citizens of Michigan erected and furnished the Detroit observatory at the university of Michigan. The donation of Gov. Pillsbury, however, seems to be the first of importance to a state university in behalf of what are generally known as natural sciences.

THE COMMITTEE APPOINTED TO ARRANGE THE MEETING of the International Congress of Geologists for 1891 met in Washington April 20 and elected the following officers: Permanent chairman, professor J. S. Newberry, vice-chairman, G. K. Gilbert, secretary, H. S. Williams. The committee also added to its number the following gentlemen: Dr. T. Sterry Hunt, Prof. E. D. Cope and Dr. Persifor Frazer. Provision was made for three sub-committees, (1) on the scientific programme of the congress, (2) on excursions and (3) on arrangements in Philadelphia. The committee adjourned to meet at Philadelphia in November at the time of meeting of the National Academy. A majority of the committee were present at the Washington meeting.

DEPARTMENT OF GEOLOGY IN THE UNIVERSITY OF NEBRASKA. For some years subsequent to the organization of the University of Nebraska in 1871 instruction in geology was included in the duties appertaining to the chair of natural sciences which was filled by Prof. Samuel Aughey. Notwithstanding his multifarious duties he made a creditable beginning both in geological field work and instruction. Chemistry, botany and physics were successively constituted separate and independent departments. Zoology is still nominally attached to the chair of geology but is practically a distinct department.

In 1884 Dr. Lewis E. Hicks was appointed to the chair of geology and allied sciences. Under his administration the work of instruction has been systematized, the collections largely increased, a preliminary geological map of Nebraska made and published, and the regents have been induced to provide more commodious rooms for lectures, laboratories and cabinets for the storage and display of the collections of this department. These rooms are situated on the second floor of Nebraska Hall, floor plan and elevation of which are presented herewith. An inspection of the floor plan will give a better notion of these rooms than verbal description. The museum has a gallery floor which nearly doubles its capacity. All the rooms are well lighted. They will be ready for occupation in a few weeks. The geological laboratory is supplied with a machine for cutting and grinding thin sections of minerals and rocks, a Bausch and Lomb petrographical microscope, tourmaline tongs, Queen's polariscope with stauroscopic attachment, and to these will be immediately added one of the best petrographical microscopes of German or French manufacture.

THE STILLWATER, MINN., DEEP WELL. At a late meeting of the Minnesota Academy of Natural Sciences Mr. A. D. Meads, of the Minnesota geological survey, read a description of this well. It was begun in June, 1888, and the work has continued with little interruption, up to the present time, when the depth has reached about 3,400 feet. Gas, probably local accumulations of marsh gas along the shore of lake St. Croix, led to the drilling, but a spirit of laudable curiosity to know what is below the city, on the part of several of the citizens who pay the costs, has taken the place largely of all expectations of finding gas, and is now the principal motive for continuing the work.

The well starts at about 740 feet above the sea, and after passing through 701 feet of drift, white, friable sandstone and green shales, belonging to the St. Croix and so-called Potsdam of the Northwest, enters a series of dark-red and brown shales and brown feldspathic sandstones, which exhibited a thickness of more than 1500 feet. These gradually assume the characters of a volcanic detrital tuff—"amygdaloidal," calcitic, kaolinic, still brown, slightly siliceous—and finally at the depth of about 3300 feet unmistakable beds of trap rock were encountered, alternating with sandstone beds. At this depth some grains of native copper were seen in the drillings.

Water was found in the sandstones near the top of the drill, and down to the depth of about 740 feet. Small quantities of salt water were obtained at about 1950 feet, and at the depth of 2250 feet a small amount of gas was said to have been noted in connection with another stratum giving brine.

Mr. Meads' main conclusions were as follows. (1) The

Stillwater well is wholly below the Trenton limestone. (2) From 717 feet to the bottom of the well is Keweenawan. This thins out or runs deeper, toward the south, not appearing at the depth of 1160 feet at Hastings. (3) The Keweenawan rocks at Stillwater are almost identical with those at Keweenaw Point. (4) The well may be of some value as a source of water-supply; but as a source of gas the prospects are poor—or we might say there are no prospects whatever. (5) The well is of great value to geologists, as it fixes the place of the Keweenawan below the light-colored sandstones of the Northwest, and hence effectually removes them from the mesozoic age. In several places the brown shales and sandstones that here are shown to overlie the traps, have been pierced by wells in Minnesota but not penetrated, and hence the question was left open as to the age of the traps. This question is, therefore, no longer a debatable one.

The Geological Survey of Sweden has presented to the State of Illinois a complete set of its publications, comprising 121 lithographed maps, each accompanied with a descriptive octavo pamphlet, and ninety-nine monograhps, seventy-three in octavo and twenty-six in quarto. These publications are not gratuitously distributed at home, but sold at the cost of paper and printing, the aggregate price of the set being 390 kronor, or about $106. The postage on the whole lot (prepaid) amounted to nearly $12. But very few institutions outside of the kingdom have been honored with a similar courtesy.

This survey was organized in 1855 under the direction of professor A. Erdmann, who at his death in 1870 was succeeded by the present director, professor Otto M. Torell, of Arctic fame. The officers permanently employed on his staff number twelve, all professional scientists, besides janitors, etc., and in the summer seasons extra forces are added for special work. The annual appropriations have gradually increased from 60,000 kronor, or about $16,000 in 1885, to 88,500 kronor, or about $24,000 in 1889. Still this survey only comprises the purely geognostical branch of the science, with its bearings on economy, while the paleontology is cared for in another institution, viz, the (two) paleontological departments of the Royal Academy of Sciences.

The population of Sweden is not much larger than that of Illinois, while its area covers 171,749 English square miles or more than three times the area of that state. The national wealth of the kingdom is undoubtedly far below that of Illinois (I have no statistical figures to offer), and the natural resources of the soil and rocks of Sweden are still smaller, as compared with those of Illinois. But the intelligent rulers of Sweden realize that the people can not afford to neglect scientific investigations which will enable them to take the full advantage of all that there is to be obtained from the soils and rocks, and they invest in those investigations every year about as much as the rich State of Illinois has done in half a century.

The yearly expense of the Roy. Acad. of Sciences is 100,000 kroner, or $27,000. The said Academy has the following departments, each headed by an eminent scientist, viz: Lower Evertebrates (Sven Lovén), Insects (Aurivillius), Vertebrates (F. A. Smith), Fossil animals (G. Lindstrom), Recent plants (V. B. Wittrock), Fossil plants (A. G. Nathorst), Minerals (A. E. Nordenskjold)—these seven departments constituting the Roy. Museum of Natural History—Physics (A. Edlund, died recently), Meteorology (Rubenson), Astronomy (H. A. Gylldén), Mathematics (A. G. Lindhayen, secretary of the Academy). The above $27,000 are the proceeds from funds and estates, the property of the Academy. Special appropriations are often granted by the parliament for special purposes.

The Council of the Geological Society of America recently held a meeting at Washington. Nominations for fellowship were made to the society of about fifty candidates, all of whom had expressed a desire for election. Prof. C. H. Hitchcock was designated to make arrangements for an excursion from Toronto, and another attempt is likely to be made in favor of the Huronian region. He was instructed to correspond with the Local Committee at Toronto, and with the officers of the Canadian survey. The program of the meetings of the society at Toronto was ordered to be independent of that of the association. The committee on revising the constitution held a meeting and decided on several important matters relating to the constitution. The committee on plan of publication, through Mr. W. J. McGee, secretary, made a voluminous report embodying facts concerning the manner and success of publications by various leading scientific societies in Europe and America. This committee will render a final report, making recommendations of its conclusions to the Council at its next session, probably at Toronto.

The discovery of the electrolysis method of producing aluminum alloys is not only patented in the United States but in France and Germany, although under different titles and claims. The Heroult process is about to be put to an extensive and practical test in Switzerland, where, near Zurich, at the falls of the Rhine, a large establishment is set on foot for the production of aluminum by this method.

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QUATERNARY DEPOSITS AND QUATERNARY OR RECENT ELEVATION OF REGIONS AND MOUNTAINS IN BRAZIL WITH DEDUCTIONS AS TO THE ORIGIN OF LOESS FROM ITS OBSERVED CONDITIONS THERE.

By JAMES E. MILLS.

The greater part of the large gold product of Brazil has been obtained from Quaternary loose materials. In the years 1875, 1878 and 1879 I had occasion while examining gold mines there for economic purposes to study these Quaternary deposits in the provinces of Rio Grande do Sul and Minas Geræs, and the subject proved to be of deep interest not only on account of its bearing upon the geological history of a large continental area but also because loess occurs there under conditions that throw light upon the origin of loess deposits generally.

In Rio Grande do Sul (the most southerly of the provinces of Brazil) I went from the city of the same name via Pelotas and Bagé to the little village of Lavras in long. 10° 49′ west of Rio de Janeiro, and lat. 30° 44′ south,[1] and to Cacapava. My more detailed studies of the loose materials of the province were made at the so-called Lagoa da Nacao near Lavras.

At the city of Rio Grande do Sul the coast is low and sandy, and the city is built on a sand spit. Pelotas is built on strati-

[1] Determined by Mr. A. A. Stukey.

fied sands and clays which have been terraced as they rose from the sea. The road from Pelotas continues on these deposits from 3 to 4 leagues inland, then leaves the terraces and passes into a hilly country; and thence all the way to Bagé and Lavras the rocks are very generally hidden by a deposit which is allied in character and I think in method of formation to the loess of the Mississippi valley and elsewhere. It is of fine grain and of even fineness, and shows either no signs or very obscure signs of stratification or sorting by water, except near the bottom where it sometimes contains streaks of sand, or passes downward into sand by gradation. It is generally of yellow or drab color except near the surface where it becomes colored with organic matter and passes upward into a dark colored soil. It is not readily eroded, that is, readily in comparison with other kinds of loose materials, and it makes a smooth road, not quickly worn into ruts by wagon wheels. The loess is not exclusively derived from rocks in the immediate neighborhood in which it occurs, for it preserves identity or great similarity of character over considerable areas within which the rocks vary widely.

Underlying the loess where both occur, but also uncovered in places along streams and elsewhere is the "cascalho," which is the gold-bearing loose material of the region. It rests directly upon the surface of the rock. It consists of gravel and sand or fragments of quartz or other resisting material, and is found in two conditions; in one it lies along the beds and banks of streams, and has been moved forward a greater or less distance by the streams; in the other it rests at the outcrop of the quartz vein or other deposit from which it is derived. This latter is the debris of the vein or stratum of hard, resisting material which, having been left unsupported by the wearing away of the more easily decomposed imbedding rock, has become reduced to fragments and fallen along where it had existed in place. It is covered for the most part by loess, but judging from exposures at streams and elsewhere, it occurs in patches over the surface of the rocks generally wherever there are veins or strata or other masses of material harder than the rocks in which they are imbedded.

The so-called Lagoa da Nacao is simply a deepened and widened portion of the Camaquam river, about 3,280 feet long, with an average width of about 84 feet, occupying a portion of a basin eroded from hard feldspathic porphyry. The bottom of the pool, at the lowest point, is seven and a half feet lower than the rocky lip at the outlet. To test the loose materials on the bottom of the pool for gold, the water of the stream was carried around the pool in a canal, and the water in the basin lowered by cutting down at the outlet and by pumping until a large portion of the floor of the pool was laid bare.

Over a part of the floor the rock is bare, and over a part of it the surface of the rock is covered with sand and gravel and large fragments of porphyry. At the head of the pool there is gravel or cascalho which has evidently been brought down and deposited there by the stream; but other patches of cascalho were evidently formed from quartz veins in place there, and these pass with the outcrop of the veins under the loess on the banks. The pool bends at nearly a right angle. One strip of cascalho crosses the pool near its outlet, continues on the left bank to the pool above the bend, and crosses it there again. On the bank this cascalho was naturally overlaid with loess, but the loess has been excavated, and the cascalho has been washed for its gold. It is also gold-bearing on the bed of the pool, or rather so much of it as is left, for a considerable part of it was excavated and washed while I was on the ground. The cascalho of this sheet or strip is evidently from some small, irregular quartz veins which exist there in the porphyry, and the outcrop of which extend along with the strip of cascalho. Other patches of cascalho accompanying quartz veins occur on the bed of the pool, and pass with the outcrop of the veins under the loess on the banks. Near the quartz veins the rock on the bed of the pool is softened, and in the canal the softened rock was exposed to a depth of 12 or 15 feet, while over the greater part of the floor of the pool the rock where exposed was hard. The softened rock near the quartz veins was colored with iron oxides, and the softening was undoubtedly due to the decomposition of pyrites which accompanied the quartz and gold.

The cascalho is gathered in places around large fragments of porphyry evidently not far removed from where they were in place. The sheets of cascalho are generally but a few inches thick, rarely more than eight inches, except in furrows of the rock where the gravel is at times eighteen inches thick, and in one deep furrow I saw it three feet thick. The pebbles are partly angular but generally more or less water-worn and rounded. The yield of gold of 134 cubic yards taken from the cascalho near the outlet was at the rate of 35.3 grains to the cubic yard. It was in flattened scales, and evidently had not travelled far. Associated with it was black iron-sand, mostly titaniferous, but a part of it feebly magnetic.

A larger part of the surface of the pool was of sand than of gravel, and a still larger part was surface of rock.

There is no loess on the bed of the pool, but it comes down to or nearly to the edge of the water on either side, and is spread out far and wide over the region generally, thinning out and disappearing in places. At one place the excavation of the canal near the pool exposed a thickness of 13.6 feet of loess. Along the canal the loess in places shows streaks of sand near the bottom or passes down by gradation into sand.

The pool does not occupy the whole of its rocky basin; but the latter extends some distance above the head of the pool, and is filled there with sand and gravel brought down, in part at least, by the stream. On either side of this portion of the basin there are deposits of sand at a higher level than any which the water ever reaches now. These sands I did not find overlying loess, but they seemed to be continuous with the loess, and to have been deposited along the stream at the same time that the loess proper was being deposited on either hand over the surface of the region generally.

Evidently the basin was eroded before the loess was deposited because sheets of cascalho resting upon the floor of the basin pass under the loess; but above and below the basin the Camaquam has considerably lowered its rocky bed by erosion since the time of the deposition of the loess, and is still eroding it, and this is true of other streams which I saw in Rio Grande do Sul. The erosion of so much of the region as I saw, excepting in the neighborhood of Cacapava has, however, been comparatively slight since the loess was deposited, for the loess, although forming but a thin sheet, covers the face of the country generally, and the region is one of loess-covered, rolling or nearly level plains and gentle slopes as a whole with small areas of rock exposures. Near Cacapava there seems to have been Quaternary or recent local uplifting which has increased erosion but I had not opportunity to verify this. The deepening of the channels of drainage though comparatively slight goes to show, though it may not prove conclusively, that the region has been raised since the time when the loess was deposited, and detailed investigations might show that the Quaternary or recent elevation is the same that caused the terracing along the coast, though the deposits from which the terraces were carried may be of Tertiary age.

The elevation above the sea level at the Lagoa da Nacao was barometrically determined by Mr. A. A. Stukey to be about 675 feet, and according to a railroad survey the bed of a little stream near Bagé is about the same.

My opportunities of observation in Minas Geræs were limited to a belt of country traversed by the routes from Parahyba river to the city of Diamantina. One of these routes leaves the Parahyba at Entre Rios and the other at Porto Novo da Cunha, and the two meet between the villages of Sao Sebastiao and Inficionado. The route from Entre Rios leaves the Parahyba at an elevation above sea-level of 883 feet (R. R.);[1] passes along the Parahybuna, up the south-easterly slope of the Mantiqueira range to its crest, where the saddle in which the railroad now passes has an elevation of 3,665 feet (R. R.), and thence continues on or near the divide of the head-waters of the Doce and Gequitinhona on the east; and those of the Parana and Sao Francisco on the west. The country is, compared with the portion of Rio Grande do Sul above described, a high and mountainous one. Barbacena, a short distance east of the crest of the Mantiqueira range is at an elevation of 3,786 feet (R. R.); the railroad crosses the Carandahy at 3,494 feet (R. R.): the common road crosses the divide between the waters of the Parana and Sao Francisco at 3,700 feet, crosses the stream at foot of the Serro de Oaro Branco near the village of Oaro Branco at 3,126 feet, the crest of the Serro de Oaro Branco which is the divide between the waters of the Sao Francisco and of the Doce at 3,946 feet, the Falcao at 3,113 feet, the crest of a spur of Itacolumi at 4,064 feet, and the Rio do Carmo at Oaro Preto at 3,319 feet, and the same

[1] Elevations marked R. R. are from reports of railroad surveys; those given without this mark or other reference to authority are from my own determinations with aneroid barometer. These are checked only by repetition, and I give them reluctantly; but they are approximately correct and will serve for present purposes.

stream at Marianna at 2,332 feet. From Marianna to Serro the road crosses streams flowing to the Doce at elevations between 2,300 and 2,000 feet. The crest between Mono Grande hamlet and Cocaes village is 2,837 feet. Going off the main route, the Rio das Velhas at the little hamlet of Raposas is at the same elevation as the hamlet of Mono Grande on waters of the Doce, namely 2,302 feet, while the crest between the two is 3,956 feet at the saddle where the road crosses it. To return to the direct route: the village of Serro is 2,707 feet; the hamlet of Itaipaba on a stream flowing to the Gequitouhana, 2,465 feet and the city of Diamantina 3,714 feet. This last elevation agrees with that given for Diamantina by Geber; it is but 72 feet lower than that of Barbacena.

The route from Porto Novo da Canho leaves the Parahyba at that place at an elevation of 509 feet (R. R.), crosses the divide between the waters of the Parahyba and Doce (the Montiqueira range) at 2,402 feet (R. R.), and at the village of Santa Rita do Turvo on waters of the Doce is at an elevation of 2,257 feet (R. R.).

The elevation of some of the principal peaks of the region are given by Val Delden Laerne in his work on Brazil and Java without reference to authorities as follows: Itacolumi 5,748 feet, Caraca 6,414 feet, Itambe 5,981 feet, Piedade 5,850 feet.

These elevations are given because the elevation and contour of the surface have a very important bearing on the character and history of the Quaternary deposits, and because they are the result principally of Quaternary upliftings. The region is a mountainous one with steep slopes both of uplift and erosion. The streams flow in deep, V shaped channels except where the material is such as to strongly resist erosion, and I did not see between Barbacena and Diamantina any plains of considerable size except two which will be below described, both preserved from erosion by a hard, thick pavement of oxides of iron.

The rocks consist of gneiss, slates, and micaceous sandstones (itacolumites, etc.) with a few exposures of limestone and trap, and extraordinarily large masses of oxides of iron. The rocks as a whole contain an unusually large proportion of oxides of iron, and in the sandstone and slate series there are many and very massive deposits of specular hematite which generally has a flaky, felted structure, and which is called in the country "Jacutinga."

The gneiss and slates are softened to great depths from the surface. I have seen sections showing a thickness of over 100 feet (estimated with the eye) of this softened rock, and yet not reaching to the bottom of it. The softened mass retains to a great degree the lamination and other structure of the rock. The quartz veins imbedded in it remain comparatively intact.

The softening may be accounted for in part by the abundance of animal life in the soil overlying these rocks. Ants especially occupy the soil everywhere. They are continually pouring carbonic acid gas into the upper layer of loose material, which the abundant rain-water washes down into the rocks, and carbonic acid is the great decomposing agent in rocks, taking out lime, the alkalies, and iron oxides and starting a whole train of alterations. But even with the added agency of abundance of animal life these rocks must have been very long, geologically speaking, under the decomposing action of carbonic acid brought to them from the atmosphere by percolating waters. They must then have been for a long time not covered by the sea or other sheet of water but exposed to the atmosphere. As the softened rock is overlaid by the Quaternary cascalho and loess which have not been visibly softened since deposition, it is plain that the softening was mostly produced before the time of the deposition of the loess at least. The cascalho being mostly of resisting material would not show effects of decomposition. The rocks themselves are of Archæan or of Archæan and early Paleozoic age, consequently the softening has certainly taken place between Archæan and Quaternary time. Prof. O. A. Derby[1] gives an account of borings, through great thicknesses of this softened material in the coal basin of the Arroio dos Ratos in the province of Rio Grande do Sul. One boring passed through first, 4 metres of clayey soil, then through 120 metres of softened strata, and then went 17 metres farther in material sufficiently hard to be called stone. A part if not all of the softened strata are certainly of Carboniferous age. Another boring went through 20 metres of clay and sands with a gravel bed, then through decomposed shales 60 metres, then 18 metres in

[1] American Journal of Science; third series, vol. 27, p. 130.

softened gneissoid rock without striking sound rock. I suppose the upper 4 metres in the one case, and the upper 20 metres in the other to be in Quaternary loose materials.

From this it is plain that the softening in the Rio Grande do Sul has been produced on a very large scale since the Carboniferous strata were deposited and raised above the sea level. The region of the coal basin of the Arroio dos Ratos is comparatively low and level, with gentle slopes, though as before said this part of Rio Grande do Sul has probably been somewhat elevated in Quaternary or recent time.

In Minas Geraes the softened layer occurs over a region of much greater elevation, of steep slopes and of V shaped drainage channels, and this too while it is a region of abundant rainfall. Frequently and over considerable area the steep-sloped surface of the softened rock bears a meagre vegetation although in a tropical climate of abundant moisture. The vegetation is of feeble growth there because the soil proper, that is, the soil enriched by organic matter, is washed off.

In a country of abundant rainfall the V shape of the drainage channels is proof of comparatively recent elevation, but it seems impossible that the softened layer could have been formed or could long have existed at the present elevations with the present steep slopes and rapid erosion. The water runs off quickly and under a tropical sun the evaporation is great; the drainage from the upper portions of the rocks also must be comparatively free where deep ravines abound. The conditions are therefore not favorable for deep penetration and saturation of the rocks by water carrying the carbonic acid necessary for rapid decomposition, while the conditions are very favorable for rapid erosion, and the softened rock is very easily eroded, and in fact has been eroded away leaving the solid rock bare in many places. For these reasons I conclude that the region was raised above sea-level and worn down to a "base level of erosion" at an early period, and remained a low-lying region for a very long time, and has been within Quaternary or recent time raised to its present elevation. This conclusion is confirmed by other reasons to be hereafter given.

On the surface of the rocks,—softened where consisting of gneisses and slates, and hard where consisting of sandstones and other resisting materials,—rest the Quaternary deposits.

They consist, as in the Rio Grande do Sul, of two groups, namely, of cascalho and loess. The cascalho of Minas Geraes has been the source of the larger part of the great gold product of Brazil.

The cascalho began to be deposited before the loess, but a part of it is contemporary with the loess, and erosion since the time of the deposition of loess has added gravel as in Rio Grande do Sul, and to a larger extent than there. Recent erosion has also shifted and carried forward a part of the gravels that had been deposited before the loess. In fact the cascalho and loess have been removed from considerable areas by recent erosion which has cut down through these superficial deposits into and sometimes through the underlying layer of softened rock; still much the larger part of the surface is covered with these loose materials. They extend through a wide range of elevation. Going from the Parahyba up the southeasterly slope of the Mantiqueira range one sees exposures of gravels with overlying loess in places from the foot of the slope to the saddle through which the railroad passes over the crest, and such exposures continued west of the crest down to the streams and over the divides onward to Diamantina, or as far north as I had opportunity to observe. I ascended but one of the highest peaks—Itacolumi—and I recall that on the upper portions of the mountain from elevation of about 4,000 feet to the summit the rocks were nearly or quite bare of Quaternary deposits; but I did not make a definite note of the fact at the time.

On the southeasterly slope of the Mantiqueira, and between the crest of that range and Itacolumi mountain there are frequent exposures of cascalho containing or associated with clays in places, and these clays are commonly more or less Carbonaceous. In places the cascalho consists entirely of clay. Between where the road crosses the spur of Itacolumi south of Oaro Preto, and Diamantina the road passes for a large part of the way over a series of sandstones (itacolumites, etc.) and shales which contain great masses of specular iron ore as above mentioned, and also large proportions of oxides of iron disseminated through the sandstones (itabyrites) and rocks generally. And here oxides of iron chemically precipitated form a considerable part of the lower group of Quaternary loose materials,—the cascalho, between the villages of Inficionado and Agua Quente the road passes continuously for about a league over a plain paved with a superficial sheet of oxides of iron, and Burton speaks of riding over the same plain between Agua Quente and Fonseca.[3] It is one of the two plains before mentioned. The oxides consist of hematite and limonite, and are more or less mingled with gravels. They are evidently altered bog-ore deposited by waters which obtained their iron from the great masses of specular ore (more than 300 feet thick across the stratification at one place near Catas Altas where I measured it) which lie uptilted on the easterly flank of Caraca mountain.

No such sheet of bog-ore could be formed with present drainage; for streams flow by the plain from 187 to 320 feet lower than its surface, and the streams have rapid currents, and there are no bogs or pools of still water of considerable size throughout the region. The plain at the highest point on the road is about 2,785 feet above sea-level. There can be no doubt therefore that the region has been elevated since this sheet of oxides of iron was deposited, and that the bog-ore was formed when the region was in a low-lying condition, with streams flowing nearly at the general elevation of the surface, which was the condition as already shown when the softened layer of rock on which the sheet of bog-ore now rests was formed.

The other of the two above mentioned plains is much smaller than the one just now described, but still a remarkable plain for that region. It also is in part at least underlaid with iron oxides, and has undoubtedly been preserved from erosion by them. The extent of this sheet of oxides is not evident because it is overlaid by sandy loess, but it is exposed where the road passes down off the loess. The plain is high up near the divide between the waters of the Doce and the Gequitinhona, on the slope drained toward the Doce by the Rio de Peixe, extending to within about a mile of the divide, at an elevation of about 3,416 feet which is somewhat less than 300 feet lower than that of the divide. The Rio de Peixe falls at an average rate of 120 feet to the mile for fifteen miles below the plain, and the cascalho and loess fall at nearly the same rate; for at a point 15 miles below, the loess overlies cascalho which rests but a few feet below the level of the present stream. A bog could not have existed in such a position, on a steep

[3]Highlands of Brazil. Vol. I. p. 315.

slope, near the divide, at the head of a rapidly falling stream. It follows that the region has been upraised since the deposit of iron ore was laid down.

One of the areas most productive of gold when the gold product of Brazil was largest was the one comprising the slope of Oaro Preto mountain facing southwesterly, southerly, and southeasterly. The gold here was found principally in the cascalho at the bottom of a layer of iron oxides similar to the one which paves the plain between Inficionado and Agua Quente. These superficial iron ores are called in the country " Canga." The surface on that slope of Oaro Preto mountain is dotted over with pits sunk through the Canga for gold. The Canga is reported to be from 3½ to 9 feet thick there. The surface on which it rests is a steep mountain slope, too steep to allow bog ore to be deposited in a broad sheet upon it.

The gravels underlying and mingled with the Canga, as well as the gold found in them are the remains of a stratum or group of strata of thinly laminated, greenish talcose slates containing irregular masses of quartz and quartzite with arsenical pyrites, tourmaline and gold. It is overlaid by itabyrite which consists of laminæ of pure, flaky specular iron-ore alternating with laminæ of quartz and mica and iron oxides of rusty colors. On the slope this and other strata were decomposed, leaving quartz and gold and iron ores at the surface. At the foot of the slope the gold-bearing stratum or group of strata is found in place, at first softened, but gradually becoming firm and hard going down the dip which is in the same general direction (from southwesterly to southeasterly) as the slope. The softened portions of the gold-bearing slates have been excavated for gold, and at the Passagem mine the excavations have been carried down into the solid rock where it is overlaid by other strata. On the mountain slope the gravels would have been washed away if they were not protected by the Canga, and during the long process of decomposition of the rock from which the gravel and gold originated, before the Canga was deposited upon them, the slope must have been much less steep than now. Moreover, the Canga, whether deposited in a bog or by springs on a slope, was soft when first precipitated, and could not have remained widespread over so steep a slope.

It follows from the foregoing considerations that not only does the region generally owe its present elevation to Quaternary or recent uplifting, but that mountains rising above the general level of the region have been uplifted in Quaternary or recent time.

Canga is by no means limited to the areas above mentioned; but is commonly associated with the other materials of the cascalho along the road through the the region of massive hematite deposits from Oaro Preto to Diamantina. I did not see it in process of formation anywhere, and with present slopes soft, precipitated oxides of iron could hardly find resting place in considerable quantities. It is possible that when the faulting and uplifting were taking place hot springs added to the deposits of iron oxides.

The cascalho consists of the harder and more resisting portions of the rocks (from which the finer disintegrated portions have been removed by wind or water or both) and the chemically deposited oxides of iron. A part of the quartzose gravels of the cascalho rests on the surface of the rock near where its materials had existed in place, while another portion lies along the streams, having been moved forward by them a greater or less distance. These stream-moved gravels are always in comparatively thin sheets. I nowhere saw them accumulated in thick masses as in California. It follows that the uplifting which has taken place in Quaternary or recent time has not obstructed the drainage by lessening the slopes or raising mountain masses across the pathway of the streams faster than the streams could cut down through them. The *general* increase of elevation has increased the slope of the streams and increased their power of erosion, and caused them to cut their channels down deeper below the general surface, making the region one of steep slopes. The *local* uplifting has also increased the slopes of the streams in places, and as it nowhere, within the field of my observation, obstructed the drainage so as to cause massing of the gravels, I infer that it took place quite generally at least along the same axis as the older uplifting which caused the divides and determined the position and direction of the streams.

Near Itambé do Matto-dentro the streams flow over itacolumite and I noticed that they have not eroded channels of considerable depth, but flow near the general elevation of the surface. The itacolumite is comparatively hard and resists erosion far more than the softened slates, still the streams flow over it with rapid currents, and in places fall over precipices of it, and would erode deep into it in comparatively short geological time; and the fact that the erosion has been so slight since the uplifting took place which gave to the streams their present fall and rapid currents, goes to confirm the conclusion that the uplifting is of Quaternary or recent time.

The loess of the region has the principal characteristics of loess generally; it is of fine material and of even fineness throughout, showing very little if any sorting of material or distinguishable stratification except near the bottom where it sometimes mingles with sand or passes into it by gradation. It is not traceable to the rocks immediately underlying it as is the cascalho when not transported by streams; but nevertheless its character is modified by that of the rocks prevailing in the vicinity. Where sandstone outcrops over a wide area the loess is sandy, and where shales outcrop over a wide area the loess is clayey, and where iron oxides abound the loess is of a red color; and as iron oxides do abound in the shales generally, the loess is a kind of red clay over the large portion of the region where shales outcrop. Where gneiss is the prevailing rock the loess is sometimes red and sometimes of a drab color.

The loess is more wide-spread than the cascalho. It generally overlies the latter where it occurs except along the streams, and also rests upon the rock where the gravel is absent. Before the erosion caused by the Quaternary or recent uplifting, it must have spread out far and wide over the surface of the region except where streams were flowing, and except isolated areas of bare rock at and near peaks and crests. Its vertical range is great; it passes up mountain slopes and down into valleys, and in this respect it differs from loess over large areas in other parts of the world where it occurs on level or gently rolling plains or valleys rather than on mountain slopes. But as already shown when the softening of the rock took place and when the greater part of the cascalho was deposited the region was a low-lying one, and for reasons to be hereafter given I conclude that it was still a low-lying region as a whole when the loess was being deposited, although the uplifting had begun.

A section of the loose materials on the left bank of the Rio de Peixe near the Hamlet of San Antonio do Rio de Peixe shows from 30 to 40 feet of loess consisting of red clayey material with grains of quartz scattered through it, resting on about 10 feet of white and yellow sand, and this on a thin, irregular sheet of rounded quartz pebbles in which gold and diamonds occur. This cascalho is not continuous, but occupies furrows in the rock, and is no where more than a few inches thick. The loess passes by gradation into the underlying sands. The occurrence of quartz grains in the loess is unusual.

About two miles up-stream from this section, artificial excavations afford exposures higher above the level of the stream, showing 20 feet in thickness of loess, and under it on the rock, thin, irregular patches of gravel in places.

I did not observe stems of plants or shells or other fossils in the loess of Brazil; but I did not make careful search for them. My geological studies there were pursued to determine the character and extent and value of the gold deposits of the region, and I had not time to pursue investigations that did not bear on the work in hand.

Although the region was a low-lying one when the cascalho was deposited, and was probably such when the lœss was deposited, there is no evidence that the region has been covered by the water of either sea or lake during the Quaternary or recent time. There are no terraces or other effects of erosion by waves or currents of a broad sheet of water; no sand ridges or shingle or pebbly beaches or other deposits such as are found on shores of seas and lakes, and which are repeated at greater or less intervals on areas over which such sheets of water have advanced and retreated. This together with the absence of stratification and sorting other than might be produced by the streams now flowing precludes the possibility of submergence of this region during the time of the deposition of the loess. The same arguments are valid against the theory of the lacustrine or marine origin of lœss elsewhere; but one other condition prevailing here adds great weight to the argument; it is the great depth of the softened rock underlying the loess. It seems impossible that this thick sheet of soft, easily eroded material could be submerged and rise again from a sheet of water without being to a large extent washed away and terraced and otherwise carried by waves and currents, and having its quartz and other hard materials strewn along the shores in beaches and sand ridges.

Richtofen's theory of the deposition of loess by wind fails also to meet the conditions here. The region is near the sea, and is in the pathway of the tradewind blowing from the sea, which now comes laden with moisture, and there is no reason to think that there has been within Quaternary or recent time a dry region to the windward where the wind could be charged with dust to be dropped here.

I think that facts from the Quaternary history of the region already stated afford a full explanation of the origin of the loess. The region had been above sea-level for long periods, and had been worn down to a "base level of erosion" so long that a very thick layer of decomposed rock had been formed at the outcrop of all but the most resisting rocks. It was therefore a low-lying region, and its streams were sluggish and deep, and their waters nearly up to the level of the general surface of the land, and with water clear except as colored and rendered turbid by organic matter; for the slopes of the region had become so low that erosion was reduced to a minimum and furnished very little sediment to the streams. Then began the Quaternary uplifting. The uprise was greatest along axes of former uplifting that is, along the divides at the heads of the streams. As soon as portions of the region began to rise erosion there was increased and on account of the softened condition of all but the most resisting rocks, was very rapid. The streams became charged with sediment then, and as they were flowing away from the lines of greatest uplift, and their slope and velocity decreased as they flowed on, their power of transportation decreased relatively to their load of sediment, and when they reached the still undisturbed low-lying portions of the region they dropped the coarser materials of their load—the sands and gravels—upon their beds. An overloaded stream cuts away its banks, because it drops its load unevenly on its bed, and so obstructs and deflects its current, and each deflection starts a series of undulations from side to side, and the stream cuts into its bank right and left, and so takes up more sediment to be deposited near by. This is the origin of the more locally derived sediment. In time the beds of the streams in the low lying portions of the region rose to near the level of the general surface, and the sediment-charged waters spread out in their varying pools of water with little or no current, so shallow that vegetation continued to flourish and rise through the water. The streams flowed along by or through these swampy lands in shallow, shifting channels, and along these channels there was current enough to hold the finest sediment in suspension, and only sand and gravel was deposited there, while the finer sediment was carried by the overflowing waters to the right and left and quietly deposited, with only slight variation in coarseness or fineness, and obscure, if any, demarcation of laminæ or strata, short, with the characteristics of loess.

At first the loess was deposited but a short distance from the water-sheds where the uprise began, but as the uplifting went on and its effects extended farther and farther from the water-shed, the area of erosive action of the streams was carried forward, and the area over which the streams were depositing loess moved forward also down stream until the whole region had received the sediment, except the highest portions near water-sheds.

The loess of the region is therefore a deposit made when it was a low-lying region by the overflow of its streams charged with sediment by erosion of portions of their drainage-area nearer the water sheds than the place of deposit, which had been or were being uplifted.

The same explanation of the origin of loess meets the requirements of all its observed conditions in Rio Grande do Sul.

I have compared the loess of Rio Grande do Sul to that of the Mississippi valley. The foregoing explanation of the origin of loess meets, I think, all the requirements of the conditions and characteristics of the deposit in the Mississippi valley, including the occurrence of stems of plants and shells of fresh-water and moist-land and dry-land mollusks. But there the sediment which obstructed the streams and furnished the material of the loess was in part, at least, derived from glacial drift.

The mass of loose material on the bank of the Rio de Peixe of which a section is given above is a remnant of the masses of sands and gravels partially overlaid by loess that filled or nearly filled the channels of the streams. The greater part of the sands so deposited were carried away by the erosion which followed the general uplifting of the region; but this mass is in a sheltered position on the down-stream side of projecting rocks, and so withstood erosion. It is the counterpart of remnants in similarly sheltered places of much thicker masses of gravels and sands, some of which are overlaid by loess, in the cañon of the Mississippi river; but the greater part of the pebbles and sands of these deposits can be traced to their origin in glacial drift, and were evidently carried forward, from where the glacier left them, by the river or its tributaries and dropped upon its bed. Moreover it has been shown,[1] that the deposition of loess in the Mississippi Valley was in part, at least, contemporaneous with that of glacial drift, and the material of the loess itself has been shown[2] to be in part at least made up of the finer portions of glacial debris sorted and moved forward by water.

In those portions of Brazil which came within my field of observation there is no glacial drift and there are no glaciated rock surfaces or glacial topography or other signs of the existence of glaciers, and the material of the loess there is wholly a product of erosion by water. But in both Brazil and the Mississippi Valley *loess is a deposit made upon a low-lying region by the overflow of overloaded streams, that is, by the overflow of streams bearing to the region more sediment than they could carry through it with the descent and consequent velocity of their current due to its elevation.*

THE STORY OF THE MISSISSIPPI-MISSOURI.

DR. E. W. CLAYPOLE, AKRON, O.

For the purposes of this paper the geological history of the North American continent may be divided into four ages, the Archæan, the Palæozoic, the Mesozoic and the Tertiary. The telescope of geology has revealed to us more or less of the details of all these four great eras but, as might be expected, with very different degrees of clearness. Concerning the first it is not too much to say that we are only just beginning to make out through the vast distance which separates it from

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[1] By N. H. Winchell in the sixth annual report on the geology of Minnesota.

[2] By T. C. Chamberlin & R. C. Salisbury in the sixth annual report of the U. S. Geol. Survey.

our day the dim outlines of what then existed. We are beginning to suspect the action of causes of which we see few traces in recent times, the occurrence of changes on a scale and of a nature that can no longer be matched, and the lapse of æons whose length must be measured with a different unit from any of those in use for later eras. The Archæan age in fact is a simple expression for a complex reality which we have not yet begun to comprehend, a single word to denote almost an eternity. For even when we have made all possible allowance for greater intensity of causation and therefore for vaster results in equal times the conviction grows with investigation that the Archæan age was far the longest of the four and perhaps as long as all the other three together.

The view of that distant field, even with the aid of the powerful telescope of geology and with the strong light which is now thrown on it is however so dim that for the purposes of the present review it will be disregarded and no further reference will be made to it. Our sketch will begin at or about the commencement of the next or palæozoic age.

In attempting to bring into one view what is thus far known or has been rendered highly probable concerning the geological history of the Mississippi-Missouri river-system the writer claims no merit for originality. His aim is solely to unite into a whole what is well known to every American geologist whose attention has been turned to this department of his favorite science. It is moreover quite possible that in some of the details there may not be perfect agreement. This is, however, a matter of secondary moment and if further consideration and discussion should modify the story in particular parts and reduce it into closer accord with nature one purpose of the writer will be served.

The commencement of the palæozoic era shows us the earliest condition of North America that is at present attainable. It was then lying for the most part below the waters of an immense ocean. Where now we see the busy midland, eastern and southern states, rolled its waters tenanted by strange forms of life long since extinct. Since that ocean existed millions of years have elapsed and save for the researches of geologists its very existence would never have been known. Variations doubtless occurred from time to time in the outline of its shores and in its depth but speaking of the region as a whole it was occupied by sea from a very early date in the palæozoic history to its end.

The annexed table will render the sequence of geologic time clear to the reader. The increasing spaces downward may be taken to rudely represent the greater length of the eras.

Post-Tertiary.	
Tertiary.	Pliocene. Miocene. Eocene.
Mesozoic.	Cretaceous. Jurassic. Triassic.
Palæozoic	Carboniferons. Devonian. Silurian. Ordovician. Cambrian.
Archæan.	Huronian. Laurentian, upper. Laurentian, lower.

The Cambrian age had already passed away and we have little or no knowledge of the condition of the continent during its continuance. Our first view of the palæozoic ocean of North America is at the beginning of the following, the Ordovician, or as it is still called by many geologists, the Lower Silurian. The northern shore of this body of water was then the Laurentide mountains of Canada, ranging from the Atlantic coast in Labrador along the northern side of the great lakes to the southwest and there turning sharply northwestward to the shore of the Arctic ocean near the mouth of the Mackenzie river. Its eastern limit lay, so far as can at present be determined, along the line of the Blue Ridge in Pennsylvania and Virginia; thence northeastward through New England and Lower Canada to Newfoundland; and southwestward through Tennessee to Alabama. Between the northern part of this coast-line and the Laurentides along the present St. Lawrence valley there lay a long depression occupied during a part at least of the era by the sea. Southward from Alabama all traces are lost, the old coast-line being deeply covered by later deposits.

Regarding the southern shore of this palæozoic ocean nothing is yet known. Its waters may have extended over the present gulf of Mexico into Central and South America. But in the total absence of evidence all attempt at delineating it would be mere guessing. Nor are we in much better position in attempting to define its western shore. Where now stand the various ranges of the western states it is certain that large areas were covered with water. But a few ranges of highlands raised their heads above the ocean, forming an imperfect barrier on that side.

These are all the relics that we have yet succeeded in discovering of the boundaries of this great palæozoic ocean. But that others existed and that these were then more extensive may be readily inferred by the student of geology. The great masses of strata that lie in the west must have come from the destruction of pre-existing land and they indicate the past existence of much more than the scanty fragments outlined above. Probably it was not continuous but consisted of separate and perhaps scattered reefs and islands.[1]

In the ocean basin thus formed the post-Cambrian deposits of

[1] Regarding the probable past existence of greater land surfaces as quarries from which the massive palæozoic sediments of the east were derived see a paper by the writer in the American Naturalist for December, 1887, entitled "Materials of the Appalachians."

the palæozoic era were laid down in succession. Avoiding details these were the Ordovician, the Silurian, the Devonian and the Carboniferous. Some of these, especially the earlier ones, extended over the whole region, while owing to local conditions others were confined to much smaller areas. The vast masses of sediment stretching from the Appalachians to the Rocky mountains and from the Laurentides to the gulf of Mexico are composed of the wash and waste of their contemporary lands. Rivers that have long ago disappeared bore down their tribute of sand and mud and strewed it over the floor of the ocean, to to be further distributed by its waves and tides. The greater part by far of this sediment was scattered along the Atlantic border where a continuous depression of the ocean bed was in progress. This is amply proved by the fact that in some places forty thousand feet of strata have been accumulated bearing through their whole mass the marks of shallow water. Whether this depression was the cause or the consequence of the deposit is still, after years of investigation, a moot point in geology. But certain it is that the two proceeded contemporaneously and that the ultimate extent of the depression was not less than seven or eight miles, over an area at least three hundred miles in width and running along the whole length of the coast line traced above.

This trough is filled with the shales, sandstones and conglomerates that resulted from the weathering and wasting of a passed-away continent. It contains but few limestones. Limestones are the result for the most part of deep sea conditions and accordingly as soon as we recede from the coast we observe a change in the nature of the strata. The same bed which in Pennsylvania is a shale or even a sandstone becomes a limestone when it is traced into Indiana and Illinois. Thus the Utica and Hudson-River shales of the East become limestones in the interior basin. Even the sandstones of the Coal-Measures are in like manner represented by limestones in the midland states. Their thickness also diminished at the same time. Instead of the six, seven or eight miles that measure them in New York, Pennsylvania, Virginia, Tennessee and Alabama we find the whole series so reduced as not to exceed five thousand feet in depth. So great is the difference both in mass and in material that in many cases it has proved impossible to identify the strata in the west with their counterparts in the east save by means of their organic remains. The study of the fossils has been the only means of binding the two together where it was not possible to trace the beds continuously from one place to the other.

Although taken as a whole the palæozoic era was, in the midland states, a quiet and undisturbed time yet there were not lacking signs of coming trouble. In the later portion of the Ordovician age, or perhaps in the early part of the Silurian, a thrust occurred which had the effect of bending the strata already deposited and of forming a long, low arch extending from the southwestern portion of Ontario near the southern end of the Georgian bay through Ohio and Kentucky into and beyond Tennessee. The flexure was slight but its results were great on the geology of those states.

At about the same time and owing probably to the same cause, whatever that may have been, a similar thrust elevated the Green Mountain region which has ever since remained above water. This change probably cut off the previously existing connection between the interior basin and the sea to its northeast.

Again at the close of the Devonian age were heard the mutterings of the restrained earth-forces. The strata laid down during all this period in Maine and in some other parts of the northeastern states and adjoining regions of Canada suffered compression and were folded, crushed and elevated above the sea-level.

But the great catastrophe did not come till the end of the palæozoic era. Then the long period of rest was broken by violent thrusts from the southeast before which the massive sediments gave way and were flexed and crushed as so many sheets of paper. The long arches of the Appalachians arose fold behind fold just where the strata were thickest. From these arches have since been carved by erosion the Allegheny mountains which despite their hight and extent are but the fragments of the thicker and heavier masses of strata out of which they were made.

The "Appalachian revolution" as this great catastrophe in the geological history of North America has been aptly named, not only raised the vast rampart of the Allegheny mountains between the interior basin and the Atlantic ocean but it also produced or at least was synchronous with the permanent drying of the greater part of that basin. At the close of the palæozoic era midland North America raised its head above the water and has never as a whole been since washed by the sea. The long continued subsidence to which I have already alluded, and which, though most profound on the Atlantic sea-board yet, doubtless, extended over the whole Mississippi valley, ceased in the east at that date. The consequent accumulation of sediment was arrested and the opposite process of erosion immediately set in.

Whether this important geological change was caused by elevation of the land or by depression of the bed of the ocean somewhere else it is not at present possible to determine. Not a little significant evidence points in the latter direction. But for our purposes here the question is not very important and we will not enter on any further consideration of it. It will be sufficient to point out that the palæozoic sediments thin regularly away from the eastern highlands to the west and that on approaching the site of the present Rocky mountains they again grow thicker often to a considerable extent.

On the emergence of the wide, low flats on which for so many ages had been growing the humble but gigantic vegetation of the Coal-Measures, lines of drainage were of course at once established. These followed the original slope of the ground and the great trunk stream took its channel at the lowest line of flow. Here is the physical cause of the position of the Mississippi river. It lies where the strata were thin if not thinnest and collected its waters from both sides of the interior basin.

As the land slowly rose above the waters the great river developed. But it was not the great river as we know it at the present day. At first an insignificant stream showing little promise of what it was destined one day to become it drained the high lands and plateaus of Minnesota and the adjoining regions not perhaps in the exact channel which it at present occupies but probably not very far from it. As the water retreated the young giant grew and was strengthened by the accession of numerous other streams that previously reached the sea by independent mouths. The retreat of the sea continued southward until the new continent was plainly outlined, its mountain-ranges defined and its shores determined. The North America that existed after the Appalachian revolution was not the North America of to-day and its great draining stream was not the mighty Mississippi as we know it. With its sources somewhere up in the northern states its mouth was near the site of the city of St. Louis. A deep gulf then extended northward from the present gulf of Mexico to that point, along the line of lowest ground, and it is quite possible that the Ohio reached this gulf by a mouth of its own without entering the Mississippi at all. Eastern North America consisted of the range of the Appalachians as a backbone with a large extent of lower land lying on both sides of it where are now the states of New York, New Jersey, Pennsylvania, Virginia, the Carolinas, Georgia, Alabama, Louisiana, Tennessee and Kentucky (the last then only in part); and farther north and west those of Indiana, Illinois, Michigan, Wisconsin, Minnesota, Missouri, with parts of Iowa, Nebraska, Kansas and the Indian Territory. It also included the whole of Canada to the foot of the Laurentide mountains. This was the area the greater portion of which passed its drainage into the sea by the young Mississippi and Ohio.

Of these two rivers it is not certain that at that date the Mississippi was the longer. The question is not easy of decision. The difference certainly was not great and there lurks in the mind a suspicion that at all events during parts of this long age the advantage may have been on the side of the now smaller river. The Ohio, however, had a limited field for growth and has remained ever since its creation very much what it then was while the Mississippi has followed the advice "Go West." It has gone west and grown up with the western country so that it has far outstripped its eastern rival and competitor. This will become clear as we proceed.

As yet there was no Missouri. The second river of the midland region, the tributary without whose aid the "Father of Waters" would sink to a very low position among the rivers of the earth, had not yet come into being. While the Mississippi is one of the oldest rivers of America the Missouri is one of the youngest. The Mississippi came into existence at the end of the palæozoic age and was one of the results of the Appalachian revolution. Geological evidence warrants us in believing that it has been flowing from that day to this with very slight and temporary interruptions and changes. There is, however, one fact which may somewhat modify the statement above made. It is not impossible that during some time or at some epochs in the mesozoic era the waters of the Mississippi may have found their way into the wide channel to be presently mentioned extending from the gulf of Mexico to the Arctic ocean. The course of the river was not separated from this body of water by more than about three hundred miles of land and this land possessed no very high ground to act as a watershed between them. There are some facts relating to the Mississippi delta which insinuate that the permanent outlet of the Mississippi into the gulf was not established until the western land had been elevated and in that case its former mouth must have been on the shores of the mesozoic channel or ocean to the westward. But on the other hand the Missouri is one of the last productions of the development of the continent. Its birth is a thing of yesterday when compared with that of its aged companion. Indeed it is scarcely out of its cradle. The Mississippi has long since worked its channel into shape and it now flows clear and steady. The Missouri is still employed in excavating a course for itself and its waters are laden with the clay and sand which it is removing from its bed. The Mississippi-Missouri—the greatest river-system on the globe—is made up of an old and a young stream but during all its earlier history the older stream worked alone and only in days comparatively recent has it been joined and reinforced by its young and vigorous companion.

The deposit brought down from the upper country by the elder stream began to fill the head of the great gulf at its mouth and in this way to lengthen the course of the river. Before long the Ohio joined it and the two formed one delta reaching below the site of St. Louis. How far this process was carried on during mesozoic time we have no means of determining. But through all this time the Mississippi basin was washed by the waters of the great river and was contributing of its substance to the formation of the delta.

The long palæozoic depression which came to an end in the east at the close of the Carboniferous age seems to have continued or to have set in again immediately afterwards in the west. For we there find that a wide arm of the sea extended up from near the mouth of the gulf already described that is from the site of the Texas of our day through the western states into Canada and to the Polar sea, near the mouth of the Mackenzie river. This area includes the whole of the basin of the Missouri which river therefore we have already said had then no existence. In this sea the beds of the Triassic, Jurassic and Cretaceous ages were laid down, and it must therefore have continued perhaps with minor changes during the entire mesozoic era. All this time it is nearly certain that the older river continued the even tenor of its way through ages that witnessed great and striking events in geological history. In this interval occurred the outbreak of the volcanoes of Pennsylvania which have covered with their ashes large areas in the southeast part of that state and have intersected with dykes of dolerite the Triassic strata of that and of the adjoining region. The Atlantic seaboard has probably never experienced so violent and extensive an outburst. The outflows of lava reached from Nova Scotia to Carolina, a distance of more than a thousand miles, and the products of the eruption—the traps—are of the same nature over all this great length of country. Then it was that some of the most striking features of the scenery of the eastern states were rendered possible. Then flowed out the masses of igenous rock of which Mt. Tom and Mt. Holyoke in Massachusetts are composed. Then came from the interior of the earth the basalt of the Hanging Hills near Meriden, Bergen Hill in New Jersey and last though by no means least in this region the famed and beautiful columnar palisades of the Hudson. All these are bosses of hard trap-rock capable of resisting the action of the weather and exposed by the erosion of the softer material under which they formerly lay buried.

The volcanic action and the outflow of trap were not confined to the spots already indicated. Further to the north there were vast eruptions in New England and in Nova Scotia. All along the valley of the Connecticut the edges of the lava beds can be seen and on the shores of the bay of Fundy lies a massive sheet of basalt well seen in the red and commanding bluffs of cape Blomidon on the bay of Mines.

Southward again extended the region of volcanic action and the Triassic strata of Pennsylvania and of Virginia are cut in all directions by basaltic walls and sheets of igneous rock. The now sadly memorable features of the desperate and decisive battle-field of Gettysburg are consequences of those distant outbreaks. Seminary Ridge, where the Confederate army was stationed, and the Little and Gray Round Tops are merely bosses of dolerite whose hardness has enabled them to survive the softer beds that formerly overlay them, while the famed Devil's Den is a valley of erosion lying between them and heavily strewn with their wreckage.

During this long lapse of time mutterings of coming disturbance were not unheard in the west. The regions of the Rocky mountains, so long at peace, began to feel the thrusts of a mighty earth-force. And though the geology of the western district is yet far from being worked out we know that during the age in question the range of the Sierra Nevada was elevated and that about the same date the Wahsatch and the Uinta ranges came into being. These were but forecasts of what was about to occur and heralded the second great revolution in the geological history of the continent.

But the Cretaceous age passed away without, so far as we are at present aware, any very great disturbances in the North American area. Yet we are certain that there must have been changes of no small extent in other parts of the globe for at the end of this era there occurred the widest extinction of species that geology has yet revealed. So far as North America and Europe are concerned very few animals or plants passed up from the Cretaceous into the Tertiary deposits. Into the cause of this significant fact we need not enquire here. It was probably the result of great changes in the distribution of land and sea. We have ample indications of this in the disappearance of the waters from the long channel already described running from the gulf of Mexico to the Arctic ocean. In this had been successively laid down the Triassic, Jurassic and Cretaceous strata. But at the end of the latter age the channel became dry land and never since that day has the ocean invaded the heart of the continent.

The geological history of the western states was in fact a repetition of that of the east. Through all the secondary or mesozoic era the greater part of that area was in a condition of slow and intermittent subsidence like that of the eastern border during the eras of palæozoic time. But soon after the close of the Cretaceous age this subsidence was arrested and a counter movement set in. Before the Tertiary era had far advanced vast areas of the western country began to emerge from the sea and a process of crumpling and crushing set in corresponding to that which the Atlantic states had undergone. The massive Cretaceous and early Eocene beds between ten and twenty thousand feet in thickness were upheaved by an earth-thrust from the Pacific to form the backbone of the Rocky mountains, which, buttressed and reinforced by other ranges of somewhat later date, elevated at the end of the Eocene and during the Miocene, have raised the high western rampart of the continent from Mt. St. Elias to Mexico.

During the same period also occurred that elevation of the Cretaceous and Tertiary rocks of the Atlantic border which has placed some of them six and eight hundred feet above the sea and not improbably the peninsula of Florida dates its origin to about the same epoch.

The reader can now realize the progress made by the continent during the secondary and Tertiary eras. The whole western area was then added and the land out of which the wide western states are made was for the first time laid dry.

Not until this had occurred was the Missouri river possible. But when the Pacific revolution had exposed the large western region and raised the Rocky mountains to a hight far exceeding that of the Appalachians and had added to North America a tract of land as great as its whole previous area a new system of drainage ensued and the magnificent rivers of the Northwest were developed. From the slopes of newly risen mountains, from the wide, flat prairies lying between them and from the plateaus and isolated groups of hills scattered over the land came the new streams all making their way into the great central valley. During the elevation and for a long series of years this western country was a lake region. Broad sheets of fresh water lay here and there over its surface dammed in by the unequal rising of the land. One of the most striking features of the geology of these western states is this great development of lakes. They held the waters brought down by the rivers from the upper lands and were swelled by the melting snows on the mountains. These torrents brought in vast masses of sand and mud which filled the beds of the lakes while the outflowing streams cut down their outlets so that in process of time this "lake-age" of the west passed away. It did not pass however without leaving an ample monument of its existence in those wonderful bone-fields in the " bad lands " and other places from which palæontologists are now extracting material for filling our museums and for reconstructing the mammalian history of the American Tertiary era.

The longest of the new streams born on the eastern slopes of the western mountains was the Missouri. From its source it now flows at first eastward and then southward gathering on its right bank all the others that descend from the same range, the Yellowstone, the White, the Niobrara, the Platte, the Loup and the Kansas, and many of smaller size. Its rapid fall and headlong, impetuous course are to the geologist clear indications of a young river that has not yet worn down its channel. The sand and clay that are constantly borne down by its waters confirm the indication and fully bear out the belief that the Missouri river is still in the days of its youth. As we have seen, it only dates back to the middle or perhaps even to the latter part of the Tertiary era.

The same changes that called the Missouri into being also contributed to increase the Mississippi. The elevation of the southern land and the increased mass of sediment brought down by the united waters carried the mouth farther and farther out to sea adding acre after acre to the great delta until now it extends more than five hundred miles to the south from the original mouth of the river near St. Louis. It is probable that nearly all this vast mass has been brought from the mountain region since the Missouri began to flow. The chief work of this river therefore has been to undo to a certain extent the elevation which produced the Rocky mountains and the dry land of the west as far as the Pacific watershed.

By this immense extension of its length its volume was proportionately enlarged. The creation of the great delta intercepted the other streams coming from the mountains further south and rendered them tributary to the Mississippi. The St. Francis, the White, the Arkansas, the Washita and the Red rivers are all in this condition. They have lost their individuality and instead of reaching the sea on the west of the great southern gulf they joined with the trunk stream and are lost in it before they enter the gulf of Mexico. Each of them contributed huge masses of material to the delta which therefore increases rapidly. Each no doubt had its own separate and independent delta but these are now buried and lost in the greater one formed by their union.

Hundreds of thousands, perhaps millions of years have passed away since the Mississippi-Missouri river was finally developed and complete. All the later Tertiary ages saw it in perfect running order, mainly as it exists in our own time, except near its mouth where the annexation of the great southwestern streams has been in process. The Pliocene age in North America seems to have passed quietly without any of those special changes which were witnessed by the ages that immediately preceded it. But our river-system did not pursue the even tenor of its way without disturbance and interruption even after its development was complete. Once at least, probably twice, and possibly several times has its domain been invaded by the icy hosts of the frost-king. Creeping slowly down from the high lands of Canada they have overrun the northern states carrying ruin and destruction before them. Slowly they marched forward sweeping the very soil clean beneath them and burying all under one white deluge of ice and snow. Dispute as we may about the causes of the ice-age there is no ground for doubting its reality. The invasion from the north spread farther and farther southward until all New England was covered. It gained allies from the then snow-clad Adirondacks and the two crept on, crossed the great lakes, landed on their nearer shores and slowly overwhelmed the adjacent country. Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Dakota, Nebraska, Iowa and Missouri disappeared under the ice-sheet. The slopes of the western mountains sent down their reinforcements and the states along their eastern flank were buried beneath the glacier. More than half the continent disappeared and the entire basin of the Mississippi-Missouri was blotted out, except possibly its mouth. The Ohio then for a time resumed its rank as the great river of the continent, but even this was probably subject to more or less interruption.

Such was the condition of North America during the ice-age. In all probability this inroad occurred twice for there is very strong ground for believing that the glacial-era consisted of two extreme periods separated by an interval when the cold was less severe. It is also probable that the extent of the glacier was less in the second onset than in the first. The marks which it has left show that in the first period the ice extended nearly to the mouth of the Ohio but in the second its range was probably limited to the northern line of states and reached litttle south of the lakes. Even then, however, it buried in ice the northern part of the Mississippi and the head waters of the Missouri so that these rivers were considerably reduced in size and extent. But in both cases as the ice melted away and the land was again uncovered their main channels of drainage resumed almost exactly their previous lines of flow and the preglacial hydrography of the country was restored. It is true that in some cases the deposits left by the ice blocked up the old courses and the returning rivers were in consequence compelled to find new ones. But such instances, though considerable in number, were chiefly confined to the smaller streams and did not affect the great trunk lines so that they need not be further considered here. The present drainage of the valley of the Mississippi is an almost exact reproduction of that which existed in pre-glacial times.

If, however, as some geologists believe, there has been a series of glacial invasions following one another from at least the beginning of the Tertiary era then we must intercalate into the life of this great river-system as many interruptions of the kind just described. For every such period must have caused a stoppage of the drainage as complete as that produced by the one ice-age of whose recent occurrence the geologist has no doubt. Such intercalations will not affect in any degree the truth of the story as here given but will render it more complex in proportion to their frequency. As however we have thus far no certain proof of this recurrence of cold conditions it will be unnecessary further to consider the subject.

We have traced this great river-system from its tiny beginnings on the wide flats and gently sloping beaches of a continent emerging from the waters of the palæozoic ocean through the long Secondary and Tertiary eras of geologic history. We have seen it, small at first and draining a comparatively limited basin, grow with the growth of the country as the American Mediterranean sea of the Triassic, Jurassic and Cretaceous ages became less and less and ultimately passed away. We have seen it reinforced by the addition of the waters of all the new region to the west as the elevation of the Rocky mountains slowly progressed. We have watched the development of its great tributary, the Missouri, as it brought down the waters of the large western lakes and the melting snows of the mountains until the lakes passed away, drained by the cutting down of their outlets and filled by the mud and sand of their tributaries. We have seen the domain of the united rivers overflowed by the northern ice and well nigh buried beneath the snowy mantle which the age of cold spread over the face of the country. We have noted the probable, the almost certain recurrence of this disaster a second and possibly more than a second time. And finally we have seen the two great rivers reassert their supremacy as the ice sheet disappeared and resume their ancient channels almost without change. The Missouri still carries down to the gulf loads of sand and mud such as it carried in its early days and the Mississippi still flows, clear and generally placid, as becomes the older stream.

Shall we in conclusion look forward and try to see what the future has in store for this mighty river-system? The geologist sees in every lake only a transient phase of the earth's geography. The existence of a lake is only a question of time. If it has a feeder that feeder will ultimately fill it up. If it has an outlet that outlet will ultimately drain it dry. If it has neither the one nor the other the growth of vegetation in its waters and the wash from its banks must in the end bring about the same result. Thus the Missouri has drained the great Tertiary lakes that once occupied a large area in the western states, in Dakota and Nebraska, and they have passed away. And it is now engaged in the work which may be called the special function of all rivers—it is carrying down the continent to the gulf. In this it is aided by the other rivers of the system, the Mississippi, and the Ohio and their tributaries in the south. All are slowly washing North America into the sea, and give them only time enough and they will accomplish their task unless the counter forces that in days gone by elevated it above the waves again come into play bringing up new mountains and new plateaus or raising to a higher level some of those already existing. Such changes are to be looked for in the distant future but it is beyond the ken of the prophet to foresee their date. If, as experiment and observation seem to show, the result of the action of the Missouri is now lowering the level at the rate of a foot in about four thousand years it is easy to calculate the date when it should be at a sea-level. But the process becomes less and less rapid as the land becomes low and the data necessary for the solution of the problem are not yet within our reach. All these geological changes are inconceivably slow. Generations have come and gone and generations more will come and go ere any difference in our geography will be observable. The life of man as an individual is but a speck beside the æons through which nature acts and the existence of man as a species scarcely more than an infinitesimal quantity beside the eras through which we have been tracing the existence of the great Mississippi-Missouri water-system. Long before these rivers have accomplished what has been aptly called "their contract of filling the gulf of Mexico" all our existing state of things will have passed away; the face of the earth will become unrecognizable to those who now dwell on it, and possibly man, "the lord of creation" as he proudly styles himself, will be numbered among the extinct species of the globe; his remains may be treasured in the strata of the future as samples of a creature that once lived, when he himself has given place to some higher or possibly to some lower but fitter survivor in the struggle for existence.

In the above brief sketch of a very long story many of the less important points have been entirely omitted to secure greater clearness and avoid undue length. An earlier palæozoic river on a small scale may have existed among the Archæan highlands of Minnesota and Wisconsin, and great changes of level probably occurred during the Tertiary era in the southern states. But these and many other details would not affect the main story. [E. W. C.]

ON LINGULASMA, A NEW GENUS, AND EIGHT NEW SPECIES OF LINGULA AND TREMATIS.

By E. O. Ulrich.

LINGULA PROCTERI, n. sp.

Figs. 1 a, 1 b, 1 c.

Shell acutely elongate-ovate, the width and length respectively as three is to five; widest in front, narrowing gradually to the beaks. Front margin generally a little straightened, but sometimes the whole anterior third is rounded uniformly. Sides gently convex, converging posteriorly from the point of greatest width which is about two-thirds of the length from the beaks. Apex of the dorsal valve narrowly rounded, that of the ventral acute and projecting considerably beyond the other. Both valves moderately but unequally convex the depth of the ventral being less than that of the dorsal and greatest about the middle of the shell. Surface with rather fine concentric striæ and more distant undulations marking stages of growth.

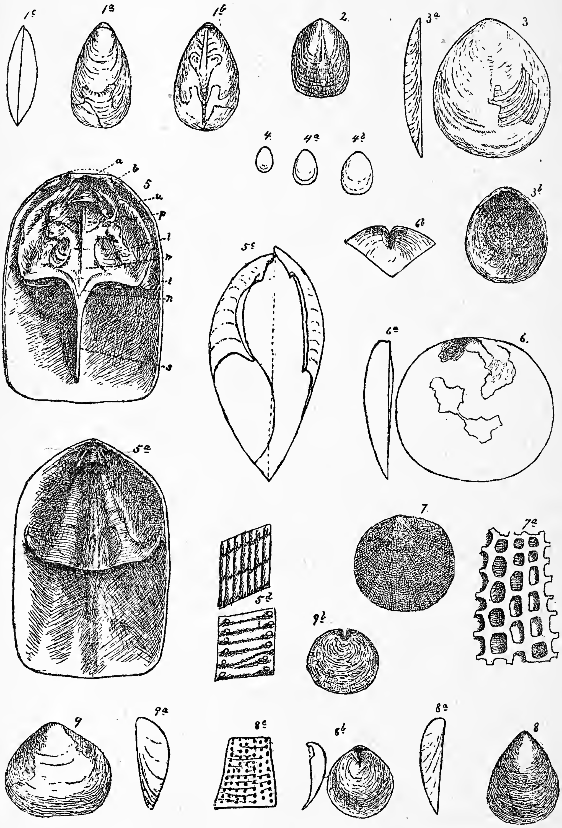

Fig. 1 *a*. An average specimen of *Lingula procteri* Ulrich, showing the ventral side. The shell is largely exfoliated. Collection of Mr. C. Schuchert.

Fig. 1 *b*. Dorsal side of same, showing, where the shell is removed, the median septum and traces of the scars of the muscular system.

Fig. 1 *c*. Longitudinal section of same to show convexity of valves.

Fig. 2. *Lingula bisulcata* Ulrich. Collection of Mr. C. Schuchert.

Fig. 3 and 3*a*. A large ventral or pedicle valve of *Lingula whitfieldi* Ulrich, preserving only a small portion of the exterior layer of the shell. Collection of Mr. Charles Schuchert.

Fig. 3 *b*. Interior of a small dorsal (?) valve of same showing indistinct muscular impressions and the pitted surface. Collection of Mr. C. Schuchert.

Fig. 4, 4 *a*, 4 *b*. Three specimens of *Lingula modesta* Ulrich, showing extremes of size and slight variations in the former.

Fig. 5. Gutta percha impression taken from the dorsal or brachial side of a nearly perfect cast of the interior of *Lingulasma schucherti* Ulrich, collected at Wilmington, Ill., and now belonging to Mr. C. Schuchert's collection. *a*, posterior transverse ridge (? crescent); *b*, subcardinal scars; *n*, umbolateral scars; *p*, post-median scars; *l*, lateral scars; *m*, median scars; *n*, anterior scars; *t*, transverse scars; *s*, median plate or septum.

Fig. 5 *a*. Gutta percha impressions of the pedicle valve of same. The figure is restored at the beak, the portion above the line being broken away in the specimen.

5 *c*. Longitudinal section of same showing elevation of platforms and median plate.

5 *d*. Surface of the shell of same x 8. The upper half represents the appearance on the lateral slopes, while the lower half does the same for the striæ near the front.

Fig. 6. Dorsal and profile views of a medium size specimen of *Trematis fragilis* Ulrich. Collection of Mr. C. Schuchert.

Fig. 7. Dorsal valve of *Trematis crassipuncta* Ulrich. The reticulation at the front and sides is represented too fine in the figure.

Fig. 7 *a*. Surface of same x 8. The shell is gone save in the depressed spaces, where it is marked with fine transverse lines.

Fig. 8. View of a dorsal valve of an elongated example of *Trematis umbonata* Ulrich.

Fig. 8 *a*. Profile view of same.

" 8 *b*. View of the ventral side of a shorter shell of this species, and a longitudinal section of same.

Fig. 8 *c*. Surface of same, x 8, showing the minute character and arrangement of the punctures.

Fig. 9. Gutta percha mould of a dorsal valve of *Trematis oblata* Ulrich; whole external form had been preserved by being grown over by a bryozoan.

Fig. 9 *a*. Profile view of same.

" 9 *b*. Ventral valve of same. A little more circular than usual.

A specimen of medium size is 18 mm. long, 10.5 mm. wide and nearly 5 mm. in thickness (*i. e.* both valves).

When the shell is exfoliated, the ventral valve exhibits a semi-circular band, situated a short distance in front of the centre, from which short lines radiate outward and forward. Just behind the middle a similar band, but without the radial fringe, is traceable. In the dorsal valve a median septum extends nearly to the front margin. Some of the muscular impressions as shown in fig. 1 b can be made out, but the appearance of the central region varies considerably, depending largely upon the degree of exfoliation.

This species resembles *L. vanhorni* S. A. Millar, but has the front proportionally wider and less narrowly rounded. In that species the valves are also equally convex. *L. obtusa* Hall has the sides more convex and the beaks more obtuse.

Formation and locality: This species ranges from the middle beds of the Trenton in central Kentucky to about fifty feet above low water mark in the Ohio river at Covington, Ky. The best specimens were collected at Bank Lick, several miles south of Covington. Specimens of this species are rare. The types are in Mr. Charles Schuchert's collection, and in the author's.

LINGULA BISULCATA, n. sp.

Fig. 2.

Compare Lingula huronensis Billings; Geology of Canada, p. 114, fig. 48, 1863.

Of this species I have seen only a single valve, whether the dorsal or the ventral has not been determined. It is of sub-pentagonal form, 13 mm. long, and 10 mm. wide. The front margin is gently convex with the median portion protruding very slightly. The anterior angles are narrowly rounded into the nearly parallel and faintly convex sides. For a short distance on each side of the obtusely pointed beak the margin is nearly straight and then rounds with a rather narrow curve into the sides. Surface with two faint diverging sulci extending from near the beak to points on the front margin a little within the angles; gradually widening and deepening, and leaving a faintly convex fold between them. The slope to the lateral margins is flat and for a short distance from the beak, even a little concave. Concentric striæ, regular, very fine and crowded on the sides. Over the front half very fine radiating lines are obscurely visible. On the inner side a thin median septum extends from the beak to a point just in front of the middle of the valve where it terminates abruptly.

As intimated above this species resembles *L. huronensis*, described by Billings from the Chazy group of Canada, very closely, and the doubt that the differences are of specific importance is not unreasonable. The figures of that species show the beaks to be more acuminate, the posterior angles more distinct and the median fold narrower than in the Cincinnati specimen. The two sulci distinguish it from all the other specimens known to me.

Formation and locality: Lower beds of the Cin. gr. about 75 ft. above low water mark in the Ohio river at a cut of the C. S. R. R. just opposite Cincinnati, Ohio. The specimen was found by Mr. Harold Wilson and now belongs to the cabinet of Mr. Charles Schuchert.

LINGULA WHITFIELDI, n. sp.

Fig. 3, 3 a, 3 b.

Shell rather large, broadly oval, the rostral margin narrowly rounded, with the beak small and scarcely, if at all, protruding. Sides for about the third of the length next the beak nearly straight. Anterior two-thirds uniformly curved, this portion of the outline being very nearly circular. Beak of ventral valve a little more produced than that of the dorsal, the length and breadth of the latter being respectively as eight is to seven, while these measurements in the ventral valve relate to each other as twelve is to ten. Outer surface with rather irregular concentric striæ, some of them often thread-like and stronger than the average. They are, however, rarely continuous and never so regularly disposed as in the associated *L. coburgensis* Billings (*L. covingtonensis* Hall and Whitfield). Both valves moderately convex, with the most elevated point near the middle. Color white to yellowish brown. A large valve supposed to be the ventral, is 24.3 mm, long, 20 mm. wide and 3.0 mm. deep.

Interior of dorsal valve roughly pitted, the pits numerous, small, unequal and generally irregularly arranged but sometimes exhibiting a tendency to an arrangement in concentric rows. The muscular impressions which are faintly indicated, form a figure something like an 8. The two halves of the figure are drawn out anteriorly, and the posterior half smaller than the anterior.

This species is related to *L. coburgensis* Billings, but differs from it in being comparatively shorter and wider in front. *L. obtusa* Hall, is smaller and narrower; *L. curta* Conrad, has a more acute beak; *L. perryi* Billings, differs in its form being sub-triangular in outline. The pitting of the interior surfaces of the valves distinguishes this species from all others known to me, save one, which occurs in the same beds with it and begins already in the middle Trenton beds of central Ky. The form of that species agrees very nearly with *L. coburgensis* Billings. The surface characters, however, are slightly different and it may be a distinct species. The specific name is given in honor of Prof. R. P. Whitfield, the accomplished paleontologist of the American Museum in New York city.

Formation and locality: Lower beds (Utica Slate horizon) of the Cincinnati group, a few feet about low water mark in the Ohio river at Covington, Ky. The figured specimens are from the cabinet of Mr. Charles Schuchert. Others belong to the author's collection.

LINGULA MODESTA, n. sp.

Fig. 4, 4 a, and 4 b.

Shell small, subovate, widest in the anterior half, the width and length, respectively, in four representative cases, 3.5 to 5.2, 5.5 to 8, 7 to 10 and 7 to 11, the figures representing the dimensions in millimetres. Both valves with exceedingly little convexity, appearing in most cases perfectly flat. Interior third or half usually uniformly rounded. Front margin occasionally somewhat straightened. Sides gently convex to near the beak which in none of the numerous specimens examined seems ever to have formed an acute termination. Surface with only very faint concentric undulations; even these are quite obsolete, when the shell is preserved in a shaly or impure limestone matrix. Color white or pearly.

The unusual flatness and nearly smooth surface of the valves are the characters relied upon in distinguishing this species. It may be argued that the flatness is due to compression, but this is evidently not the case, since numerous examples have been collected from limestones containing other species of *Lingula* none of which presented any evidence whatever, of having lost any considerable amount of their convexity through that cause. In its outline the species resembles several others, notably *L. progne* and *kingstonensis* Billings. Both those species have the front margin less rounded, the sides straighter and less converging, and the beaks, particularly that of the ventral valve, more pointed. The outline of *L. obtusa* Hall, though a larger shell, agrees very nearly with our species. It is, however, a much more convex form and generally wider in front.

Formation and locality: Specimens of this species are abundant in the hydraulic limestones near the middle of the Trenton group, at Frankfort, and other localities in central Ky. The strata which hold them are locally known as the "Modiolopsis bed" from the large number of shells of a new species of that genus (provisionally named *M. oviformis*) contained in them. These beds have yielded fine examples of *Trematis ottawaensis* Billings, and a number of species of *Lingula*. *L. modesta* is next met with in the transition beds of bluish crystalline limestone near Paris, Ky. The "river quarry" beds about Cincinnati also contain it, but individuals are not of common occurrence. I have also met with examples in the blue shales near the tops of the Cincinnati hills.

LINGULASMA, n. gen.

Shell oblong, subquadrate or sub-pentagonal; substance of valves moderately thin, apparently of the same composition as in *Lingula*.

Pedicle valve with a slightly projecting obtusely pointed beak; under it a large faintly arched deltidium, most of which seems to have been internal (*i.e.* extended within the posterior margin of the brachial valve.) Area apparently absent. A small socket on each side of the posterior ends of the converging deltidial borders, and, just opposite their anterior ends (on each side) a rather large sub-triangular scar. A large triangular platform extends from the base of the deltidium to about the middle of the valve. The platform is elevated, trilobed, with its antero-lateral extremities recurved, and the anterior end bisinuate, the central portion being a little prominent and, below, produced into a low median ridge. On the inner slopes of the anterior halves of the lateral lobes two large muscle-scars, apparently the lateral pair, are faintly traceable. The median and anterior pairs were probably attached to the anterior half of the central lobe.

Brachial valve with the posterior end narrowly rounded; beak very small. On the inner side, just within the narrow flattened posterior border, there is a small transverse ridge (*a*) sinuate centrally on its anterior side and slightly thickened at the ends. This ridge forms the truncate apex of the arch-like border of the platform and its swollen ends may have fit into the small sockets situated just within the apex of the opposite valve. The platform is concave both transversely and longitudinally, greatly elevated in front and prolonged anteriorly into a remarkably developed median plate. Just in front of the small transverse ridge already described, there is a deep excavation and at its bottom a triangular, arched, deltidium-like space (*b*). From the abruptly terminating anterior side of this triangle, which is supposed to represent the *sub-cardinal* scars, a small and gradually diminishing ridge extends anteriorly. This divides, at its posterior end, a well marked subpentagonal scar (*p*) supposed to be the *post median*, and, further on, the scarcely impressed *median* scars (*m*). The position of the *anterior* scars is faintly indicated at the point of junction between the median septum and anterior end of the platform; likewise the scars of the *transverse* pair at the antero-lateral angles of the platform. The *umbo-lateral* scars are well defined and situated on the posteriorly converging sloping sides of the cavity at whose bottom is placed the *post-median* scar. The sub-cardinal, umbo-lateral, and post-median scars together cover a somewhat transversely elongated space rudely rhomboidal in outline. Of all the scars the *lateral* pair is the strongest. These are of oval form, oblique, and placed one on each side of the medians.

Type: *Lingulasma schucherti*, n. sp.

There are two English species, *Lingula granulata* Phillips, and *L. tenuigranulata* McCoy, and one Canadian form, *L. canadensis* Billings, which I expect confidently will prove to possess the internal characters of *Lingulasma.* These three species agree with *L. schucherti* not only in the general form of their shells, but also in possessing so-called "granulations" on the concentric striæ, which, being arranged in radial series, impart a reticulate ornamentation to the surface. These *granulations*, I suspect very strongly, are not simply solid elevations of the surface but, rather, of the nature of short tubes, or, possibly, the broken bases of tubular spines similar to those of *Siphonotreta.* Should my suspicions concerning the interior of these species and the tubular character of the "granulations" prove well founded, then an additional distinguishing peculiarity may be added to the diagnosis of *Lingulasma.*

In entering upon a discussion of the relations of this remarkable genus, I may at once express my conviction that we have before us a widely diverging but transient type or spur of the *Lingulidæ*, with a strongly marked tendency to assume and, perhaps in part foreshadowing, the internal peculiarities of the *Trimerellidæ*, a family of paleozoic shells whose characters have been so conscientiously and admirably worked out by the late Mr. Thomas Davidson and Prof. Wm. King. (Quart. Jour. Geol. Soc. vol. xxx; 1874.) It should be remarked further that their memoir has formed the ground plan upon which I based my investigations of *Lingulasma*, and that their provisional designations of the various scars, where the equivalence of these could be determined with reasonable certainty, have been adopted by me in describing the internal features of the genus.

The family *Trimerellidæ*, as defined by Davidson and King, includes more or less calcareous, transversely or longitudinally elongated, and both thick and thin shells. We have here three features in which *Lingulasma* does not correspond with the family. Of these, the first is, in my estimation, by far the most important and, fearing that my intentions may be misunderstood, I will state at once that I regard the unequivocally corneo-phosphatic shell of *Lingulasma* as an insurmountable obstacle to an arrangement of the genus with the *Trimerellidæ*; and I may add that in none of its *external* characters does the new genus correspond with the trimerellids being in those respects indistinguishable from the lingulids.

After the above preliminary declarations we may pass directly to a consideration of the parts belonging strictly to the interior. Here, I believe myself capable of showing, what may be already obvious to the reader, that, while the internal characters taken as a whole deviate widely from true *Lingula*, they correspond in a great degree with those of the *Trimerellidæ*.

The most striking feature of the interior of both valves is the elongated region of the posterior halves which has been called the *platform*. With regard to this feature I may safely say that in no trimerellid is it *better* developed than in *Lingulasma*. On the contrary only in a very few is it nearly as large or so much elevated. As usual among them the platform and median plate of the brachial valve of *Lingulasma* is higher than that of the pedicle one. The platform in the latter also greatly resembles that of the typical species of *Trimerella* in consisting of two convex divisions. In *Lingulasma*, it is true, these are separated by a third convex longitudinal space, causing the platform to appear tri-lobed. But little importance, however, can be attached to this difference, since tri-lobed platforms pertain to unquestioned trimerellids, the median lobe evidently representing only a greater development of the median plate which, in *Trimerella*, supports the platform and divides the space beneath it into two tunnel-like vaults. Even these vaults, which are not always present in *Trimerella* and not at all in *Monomerella* and *Dinobolus*, are represented in *Lingulasma*.

The cast of the interior which furnished the guttapercha squeezes represented by fig. 5 and 5 a, originally preserved much of the shell and all of that pertaining to the platform. This was carefully removed and during the process it was noticed that the platform consisted of numerous cup-shaped laminæ placed within one another and so that an open space was left between each and the preceding and succeeding ones. From this it is evident that the vaults, of which in this specimen the last are only deeply concave spaces beneath the front of the platform, were closed at intervals. The development of these plates I can explain only by supposing them to have been intended to act as supports to the platform. That they were not *complete* is evidenced by the fact that some of the surrounding matrix had entered into the cavities mentioned. Indeed, in two casts of the interior from Savanah, Ill., the matrix completely fills the spaces under the platforms to the beaks.

The resemblances between the *Trimerellidæ* and *Lingulasma* already pointed out are fully sustained when we compare the muscular scars and certain other internal features of, perhaps, minor importance. In the first place we find that in both the platforms are marked by four sets of scars. These Davidson and King distinguished by the names, *medians*, *anteriors*, *laterals*, and *post-medians*. The last set those authors believed to have no relation to the others. They were inclined to refer them to the ovaries.

In comparing the relative positions of these and other sets of scars we find that the correspondence with *Dinobolus* is greater than with either *Trimerella or Monomerella*. This is to be expected, since *Dinobolus* includes species whose shells were thinner and contained a smaller percentage of calcareous matter than the shells of those other genera.

In the brachial valve of *Dinobolus* we have a rather strongly marked *sub-cardinal* scar situated in the umbonal cavity. This scar is represented by the convex triangular space marked *b* in figure 5. In most species of *Dinobolus* this part is impressed, but in *D. transversus* Salter, it is elevated and of triangular form as in *Lingulasma*. In front of this *Dinobolus* has a large sub-rhomboidal *post-median* scar, with a longitudinal median keel in at least two species (*D. transversus* and *davidsoni* Salter.) This scar is represented in fig. 5, at *p*. Directly in front of it is the faintly traceable *median* pair, the same again as in *Lingulasma* (fig. 5, at *m*), and, on each side of these, one of the well-marked *laterals*. The last scars seem to diverge posteriorly in *Dinobolus* while they converge in the same direction in *Lingulasma*. If, however, the parallel lines marking the surface of the scars be compared it will be seen that they, at any rate, run in the same direction in both. The *anteriors* are not readily determined in *Lingulasma*, yet it is scarcely to be questioned that they were placed, as in the trimerellids generally, at the center of the anterior extremity of the platform.

Lingulasma has two other sets of scars which appear to be homologues of two pairs found in the trimerellids: viz., the *umbo-laterals* and *transverse* scars of Davidson and King. In *Trimerella* and *Monomerella* the *umbo-laterals* are situated very near the "crescent," but in *Dinobolus* they are placed close to the *sub-cardinals* and *post-medians*. Thus, that genus again agrees with *Lingulasma* (fig. 5, *n*). The transverse scars (at any rate the impressions which I have identified with them) occupy positions in the valves of *Lingulasma* much nearer their sides than is the case in any of the trimerellids. This difference, however, is largely accounted for by the comparatively greater width of the platform and the elongate form of the valves.

Concerning the *crescent*, which seems to be one of the most persistent characters of the *Trimerellidæ*, I cannot say that it is unequivocally represented in *Lingulasma*. In the pedicle valve, at least, I have not found anything that might be referred to it; but the small transverse ridge just within the posterior border of the brachial valve (fig. 5, *a*), will probably prove an homologous feature.

Another point of agreement with the trimerellids is furnished by the *archlet.* This is represented, in the brachial valve, by a faintly impressed semi-circular line in front of the platform. (See fig. 5.)

In the specimen from which the gutta-percha moulds were taken, the posterior extremity of the pedicle valve is, unfortunately, broken away, so that we cannot say positively whether an area was present or not. One thing, however, seems certain, namely, that only a small portion of deltidium projected beyond the border of the opposite valve, and, consequently, that the larger part of it was internal. This, very likely, would be a unique condition, and, as I am not prepared to explain the anomaly, the safest policy, manifestly, is to let it rest with the bare statement of the apparent fact.

There yet remain several points in the internal structure of the genus which might be discussed, but as they are either not understood or deemed of only trivial importance, it would not, perhaps be wise to do so. It may be well, however, to recommend a careful study of figs. 5, 5 a and 5 c as they represent every feature seen on the fossil.

The remarkable agreement in the character of the platforms and in the disposition of the muscular scars above shown to exist between the *Trimerellidæ* and *Lingulasma*, naturally suggests placing the genus in that family. But, as is stated at the beginning of this discussion, that could not be done without violating what appear to be closer ties. The grounds upon which I base my objections to such an allocation are (1) that, though the interior of *Lingulasma* may be said to be practically identical with that of the trimerellids, it is still true that the muscular systems of both are not materially different from that of the *Lingulidæ*; and, coupling this fact with (2) the linguloid *form* of the shell of *Lingulasma*, and (3) the corneo-phosphatic instead of calcareous composition of its substance, we have an array of evidence strongly in favor of the *Lingulidæ*. Moreover, I am inclined to believe that the platforms of *Lingulasma schucherti* are exceptionally developed and that its trimerellid characters, if the expression be allowed, will not prove so marked in other species.

The position of *Lingulasma* appears therefore to be distinctly intermediate between the two families, with the composition and general outer aspect of the shell favoring an alliance with the *Lingulidæ* and probably outweighing the internal points of resemblance to the trimerellids. The course which would, perhaps, be the least objectionable, and that may be adopted ultimately, would be to establish a new family for the reception of *Lingulasma* and, possibly, *Lingulops* Hall. However, considering the present limited extent of our knowledge concerning the internal characters of the large majority of paleozoic linguloid shells, the adoption of such a course *now* would be, to say the least, premature. Still, I must confess, the word *premature* embraces all my objections, since I am thoroughly convinced that *Lingula*, as now constituted, includes several widely divergent types, and that, when the species are once studied with a view to their internal peculiarities, the genus will have to undergo great restriction and subdivision.

The *Obolidæ* might be considered in this connection, but, as they are doubtlessly removed a step further than either the trimerellids or lingulids, it is scarcely necessary. Their position seems to be about intermediate between *Dinobolus* on the one hand and *Discina* on the other.

Lastly, it may be remarked, that in *Lingulasma* we have not yet the "generalized form" which Davidson and King thought might yet be discovered, "bringing *Discina* and *Lingula*, also *Obolus*, into close myotic relationship *inter se* and with *Dinobolus*." No, *Lingulasma* is only another descendant of that as yet undiscovered type. Still, the new genus affords at least a partial verification of their expectations, since its position is unquestionably between *Lingula* and *Dinobolus*.

LINGULASMA SCHUCHERTI, n. sp.

Figs. 5, 5 a, 5 c, and 5 d.

Shell large, oblong, subpentagonal. Front margin nearly straight or very gently convex, faintly bisinuate, the middle portion produced very slightly. Anterior angles narrowly rounded. Sides almost straight, parallel for nearly three fourths of the whole length, then rounding rather abruptly into the very slightly convex postero-lateral margins. Posterior extremity of brachial valve narrowly rounded, that of the pedicle one sub-acutely terminated by the beak which projects somewhat beyond the beak of the brachial valve. Valves rather strongly convex, the brachial more than the other, and both with the point of greatest convexity a little behind the middle. The central space on each valve contained within two lines drawn from the beaks to the anterior angles, is flattened. Midway between these lines there is a more or less faintly elevated broad fold which produces the slight central protrusion of the anterior margin already noticed. The lateral slopes are also flattened and, on each side of the umbones, even somewhat concave. Surface with fine but rather irregular concentric lines, just visible to the naked eye, and, at variable intervals, with stronger undulations. The concentric lines bear hollow granule-like elevations arranged so as to form series radiating from the beaks. On the lateral slopes these "granulations" are elongated and impart a frequently interrupted or imbricating appearance to the concentric lines (fig. 5 d, upper half). On the anterior slope this appearance is not apparent. Here they look more like the broken bases of short tubular spines. Here, also, the radial series formed by them are separated by wider interspaces, there being only about eight in 5 mm. at the front margin to eleven or twelve in the same space at the posterior angles. Casts of the interior exhibit concentric furrows near the margins and obscure radial lines over the anterior half.

Length of best specimen, 40 mm.; width, 27 mm.; depth of both valves, 19 mm.; depth of brachial valve, 10.5 mm. Some specimens *appear* to have been comparatively shorter, but, as they have clearly suffered through compression, we may reasonably doubt that they were so originally.

This species must be closely related to *Lingula canadensis* Billings, from a similar position at the Island of Anticosti. Also to *L. tenuigranulata* McCoy, and *L granulata* Phillips, described from Lower Silurian deposits of England. The last is a smaller shell, and the others are proportionally shorter and wider anteriorly. All have fine surface markings.

It affords me much pleasure to connect the name of Mr. Charles Schuchert, now of Albany, N. Y., with this highly interesting species. This gentleman has selected the brachiopoda as a specialty and owns one of the finest collections of American paleozoic forms of that class known to me. It is to be hoped that he will make good use of this advantage and that we may soon be favored with some of the results of his careful and extended researches in this branch of paleontology. The fine cast of the interior, which made a diagnosis of the genus possible, belongs to his collection. Other specimens are in the author's cabinet.

Formation and locality: This species is associated with fossils marking the upper beds of the Cincinnati group, at Wilmington and Savannah, Ill.

(*To be Continued.*)

THE MESOZOIC ROCKS OF SOUTHERN COLORADO AND NORTHERN NEW MEXICO.

BY JOHN J. STEVENSON.

The mesozoic section along the easterly foot of the Rocky mountains from central Colorado southward has been studied more or less, by numerous geologists. In 1869, Dr. Hayden made a reconnaissance of the whole line from Denver to Galisteo creek, making connection with the work of professor Marcou and the later work of Dr. Newberry. The writer followed the same line, studying somewhat closely in 1878 the area between Cucharas creek in Colorado and Las Vegas in New Mexico, and making reconnaissance examinations of the region between Denver and Cucharas in 1873 and of that from Las Vegas to Galisteo creek in 1879. The portion of the line within Colorado was studied by members of Dr. Hayden's corps. Mr. St. John has given an admirable description of the upper Canadian area in New Mexico; Dr. Newberry followed the southern portion from Leavenworth crossing of the Canadian to Santa Fe along the Santa Fe road; and Prof. Marcou touched it during an excursion northward to Galisteo and Pecos.

The mesozoic section in central Colorado shows the following succession:

Cretaceous.
- *Laramie.*
- *Fox Hills.*
- *Fort Pierre.*
- *Niobrara.*
- *Fort Benton.*
- *Dakota.*

Jurassic.
Triassic.

The top of the *Laramie* is not reached near the foot of the mountains southward from Denver. The group is shown in isolated areas only, having been removed by erosion from the greater part of the region. The rocks are gray to bluish-gray and yellow sandstones with shales and numerous coal beds, which are of great value. The areas best known are the small coal field near Cañon City, Col., the extensive coal field tributary to Trinidad, Col., and lying on both sides of the line between Col. and N. Mex.; and the Galisteo area, very small, at say 25 miles south from Santa Fe, N. Mex. Leaf-beds are not rare and at many localities they yield abundance of excellent specimens. The extreme thickness is not far from 2,000 feet.

The *Fox Hills* is composed mostly of sandstones, blue to gray to yellowish, with irregular harder layers which resist weathering. Coal beds of some importance are found in the section. Northward from Denver on the Platte, where the thickness is more than 1,000 feet many of the subordinate beds are rich in characteristic marine fossils, while others are crowded with the curious nodose fucoid, *Halymenites major* Lesq. Southward, the thickness decreases until at Cañon City the vertical range of the *Halymenites* is about 350 feet; there important coal beds occur in this interval. The thickness diminishes until in the Trinidad field the vertical range of the *Halymenites* is but 80 feet. No traces of the fucoid were observed in the Galisteo area and there the *Fox Hills* is supposed to be absent.[1]

The *Fort Pierre* is a great mass of shales forming the slopes of many mesas on the plains of the Arkansas Canadian and Purgatory rivers and well shown for long distances in the immediate foothills as well as around the *Laramie* plateau of the Trinidad coal field. Beyond the Mora river in New Mexico they can be followed without difficulty to the Pecos river at the south; they are distinct at Galisteo, N. M., where they underlie the *Laramie* and rest on the *Niobrara*. The shales are black, gray and yellow, both sandy and argillaceous. The upper portions carry layers of calcareous and ferruginous con-

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[1] Dr. C. A. White, in a letter, advises against placing much reliance on this *Halymenites*, as he has found it in the *Fort Pierre* of Colorado, and in the *Laramie* of the same state, as well as in the marine *Eocene* near Laredo, Texas, where it is associated with *Cardita planicosta*, &c. The writer, however, uses it only as marking within this region along the mountain front, the disappearance of the *Fox Hills* conditions and not for positive identification of horizons.

cretions, which very often are rich in fossils. The extremes of thickness observed are 900 and 1,700 feet.

The *Niobrara* consists of limestones, gray to blue, more or less magnesian, separated by black to grayish blue shales. The lithological features are very striking, even more so than are those of the overlying *Fort Pierre*. These rocks are well shown below Cañon City, Col., and at many other localities along the immediate foot-hills until the Spanish peaks overflow is reached. Thence exposures are few though characteristic until the synclinal runs out in the Moreno valley 35 miles south from the Colorado line; but along Cimarron creek, around Ocate mesa, the Canadian hills, the plains south from the Mora river, and at Galisteo the exposures are excellent. The interruptions in continuity are due only to erosion by the Canadian, Mora and Pecos rivers and their tributaries. The greatest thickness observed is approximately 700 feet.

The *Fort Benton* is made up of dark shales and some irregular sandstones; it is thin, seldom more than 150 feet thick, and its material is yielding, so that one rarely finds any but very fragmentary exposures. These, such as they are, are numerous enough along the foot of the mountains as well as near the Canadian hills in New Mexico and near Galisteo.

The *Dakota* everywhere underlies the *Fort Benton* but the contact between the two is frequently shown only on the waters of Mora river. The *Dakota* can be traced almost uninterruptedly from central Colorado southward to Galisteo creek in New Mexico. In the writer's opinion, its variations southward are more notable than those of the *Fox Hills* northward. But before any detailed statement can be made respecting these changes it is necessary to say something about the underlying rocks.

The *Jurassic* south from Denver, Colorado, is represented by shales with thin limestones; near Cañon City it is composed of shales. The *Triassic* is represented in the same region by variegated sandstones, more or less conglomerate in many places, with beds of gypsum, the whole making a mass of great thickness. But southward from Cañon City, these groups decrease in importance, so that before the waters of the Purgatory river are reached, they are so thin as not to be recognized or they are altogether wanting. They are certainly wanting in the Moreno valley of New Mexico, 35 miles south of the Colorado line, where the *Dakota* overlaps the Carboniferous rocks there exposed, and rests on Archæan. Red rocks re-appear under the Dakota at about 30 miles further south, not far above the village of Coyote on Coyote creek. Thence these rocks were followed southwardly for nearly 40 miles to Bernal hill and thence westwardly to Galisteo creek. They have a narrow outcrop at the base of the Dakota bluffs, owing to the rate of dip, the width of the exposure being so small that it can be represented only by a line on a map with scale of one inch to four miles. These red rocks of the *Dakota* bluff, so distinct along the old stage road from Pecos river to Galisteo creek, are those which the writer referred to the *Triassic* and they are the *Triassic* of Mr. Marcou. The great mass of *Trias* and *Jurassic* more than 2,500 feet thick near Cañon City, Colorado, is unrepresented along the line examined from not less than 20 miles north of the New Mexican boundary to fully 60 miles south of that line; thence southward and around the southern extremity of the Spanish Ranges, the thickness does not exceed 700 feet. No fossils were seen in these beds by the writer, but near Las Vegas, New Mexico, Dr. Hayden found a *Modiola* of Jurassic type.

Now let us return to the *Dakota*. The sandstone, which in central Colorado lies between the *Fort Benton* beds above, and the *Jurassic* beds below is known as the *Dakota*. The thickness is not far from 250 feet near the New Mexico line, where the mass appears to consist of two plates of sandstone separated by softer material not well exposed; the "Stonewall" of *Dakota* usually shows a notch along the crest, but the character of this middle material is nowhere shown in detail, though at one locality there is evidence that a limestone is present. This is the condition certainly as far as to 15 miles south of the New Mexico line, where the overflow of eruptive rocks puts an end to the exposure and the *Dakota* is not shown again for 15 miles or until the Moreno valley is reached near Elizabethtown, where it rests on the Archæan and the Niobrara is shown above it. There the triple division is well exhibited; and this feature becomes more and more marked from this locality southward. The thickness increases rapidly so that the section, which showed less than 300 feet on the Purgatory river in Colorado, shows on the waters of the Mora river.

Upper Dakota	750 ft.
Middle Dakota	600 "
Lower Dakota	350 "
Total	1,700 ft.

The increase in thickness southward from southern Colorado is as remarkable as the increase in thickness of the *Fox Hills* northward from southern Colorado.

The *Upper Dakota* consists of little aside from sandstones in the Canadian river region; it forms bold hills on the tributaries of Mora river and its upper beds are the surface rocks of much of the plain on both sides of the Mora and Canadian cañons. It forms the upper part of the walls in those cañons, where the thickness is not far from 800 feet. The rock is hard, gray to yellowish gray and usually fine grained, so that it resists erosion admirably. This upper division of the *Dakota* shows some shales and limestone southward from Mora cañon in several of the gaps cut through it by streams tributary to the Pecos river.

The *Middle Dakota* is shown on the tributaries to the Mora river as well as in the deep cañons of the Mora and Canadian rivers, on Galisteo creek near the old stage-road and at three miles east from Galisteo. It consists of shales and irregular limestones with, in the Galisteo region, occasional beds of gypsum. Films of gypsum are not rare north from the Pecos river, but the quantity appears to be more important on the waters of the Galisteo. Some fairly good exposures on Mora creek show this group to be made up of dull-gray, flaggy and soft incoherent sandstones, with variegated shales and some excessively hard limestone. The section of this division shows a good deal of variation.

The *Lower Dakota* is represented everywhere by gray to yellowish gray sandstones, with occasional bands of white. In the many gaps in which these rocks are exposed, one can find hardly any marked characteristic by which to distinguish them from those of the *Upper Dakota*. The *Lower Dakota* is distinct first in Moreno valley at somewhat more than 35 miles north of the locality at which the *Triassic* rocks re-appear; but continuous exposures begin only on the waters of the Mora river, whence the rock can be followed to Galisteo creek, without break other than those made by streams cutting across it. It forms the top of the bluff at whose foot the Atchison, Topeka & Santa Fe railroad passes from the Pecos river near San Miguel almost to Lamy or Santa Fe junction. Should one rise upon the bluff, taking the old road from San Miguel to Galisteo, he would cross the whole of the *Dakota*, the *Fort Benton* and the *Niobrara* before reaching the latter village.

In the report on the geology of this region,[1] the writer referred this whole succession to the *Dakota*, because it is evidently the *Dakota* of Colorado northward greatly expanded; but while so doing, made the remark that the whole series may be *Triassic* or may be *Cretaceous*, the grouping having been made simply for convenience. This remark was too narrow, as it left the *Jurassic* out of consideration. As the *Dakota* in Colorado rests on rocks clearly *Jurassic*, there is a possibility that some portion of this may belong to the *Jurassic*. But the writer is inclined rather to look upon it all as belonging to the Cretaceous. Mr. Marcou would place it all in the Jurassic while others would place much of it in the Triassic. This question must be settled by some geologist sent in with time at his disposal, whose studies will not be in reconnaissance but be detailed. Every one, who thus far has touched the region, has studied the geology only in haste or as incidental to other work. The differences of opinion during late years, doubtless, owe their origin largely to this. There may be much of right in all or much of wrong in one. The wise man is he who possesses his soul in patience, for fierce invective and personal abuse have not yet become accepted or convincing arguments in stratigraphy.

But be all that as it may. The section at Galisteo can be duplicated, below the *Laramie*, at more than sixty miles northeast along the 36th parallel from Coyote to the Canadian hills; and this again by following the same parallel from the Canadian hills to the bottom of the Canadian cañon, though the very lowest beds of the *Lower Dakota* are not reached in the cañon at that point. Ascend the cañon to the old Leavenworth crossing, 21 miles further north; there, near the mouth of Cimarron creek, one is again on the *Fort Benton*. The rest of the section to the top of the *Laramie* is exposed on this stream. The Galisteo section can be duplicated at any lo-

[1] U. S. Geographical Surveys West of 100th meridian, vol. III, Supplement, chap. VII.

calities nothward, with the simple difference, that the *Fox Hills* makes its appearance between the *Fort Pierre* and the *Laramie*, while the *Dakota* loses much of its thickness. The lithological features of the *Dakota*, the *Fort Benton*, the *Niobrara* and the *Laramie* are strangely persistent along this line of nearly 300 miles, from Denver to Galisteo.

UNIVERSITY OF THE CITY OF NEW YORK.

April 9th, 1889.

EDITORIAL COMMENT.

A SANDY SIMOON IN THE NORTHWEST.—

May sixth and seventh, 1889, will long be remembered by the residents of the Northwest. On those days culminated the violence of the dry, southeasterly wind which had prevailed in some portions of the Northwest, particularly in central and eastern Dakota, for several days previous. The wind itself, while not specially violent, varying from twenty to forty miles an hour, and perhaps in some places fifty miles an hour, was remarkable for carrying with it clouds of dust and sand which filled the air and penetrated into houses, and blinded the traveler who happened to be caught in the roads, and compelled the cessation of nearly all outside labor. The wind prevailed over a large area. It seems to have reached furthest east, and been most violent, on the sixth and seventh of the month. The newspapers gave telegraphic accounts of it in Nebraska, South and North Dakota, Iowa and Minnesota. It probably also affected western Wisconsin, and considerable portions of Missouri.

A strong southeasterly parching wind, prevailing for several days, about that time in the Spring, is a familiar fact to old residents who have taken note of the peculiarities of the northwestern climate. It more frequently comes after Spring vegetation is more advanced than it was this season on the days mentioned, and its effect on small, tender twigs is disastrous. It is enervating to all animals and merciless on the wilting vegetation. But prior to this wind, which was followed everywhere by copious rains, the Spring of 1889 in the Northwest had been dry; and this was intensified in its effect on young vegetation by the preceding dry and open winter. All springs and streams were unwontedly low. Hence the soil was loose and exposed to the attack of this wind. Grass was not so large as usual, and did not shield the soil. Extensive prairie and forest fires had recently denuded large tracts of much of the protection which vegetation otherwise would have furnished. Circumstances were favorable therefore for the air to become filled with flying particles, caught up from the plowed fields, from the blackened prairies, from the public roads and from all sandy plains. These particles formed dense clouds and rendered it as impossible to withstand the blast as it is to resist the "blizzard" which carries snow in the winter over the same region. The soil to the depth of four or five inches in some places was torn up and scattered in all directions. Drifts of sand were formed, in favorable places, several feet deep, packed precisely as snow drifts are under a blizzard. It seemed as if there were great sheets of dust and dirt blown recklessly in mid air, and when the wind died down for a few moments, the dirt, fine and white, almost seemed to lie in layers in the atmosphere, clouding the sun and hiding it entirely from sight for an hour or more at a time. It was so fine, and penetrated the clothing so that life was burdensome to those who must face the storm. Mr. C. W. Fink, of Woolsley, near Huron, Dakota, stated that it was almost impossible to live out of doors at some periods of the storm, and that he would "much rather take his chances in the big blizzard of two years ago." While on his way to St. Paul over the St. Paul, Minneapolis and Manitoba railroad, Mr. Fink said the train passed through what was apparently a storm of fine dust which seemed to be almost white. It looked much like a snow storm, and the sun was hid. It was impossible to distinguish obstacles at a distance of more than a few feet away. These phenomena in their intensity did not appear at Minneapolis, but they were witnessed in the more open or originally prairie tracts, and are given on the authority of others. During a residence of seventeen years at Minneapolis the writer has not before witnessed anything that would compare with this simoon-like storm.

The occurrence of this storm has a bearing on theories of the origin of the loess. Its area is that over which the loess is abundant. It would not take long for any beholder to be convinced that there was enough material being transported in the wind to constitute, when deposited in water, or even piled up as dunes and spread as surface sheets, after a few years, a stratum as thick as, and constituted like, that of the Missouri-Mississippi valley. Given such a wind over the same region, periodically, under the same parched condition of the surface, it would only require an expanse of water in which this dust could settle, to form a loess clay, or loam. With the accompanying and following rains other particles would be washed down from the lands, mingling with some strata of sand, or of gravel, and a transition from loess to drift sand would be built up such as has been described in several places.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Marine shells and fragments of shells in the till near Boston. By WARREN UPHAM. (From the proceedings of the Boston Society of Natural History, vol. XXIV; also in *Am. Jour. Sci.*, May, 1889.) The remarkable oval accumulations of till called lenticular hills or drumlins are found to contain in Winthrop, the islands of Boston harbor, and on the peninsula of Nantasket, many fragments of marine shells, of which about twenty species are identified, all of which are now living in Massachusetts bay. These shell fragments occur in the unstratified glacial drift or till, in the same manner as its boulders and rock fragments; and Mr. Upham concludes that they were derived from the glacial erosion of marine deposits of interglacial age within a few miles northwest, from which direction the drift has been brought. None have been found farther inland, and it is thence inferred that the relative heights of land and sea there during the principal interglacial epoch were nearly the same as now. *Venus mercenaria* L., the round clam or quohog, is the most abundant species; and it is regarded as evidence that the sea on that part of the coast became warmer in the interglacial epoch than at the present time, for this species is now scarce in Massachusetts bay, but it is plentiful south of Cape Cod, with southward range to Florida.

Seventh Annual Report of the United States Geological Survey to the Secretary of the Interior, 1885-'86. By J. W. POWELL, Director. Washington, Government Printing Office, 1888. pp. xx and 656; plates lxxi: figures 114.

This valuable report, bearing date Oct. 1, 1886, has only been recently issued from the press and bindery, and was distributed to the working geologists of the county about a month ago.

The progress of the topographic surveys and engraving for a contour map of the United States, in charge of Mr. Henry Gannett, is very encouraging; though so vast a work must of course occupy many years. The scale for the greater part of the maps is 1:125,000, or very nearly two miles to an inch, with contour lines for each 100 feet; but considerable areas of the territories are mapped on the scale of 1 : 250,-000, about four miles to an inch, with contours for each 200 or 250 feet.

Professor Raphael Pumpelly, in charge of the division of Archæan geology, has studied the structure of the Green mountains and of the Hoosac range and Graylock in northwestern Massachusetts. Prof. N. S. Shaler, of the Atlantic Coast division, was occupied in field-work on Martha's Vineyard, Nantucket, and Mount Desert islands, and in the region of the Dismal Swamp in Virginia; and he contributes in this volume a memoir on the geology of Martha's Vineyard. The work of Mr. G. K. Gilbert, of the Appalachian division, with his assistants, has been chiefly devoted to an investigation of the structure of the Appalachian mountain system in the states southwest of Pennsylvania.

Professor R. D. Irving, of the Lake Superior division, reported field-work by himself and assistants in northern Michigan, Wisconsin, and Minnesota; and he presents in this volume a discussion of the classification of the early Cambrian and pre-Cambrian formations, which are so fully developed in that region.

The work of the division of glacial geology, under Prof. T. C. Chamberlin, has included various investigations across the entire northern belt of the United States, from Maine to Idaho and Washington. Professor Chamberlin has supplied to this report a very elaborate monograph on glacial striæ, with a map showing their courses and the extent of the glacial drift.

Dr. F. V. Hayden, of the Montana division, reported work in the Gallatin valley and the Bridger range, including the coal beds which are profitably worked near the Boseman tunnel of the Northern Pacific railroad. Mr. Arnold Hague, of the Yellowstone Park division, has given special attention to the later of the more massive lava flows in that district, and to their relation to the so-called fossil forests and plant remains interbedded in the 2,000 feet of volcanic ashes, muds, and breccias found there. He concludes that volcanic activity in the Park probably continued, with varying intensity and occasional periods of rest, throughout the greater part of the Tertiary and into Quaternary time.

The Colorado division, under Mr. S. F. Emmons, worked in the Gunnison or Crested Butte region and in the Denver basin region, an area around Denver supposed to be underlaid by coal. The structure has proved exceedingly complicated, even beyond expectation. Mr. George F. Becker, of the California division, reports the completion of his field studies of the quicksilver deposits of Steamboat springs, Nevada, and the beginning of work on the Gold Belt, which will form the next subject of investigation by that division.

Capt. C. E. Dutton, assisted by Mr. J. S. Diller, has studied the Cascade mountains and the coast ranges of the Pacific states. He finds that volcanic action probably prevailed there during nearly the whole of the Tertiary era.

Mr. Lawrence C. Johnson, of the Louisiana division, reports an examination of the iron deposits of that state. Mr. W. J. McGee, of the

Potomac division, has given his attention to the Potomac and later formations in the District of Columbia and in the states of the Atlantic slope; and he contributes a paper to this volume on the geology of the head of Chesapeake bay.

Brief reports of the work of the Survey in paleontology are given by Prof. O. C. Marsh, Mr. C. D. Walcott, Dr. C. A. White, and Mr. W. H. Dall; in paleobotany, by Mr. L. T. Ward; on fossil insects, by Mr. S. H. Scudder; in chemistry and physics, by Prof. F. W. Clarke; on mining statistics and technology, by Mr. Albert Williams, jr.; on forestry. by Mr. George W. Shutt; on the illustrations of the Survey publications, by Mr. W. H. Holmes; and on the library, and exchange, sale, and distribution of the publications of the Survey, by Mr. Charles C. Darwin.

Besides the special papers which have been already mentioned, Mr. Joseph P. Iddings has one on the obsidian cliff in the Yellowstone National Park; Prof. William M. Davis treats of the structure of the Triassic formation of the Connecticut valley; and Mr. Thomas M. Chatard writes of salt-making processes in the United States. These and the other papers accompanying this report will be more fully noticed later.

Elemente der Paleontologie, von Dr. Gustave Steinmann unter mitwirkung von Dr. Ludwig Döderlein. I Hälfte: Protozoa-Gasteropoda. 8 vo. pp. 336. 1888.

This rather extended course in palæontology is intended as a companion to Credner's Elemente der Geologie; and while primarily designed for European beginners in the study of ancient life, it is of considerable interest to students of this country on account of its recognition of American labor. Specifically, it is the adoption of a classification of the Crinoids proposed by Wachsmuth and Springer. Without change the systematic arrangement of the Crinoidea as set forth by the American writers is selected in preference to that of Zittel and other European systematists. It is indeed gratifying to all American paleontologists to see this worthy estimate placed upon the morphological studies and generalizations of two of their number. Inasmuch as the Elemente are adapted especially for use on the continent, and the material which is to illustrate the text is almost exclusively European, the work is not very well suited to the needs of those in this country wishing to acquire a fair acquaintance with the subject. The arrangement of the book, however, is very convenient and it would be well if some of our science text-books were constructed on a somewhat similar plan. The treatment of each class, or order, in the more important geological groups, is prefaced by a brief bibliography of the principal works discussing the general morphological features of that particular group. Thus the pupil is immediately referred to the best literature on the group he is considering; and his collateral reading and study is only limited by his time and inclination. Keys to the chief families and genera are given under each class; also synoptic tables of the geological distribution of genera. The present part is illustrated by nearly 400 excellent wood cuts. The second half of the work, comprising the remainder of the invertebrates, the vertebrates and the plants is promised during the year, and is probably now ready for distribution. C. R. K.

RECENT PUBLICATIONS.

1. *State and Government reports.*

Eighth annual report of the state mineralogist of California, Wm. Irelan; for the year ending Oct. 1, 1888, pp. 948, plates and sections.

2. *Proceedings of scientific societies.*

The coral reefs of the Hawaiian islands. By Alexander Agassiz. *Bulletin of the Museum of Comparative zoology*. vol. XVII, No. 3. April, 1889.

3. *Papers in Scientific Journals.*

The Canadian record of Science. vol. III, *No. 6.* Glaciation of eastern Canada. ROBERT CHALMERS. Gypsum deposits in northern Manitoba. J. B. TYRRELL. Classification of Cambrian rocks in Arcadia; Supplementary note, G. F. MATTHEW. Archæocyathus, Billings, and other genera allied thereto. G. J. HINDE.

Amer. Jour. Sci., May No. Marine shells and fragments of shells in the till near Boston, WARREN UPHAM. Stratigraphic position of the Olenellus fauna of North America. CHAS. D. WALCOTT. Earthquakes of California, EDWARD S. HOLDEN.

4. *Excerpts and individual publications.*

The Cretaceous and Tertiary geology of the Sergipe-Alagoas basin of Brazil, J. C. Branner. From *Trans. Am. Phil. Soc.*, vol. XVI.

The probable cause of the displacement of beach-lines, with two supplementary notes. A. Blytt.

The physical features of New England; two chapters on the physical geography and the climate of New England. By William Morris Davis. With two colored maps. Reprinted from *The butterflies of New England* by Samuel H. Scudder. 1888.

Marine shells and the fragments of shells in the till near Boston. By Warren Upham. *Proc. Bos. Soc. Nat. Hist.* vol. XXIV, 1888.

Meteoric iron from Arkansas, 1886. By George F. Kunz. *Proc U. S. Nat. Museum*, vol. X. 1887.

Precious stones, abstract from *Mineral resources of the United States*, 1887. By George F. Kunz, 1888.

Ventura county, Cal. By Dr. Stephen Bowers; from the *Eighth Annual report of the State Mineralogist*, 1888.

Some American contributions to meteorology. William Morris Davis. *Journal of the Franklin Institute.* Feb.—March, 1889.

Geographic methods in geologic investigation. Wm. M. Davis. *National geographic magazine*, vol. I, No. I.

The ash bed at Meriden and its structural relations. Wm. M. Davis. *Proc. Meriden Scientific Association*, Dec. 1888.

CORRESPONDENCE.

SOLUBILITY OF PHOSPHATES IN IRON ORES. In studying to find a more rapid method for the determination of the insoluble phosphorus, I found by referring to several works on mineralogy that all the phosphates were soluble in muriatic acid except those of alumina, which were soluble in sulphuric acid; now our soft ores which contain the most of this insoluble phosphorus contain some aluminum—working upon this hint I came to the conclusion that the so-called insoluble phosphorus (phosphorus insoluble in HCl.) was a phosphate of alumina.

Below are some results upon Pittsburg and Lake Angeline ores.

SAMPLE ONE.

Ph. sol. in HCl.	.011 %.	Soluble in HCl.	.009 %.
Residue of above fused	.013 "	Residue of above + H_2SO_4	.017 "
	.024		.026
Dissolved in HCl. filter paper and residue treated with H_2SO^4	.015	Sol. in HCl. + H_2SO_4 Average of two	.025

SAMPLE TWO.

Ph. sol. in HCl.	.0126 %		
Residue of above fused	.0135 "	Treated with H_2SO_4 alone	.0135 %
	.0261	" " H_2SO_4 and HCl.	.0224 "

The results with muriatic acid vary somewhat. Longer digesting with hot acid, particularly under pressure, will give more phosphorus in the solution and correspondingly less in the residue, which accounts for some irregularities in the results.

H. H. TAFT.

Republic Mich., May 2, 1889.

PERSONAL AND SCIENTIFIC NEWS.

MEMOIR OF DR. DOUGLAS HOUGHTON, first state geologist of Michigan. This biography, now soon to be given to the public, has been prepared by his brother-in-law Prof. Alvah Bradish of Minneapolis, Minn. This volume will be read with interest not only by his personal friends but by geologists everywhere, and by all others interested in the early history of Michigan.

The author knew Dr. Houghton intimately and was closely associated with him from boyhood. Houghton was very early in life a close student of nature. He made discoveries at ten years; a passion for natural science seemed inwrought in his very being. Careful observation, intelligence, enthusiasm, energy and industry were striking features of his character.

Before he was 20 he won honors in the scientific school at Troy, N. Y. He was invited to Detroit to give lectures on the natural sciences, and was appointed state geologist of Michigan in 1837 by the first governor of the State, Gov. Mason.

He organized the first geological survey of that state. He first examined and determined the presence and character of the valuable minerals of the Lake Superior region, and by his enthusiasm and personal magnetism be awakened a love for science among all classes of citizens.

Prof. Bradish has, we understand, interspersed many pleasant anecdotes and incidents that will serve to illustrate his character. Several interesting letters, will also be given for the first time to the public. Pen sketches of some of the distinguished persons who were closely associated with the geologist will add to the interest of the volume.

Dr. Houghton's career was a brief one. While prosecuting his chosen work, at the early age of 36, he was drowned in a storm at night in lake Superior; his death was deemed a public calamity.

Besides the narrative of his life and labors, the volume will contain some of his geological reports to the Legislature of Michigan now out of print. The Hon. Bela Hubbard long associated with Dr. Houghton as assistant geologist has arranged these reports and has given summaries of others that could not well be inserted in full.

An excellent portrait of Dr. Houghton will add interest to the volume. It is taken from the full length portrait, (by Prof. Bradish), now at Lansing. It represents him in the costume of a geologist with hammer in hand, standing on the rocky shore of lake Superior, his favorite dog at his feet and the famous "pictured rocks" of the lake forming the background. The volume is from the firm of Raynor & Taylor, Detroit, Mich.

In the American Meteorologist for April Prof. Richard Owen describes some magnetic phenomena, both theoretical and actual, in the southern hemisphere. One of the important facts is the observation made by Prof. F. M. Webster, who has recently returned from Australia. At the instigation of Prof. Owen he applied the magnetic needle to the ends of a vertical iron bar, and found that the upper end rejects the marked end of the needle, and the lower portion attracts it. This is the reverse in the northern hemisphere. On the return passage Prof. Webster, by noting the latitude at which this attraction was reversed, ascertained that the neutral zone, or equator of magnetic dip and intensity, runs perhaps 50 miles north of the terrestrial equator at the longitude of his crossing it. Thus the magnetic equator can be located by any traveler, on land or sea, by the use of a pocket compass and short iron rod.

The Texas legislature has made a most liberal appropriation for the continuance of the survey of that state. Mr. Dumble, the young state geologist, proposes to make good use of the funds and deserves the assistance and encouragement of the scientific world. Considering the obstacles he has had to combat and the delicacy of his political surroundings he has done well to secure this appropriation, and it is earnestly hoped that with two years of unobstructed opportunity he will give substantial scientific results to the world. Measured by the good appropriation secured, even the popular report reviewed in the last number may have been a wise measure.

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